Vol. 4 DECEMBER, 1950 No. 1

# FARLOWIA

## A JOURNAL OF CRYPTOGAMIC BOTANY

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# FARLOWIA

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# A SURVEY OF THE CARBOHYDRASE SYSTEMS OF SYNCEPHALASTRUM RACEMOSUM COHN

VICTOR M. CUTTER, JR.

The ability of microorganisms to survive and perpetuate themselves in given environments is largely dependent upon the efficiency of their enzyme systems. The key to survival in some special habitat may be the genetic ability to produce an enzyme allowing the primary utilization of a particular substrate. Studies on the distributive ecology of the filamentous fungi have largely ignored the interrelationships of the enzyme systems of these organisms, whereas such interrelationships have been the principal approach to the ecology of yeasts and related fungi. This situation perhaps results from the fact that efficient techniques for the measurement of growth and enzymatic activities of filamentous fungi have only recently become available. Since the carbohydrases are among the primary enzymes concerned in substrate utilization, a comparison of these systems in any series of isolates may well provide clues to the factors governing their distribution. To test this hypothesis, and also to accumulate data upon the potential value of enzyme systems as taxonomic criteria, a comparative study has been made of the carbohydrase systems of twenty-three isolates of *Syncephalastrum racemosum* Cohn, collected from diverse habitats. Grown upon a complete synthetic nutrient medium, these isolates are morphologically indistinguishable except for minor quantitative differences which have not proved consistent enough to warrant their classification as taxonomic entities. Throughout, attention has been focused upon the comparative behavior of these isolates in the presence of different carbon sources to determine whether there is a detectable relation between the carbohydrase pattern of the isolate and the substrate on which it was collected. It is realized, of course, that many other factors will influence the utilization of a given carbon source, but any direct correlation that might be made between the substrate on which the organism was collected and its enzyme systems would be of great potential interest.

## MATERIALS AND METHODS

All the studies reported here were carried out upon a basal medium of the following composition:

| | |
|---|---|
| Asparagine | 2 gr. |
| $KH_2PO_4$ | 0.5 gr. |
| $MgSO_4$ | 0.25 gr. |
| Bacto ground agar | 15 gr. |
| Distilled water | 1000 cc. |

This medium was autoclaved for twenty minutes at fifteen pounds pressure and the carbon sources, sterilized by passage through a Seitz filter, the added aseptically. The various carbon sources were supplied as molecular equivalents of forty grams of dextrose. The initial pH of the medium after sterilization was adjusted to pH 4.7 with 0.1N HCl and NaOH. The cultures were grown at 30° C. in Pyrex growth tubes of the type described by Ryan, Beadle and Tatum (1). The internal diameter of the tubes was 15 mm., the length 30 cm. All glassware was cleaned with chromic-sulfuric acid mixture and thoroughly rinsed before using.

A standard inoculum of one loopful of washed spores from a stock culture was introduced at one end of the tube and the culture allowed to grow forty-eight hours. Subsequently measurements were made at twenty-four-hour intervals for one hundred and forty-four hours. These measurements were in millimeters at the mycelial frontier. Each carbon source was tested in triplicate runs. To determine whether there were any marked changes in the enzyme systems involved, due to mutation or adaptation during continued culture, the experiments were repeated at approximately yearly intervals for a three-year period using stocks which had been maintained by serial transfer on a conservation medium of the following composition: Nutramigen (Mead Johnson Co.) 20 gr., Bacto ground agar 15 gr., distilled water 1000 cc. At the conclusion of these experiments stocks of the same original isolate which had been maintained in lyophil for the three year period were revived and also tested in triplicate for comparison. In only one case, described below, was there any significant difference between the growth rate of stocks kept in serial transfer or in lyophil.

With the system of measurement used here, the limit of reproducibility was plus or minus one millimeter. Any tubes which showed a marked deviation from the average beyond this limit, were rerun and, in the few cases where this occurred, it was traceable to faulty technique in inoculation or handling of the tubes. The material given in the graphs and tables below represents the average growth rate in millimeters over twenty-four hour periods at 30° C. of twelve runs on each carbon source (nine runs from serially cultured stocks, and three runs from the original stock carried in lyophil), taken over a three year period.

The following carbon sources obtained from the Pfanstiehl Chemical Company were tested: dextrose, d-mannose, l-sorbose, d-levulose, d-galac-

TABLE I

| NO. | SUBSTRATE | LOCALITY | COLLECTOR | DATE |
|---|---|---|---|---|
| 62 | garden soil | Ithaca, New York | V. M. Cutter | 1938 |
| 64 | sporophore of Lactarius sp. | New London, New Hampshire | V. M. Cutter | 1939 |
| 73 | soil | Cold Spring Harbor, N. Y. | A. F. Blakeslee | 1938 |
| 104 | decaying humus | Panama, C. A. | V. M. Cutter | 1938 |
| 109 | decaying humus | Panama, C. A. | V. M. Cutter | 1938 |
| 149 | surface sterilized pea seeds | Ontario, Canada | J. W. Groves | 1941 |
| 306 | surface sterilized pea seeds | Wellington, Ontario, Canada | J. W. Groves | 1943 |
| 324 | mangel seeds | Eburne, British Columbia | J. W. Groves | 1943 |
| 334 | contaminant in blood agar plate | Duke U., Hospital, Durham, N. C. | N. F. Conant | 1943 |
| 339 | human hands with mycotic lesions | Duke U., Hospital, Durham, N. C. | N. F. Conant | 1943 |
| 412 | surface sterilized sweet pepper seeds | Pedrickton, N. J. | J. W. Groves | 1942 |
| 479 | decaying canvas | Milne Bay, New Guinea Is., S.W.P.A | W. L. White | 1943 |
| 491 | face piece, U. S. service mask | Solomon Is., South West Pacific Area | 42 Chem. Lab. Co. | 1943 |
| 497 | from case of external otitis of human ear | Randolph Field, Texas | F. T. Wolf | 1944 |
| 527 | surface sterilized Red Clover seed | St. Anne de Bellevue, Quebec | J. W. Groves | 1944 |
| 534 | surface sterilized pepper seeds | Milford, Conn. | J. W. Groves | 1944 |
| 549 | decaying wood | Panama, C. A. | G. W. Martin | 1944 |
| 551 | Brazil nuts | purchased in New York City, probably from Venezuela | V. M. Cutter | 1938 |
| 554 | decaying leaves | Barro Colorado Island, Panaca, C. A. | G. W. Martin | 1944 |
| 566 | carrier, optical mask | Milne Bay, New Guinea, S.W. Pacific Area | 42 Chem. Lab. Co. | 1943 |
| 567 | outlet valve on optical mask | Milne Bay, New Guinea, S.W. Pacific Area | 42 Chem. Lab. Co. | 1943 |
| 575 | Japanese leather belt | Milne Bay, New Guinea, S.W. Pacific Area | Jeffersonville Q.M. Depot | 1945 |
| 742 | soil | Panama Canal Zone, Panama, C. A. | N R D C | 1945 |

tose, sucrose, maltose, d-lactose, d-cellobiose, melibiose, d-raffinose, d-melizitose, d-arabinose, l-arabinose, d-xylose, soluble starch, l-rhamnose, d-mannitol, d-sorbitol, dulcitol, and glycerol. In addition, cellulose was used in the form of finely powdered Whatman #5 filter paper (80 mesh), and as regenerated cellulose prepared from the same filter paper. In no case were any of the isolates able to maintain growth on either type of cellulose although in all cases washed spores of the isolates germinated and some growth ensued. Since it was not possible to secure reproducible measurements on cellulose these data are not reported below.

The isolates used in these experiments were obtained from the sources and collectors indicated in Table I. Immediately upon receipt of the culture, single sporangiospores were isolated and used as the basis for monosporous lines. It should be emphasized that these sporangiospores are predominantly multinucleate, and hence in all probability heterocaryotic, since *Syncephalastrum* is a heterothallic organism. The stability and freedom from somatic variation displayed by these monosporous lines is probably traceable to this fact. In each case one monosporous isolate was selected from each original isolate and this line was immediately lyophilized in quadruplicate, and was also carried in serial culture on nutramigen agar under mineral oil. All stocks used were handled in this way.

## RESULTS AND DISCUSSION

When the results of this study were plotted on the basis of average growth over twenty-four-hour periods, the data tabulated as bar graphs and these graphs superimposed on one another, eight patterns of behavior were immediately apparent in regard to the utilization of the respective carbon sources. These eight patterns are shown in Figs. 1–2. In assembling these patterns the growth data from individual isolates were compared for overall agreement. It was obvious that minor differences would occur between comparable isolates in growth rate and therefore in this particular comparison a discrepancy of plus or minus two millimeters for any given carbon source was allowed. The tabulated data all fall within these limits, and the figures as given represent the average performances of all isolates showing that particular behavior pattern when grown under the conditions of the experiment. In essence, these patterns constitute a key to the carbohydrase activity of this group of organisms since it is perfectly feasible to identify any of these isolates by repeating the above procedure, plotting the results schematically and superimposing the specific bar graph on these established patterns. This removes to a considerable extent the element of opinion in classifying the subspecific entities of *S. racemosum* on the basis of carbon utilization.

Perhaps the most striking feature of the carbohydrase systems of *S. racemosum* is their high overall efficiency. All the sugars tested can be utilized to some extent as growth substrates by most of the isolates. This high enzymatic efficiency may be reflected in the wide distribution of

*Syncephalastrum* both geographically, and with regard to substrates. There is little evidence that ability to utilize carbohydrate is a limiting factor in the ecology of the genus.

Although at this time sufficient data is certainly not available to determine the direction of evolution of these enzyme systems, certain trends may be discerned. Pattern 1 is very generalized and there is less variation in the ability to utilize all the sources than in any other pattern. It will be noticed that sucrose is a good carbon source for these isolates and that in the succeeding patterns this sugar is less effective. It is also apparent that sorbose, d-arabinose, rhamnose and dulcitol are poor sources for this group of isolates, and a glance at Fig. 3 where the utilization of carbon sources by pattern is diagrammatically represented, brings out the fact that this tendency is generally true throughout the group. In pattern 1 it will also be noted that the disaccharides are generally as good sources as the monosaccharides, a relationship which undergoes marked changes in the succeeding patterns.

In pattern 2 the utilization of disaccharides in relation to monosaccharides falls off sharply, while at the same time the ability to utilize the pentose sugar l-arabinose, and the alcohols, mannitol and sorbitol, is accelerated. These isolates are also characterized by their very poor utilization of starch and their good utilization of glycerol.

These tendencies are maintained in pattern 3 but lactose utilization becomes very poor, xylose becomes a relatively good source and these isolates have almost lost their ability to use rhamnose. Pattern 4 shows many similarities with pattern 3, but it is marked particularly by the poorer use of sucrose and the much better utilization of rhamnose.

Pattern 5 illustrates a reversal in several directions. Sucrose is hardly used. The trisaccharide, raffinose, is an excellent source and growth on sorbitol becomes comparatively better than on mannitol. This is a very vigorous strain showing better utilization of more carbon sources than any other group and greater extremes of activity are present here than elsewhere.

The remaining three groups are all depauperate and are characterized by poor usage of sucrose. Pattern 6 is interesting since, of the four isolates with this behavior pattern, two can use rhamnose and two cannot. This might be of significance in interpreting the evolution of these patterns. Both patterns 6 and 7 show dextrose to be a poor source relative to the other hexoses. The major difference between the two patterns is the fact that in 7, xylose becomes a better source than l-arabinose, thus reversing the previous tendency. This characteristic is culminated in pattern 8 where xylose becomes the best carbon source.

It should be obvious from a survey of this sort that we cannot at present comment intelligently upon the significance of these patterns in terms of speciation. Since all these variations exist within a complex of morphologically indistinguishable forms, some mycologists would feel that these patterns are sufficient basis for the establishment of specific units. Certainly in the past, species have been erected upon much less tenable bases. We question, however, what useful ends may be served by the further subdivision of the species since *S. racemosum* is an easily recognized coherent entity. It seems certain that further research would reveal other patterns of carbohydrate utilization within isolates of this species, and it does not seem too much to expect that, ultimately, isolates may be found which span the entire range of utilization for each respective carbon source. In the interim, sufficient data have accumulated to warrant the statement that in regard to carbohydrase systems *S. racemosum* is a species showing a considerable degree of evolution.

We come finally to the question of a correlation of the carbohydrase pattern of individual isolates with the substrate from which they were collected. Table II, where the isolates are arranged according to pattern, substrate and locality, shows very clearly that there is no defensible correlation between the substrates upon which these organisms were encountered in the field and the carbohydrase patterns of the individual isolates. It will also be noted that there is probably no geographic coincidence in the carbohydrase patterns of these isolates. It must be remembered that our field collection techniques for the mucoraceous organisms are still so crude that it is probably unfair to attempt such a correlation at all. In reality all our present isolation techniques tell us, in the case of a saprophytic organism

TABLE II

| | CULTURE | SUBSTRATE | LOCALITY |
|---|---|---|---|
| Pattern 1 | 527 | clover seed | Quebec, Canada |
| | 567 | plastic valve | New Guinea |
| Pattern 2 | 479 | decaying canvas | New Guinea |
| Pattern 3 | 339 | human hands | North Carolina |
| | 334 | blood agar | North Carolina |
| | 742 | soil | Panama Canal Zone |
| Pattern 4 | 551 | Brazil nuts | S. America |
| | 566 | canvas cover | New Guinea |
| | 575 | leather belt | New Guinea |
| | 549 | decaying wood | Panama |
| Pattern 5 | 554 | decaying leaves | Panama |
| Pattern 6 | 64 | sporophore of Lactarius sp. | New Hampshire |
| | 109 | decaying humus | Panama |
| | 62 | garden soil | Ithaca, N. Y. |
| | 306 | pea seeds | Ontario, Canada |
| Pattern 7 | 149 | pea seeds | Ontario, Canada |
| | 491 | face piece on mask | Solomon Islands |
| | 497 | external otitis of ear | Texas |
| | 534 | pepper seeds | Connecticut |
| Pattern 8 | 412 | pepper seeds | New Jersey |
| | 324 | mangel seeds | British Columbia |
| | 104 | decaying humus | Panama |
| | 73 | soil | L. I., N. Y. |

such as *Syncephalastrum*, is that at least one spore of this organism happened to be on that particular substrate at the time collections were made.

In terms of the taxonomy of *Syncephalastrum*, the most important contribution of this study lies in a consideration of the growth behavior and change in morphology exhibited by any one of these isolates grown upon different carbon sources. It was previously stated that when grown upon a complete medium these isolates were indistinguishable. In contradistinction to this, when any one isolate is grown upon different carbon sources a tremendous degree of morphologic variation is immediately apparent. That such must be the case is readily understandable from the differences seen in the growth rate of any isolate upon different carbon sources. These rate differences are the reflection of different morphogenetic tendencies in the individual colony. It would hardly be an exaggeration to say that within the range of morphologic variation expressed by one isolate upon the carbon sources used here, under the conditions described above, may be found the entire range of variation described in the literature on the genus *Syncephalastrum*. To state this in another way, it is possible by selecting any one of these isolates and varying the carbon source appropriately, to produce cultures identical with the several described species of *Syncephalastrum*. This in itself is not surprising since this genus is little known and all the species were described before present day cultural techniques were in vogue. Yet if this premise is true, there can be little justification at the present time for random description of taxonomic entities in such a group without previous exhaustive physiological studies to determine the extent of variation under standard conditions. At the same time a caveat should be sounded concerning the interpretation of such growth data in terms of the ability of organisms to survive under given conditions. Growth rate as such is only one aspect of assimilation and a slow growth rate is not *a priori* evidence of poor utilization. A case in point is the utilization of sorbose by this organism. Figure 3 shows that all these cultures grow very slowly upon sorbose. As has been pointed out elsewhere (2) the total dry weight of *Syncephalastrum* cultures grown upon sorbose and upon sorbose in combination with other sugars compares rather favorably with cultures grown upon dextrose. The slow growth rate on sorbose is not due to poor utilization alone but to a morphogenetic change in the form of the mycelial cells which under these conditions become shortened and ovoid, or even yeast-like, instead of assuming their normal elongated cylindrical shape. To this extent the data presented here may be misleading, but in the morphogenetic changes which can readily be detected in this manner may lie the key to an understanding of specific variation.

Since the data presented above deals exclusively with the carbohydrase systems of the somatic haploid stages, it was of some interest to discover whether the sexual reproductive cycle of the organism could be correlated in any way with these carbon utilization patterns. Therefore, compatible strains of *S. racemosum* were crossed upon the medium used above with all the individual carbon sources, at the same concentration on which the growth rate studies had been made, and these crosses were tested for their ability to form zygospores upon the different sugars used. The results in terms of the presence or absence of zygospores are presented in Table III.

TABLE III

| | 479 x 554 | 479 x 551 | 479 x 534 | 479 x 104 | 64 x 534 | 62 x 534 | | 479 x 554 | 470 x 551 | 479 x 534 | 479 x 104 | 64 x 534 | 62 x 534 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dextrose | + | + | + | + | + | + | d-Melizitose | — | — | — | — | — | — |
| d-Mannose | + | + | + | + | + | + | d-Arabinose | — | — | — | — | + | + |
| b-Sorbose | — | — | — | — | — | — | l-Arabinose | + | + | + | — | + | + |
| d-Levulose | + | + | + | + | + | + | d-Xylose | + | + | + | + | + | + |
| d-Galactose | + | + | + | + | + | + | Soluble starch | + | + | + | + | + | + |
| Sucrose | + | + | + | + | — | — | l-Rhamnose | — | — | — | — | — | — |
| Maltose | + | + | + | + | + | + | d-Mannitol | + | + | + | + | + | + |
| d-Lactose | — | — | + | — | + | + | d-Sorbitol | + | + | + | + | + | + |
| d-Cellobiose | + | + | + | + | + | + | Dulcitol | — | — | — | — | — | — |
| Melibiose | + | — | + | — | + | + | Glycerol | + | — | + | — | + | + |
| d-Raffinose | + | + | + | + | + | + | Cellulose | — | — | — | — | — | — |

In general the carbon sources which did not promote rapid vegetative growth did not favor zygospore formation. Thus no zygotes were formed in crosses carried out on sorbose, melizitose, rhamnose, dulcitol, and cellulose. In the case of other negative crosses the degree of compatibility of the respective strains appeared significant when the crosses were made upon certain sugars. Crosses 479x551 and 479x104 failed to produce zygotes on nine and ten carbon sources respectively, and likewise on all the carbon sources which permitted zygote formation their reaction, as judged by the number and size of the zygotes produced, was weak compared to the other crosses. Since it has been shown many times by various workers in the Mucorales that vegetative vigor is one of the necessary prerequisites to successful gametic reproduction, it is not surprising to find that in any cross where one or the other compatible member is somewhat limited in its ability to assimilate the particular carbon source the zygospore production will be scanty. Likewise in the case of crosses 62x534 and 64x534 no zygotes were produced on sucrose, which would be expected since none of these isolates can assimilate sucrose to an appreciable degree. It will take further study to evaluate the specific role of carbohydrate assimilation in gametic reproduction and zygospore formation in *Syncephalastrum*, but the results of this survey substantially confirm the classic idea that successful sexual reproduction in this group is in large measure based upon proper environmental conditions and that the carbon source of the substrate is a prime requisite in this connection.

Finally we must consider the affect of mutation and adaptation of these enzyme systems upon their usefulness as taxonomic criteria. If such phenomena produce great variation in these cultures with time, any system of classification based upon cultured material will hardly be workable. On the basis of the results obtained by many other workers on carbon utilization in microorganisms, one would expect that at least some of these carbohydrase systems would be adaptive. With the method used above it is not possible to detect adaptation if it occurs at any time except during the actual period of testing of a culture. The only check that may be obtained on this is by repeating the experiments at intervals and investigating the closeness of agreement in the results. Even this procedure will not adequately separate the phenomena of adaptation and mutation if they may be considered different processes. Our results given here would indicate that if adaptation occurs it has very little effect in creating greater variability of the cultures over a three year period. On the other hand spontaneous somatic mutations which allow better utilization of a particular carbon source may be readily detected by this method. Only one such mutant was encountered during the course of this work. In the case of isolate 742 in pattern 3, which cannot utilize rhamnose, in one run after a period of four days of very slow growth the culture suddenly began to grow at an average of 8 mm./24 hours. Contamination was suspected and a new run from the original stock confirmed the fact that some change had occurred in the tube in question. When the aberrant culture was checked for its behavior on the other carbon sources it showed the typical behavior of pattern 3 except in regard to rhamnose utilization. This was interpreted as fairly convincing evidence of a mutation at a locus controlling rhamnose utilization. Indirect evidence for the same type of mutation may be seen in pattern 6, where of four isolates showing practically identical behavior on all other sources, two can use rhamnose and two cannot. These may be interpreted as either gain or loss mutations at a single locus. However, in an organism such as this with multinucleate sporangiospores any somatic loss mutation will be so quickly submerged in the general population that it will not be the source of any great variation under the conditions used here. Gain mutations on the other hand, if they occur, will be easily detected by marked changes in the growth rate of individual cultures, and therefore should cause no difficulties when the procedures are used as bases for classification.

## SUMMARY

1. The comparative ability of twenty-three isolates of *Syncephalastrum racemosum* to utilize twenty-one different carbon sources has been investigated. These isolates are shown to fall into eight carbon utilization patterns on the basis of growth rate studies.

2. The effect of carbon source upon the production of zygospores by compatible strains has been tested. It is shown that zygospores are produced on all carbon sources which support good vegetative growth, but that in the case of carbon sources which do not support vigorous somatic growth the degree of compatibility of the opposed strains is important in

determining the sexual reaction as judged by the number of zygotes produced.

3. The effects of adaptation and mutation of the genes controlling carbohydrase synthesis in this study are briefly discussed.

## ACKNOWLEDGMENTS

It is a pleasure to acknowledge the technical assistance of Mr. Bruce Pollack, Mr. Morris Jalazzo and Miss Nancy Rhynedance during the period when this study was in progress. The author is also under great obligation to the late Dr. D. H. Linder and to Drs. J. Walton Groves, N. F. Conant, G. W. Martin, W. L. White, and F. T. Wolf, who at one time or another donated most of the cultures which made this study possible. This work was initiated and a portion carried out in the laboratories of the Department of Botany, Cornell University, and for the facilities provided there the author is duly grateful. A selected portion of this study was reported before the Microbiological Section of the American Botanical Society at the Washington Meetings, September, 1948.

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2. **Tatum, E. L., Barratt, R. W. and Cutter, V. M., Jr.** Chemical induction of colonial paramorphs in *Neurospora* and *Syncephalastrum*. Science **109**(2838): 509–511, 1949.

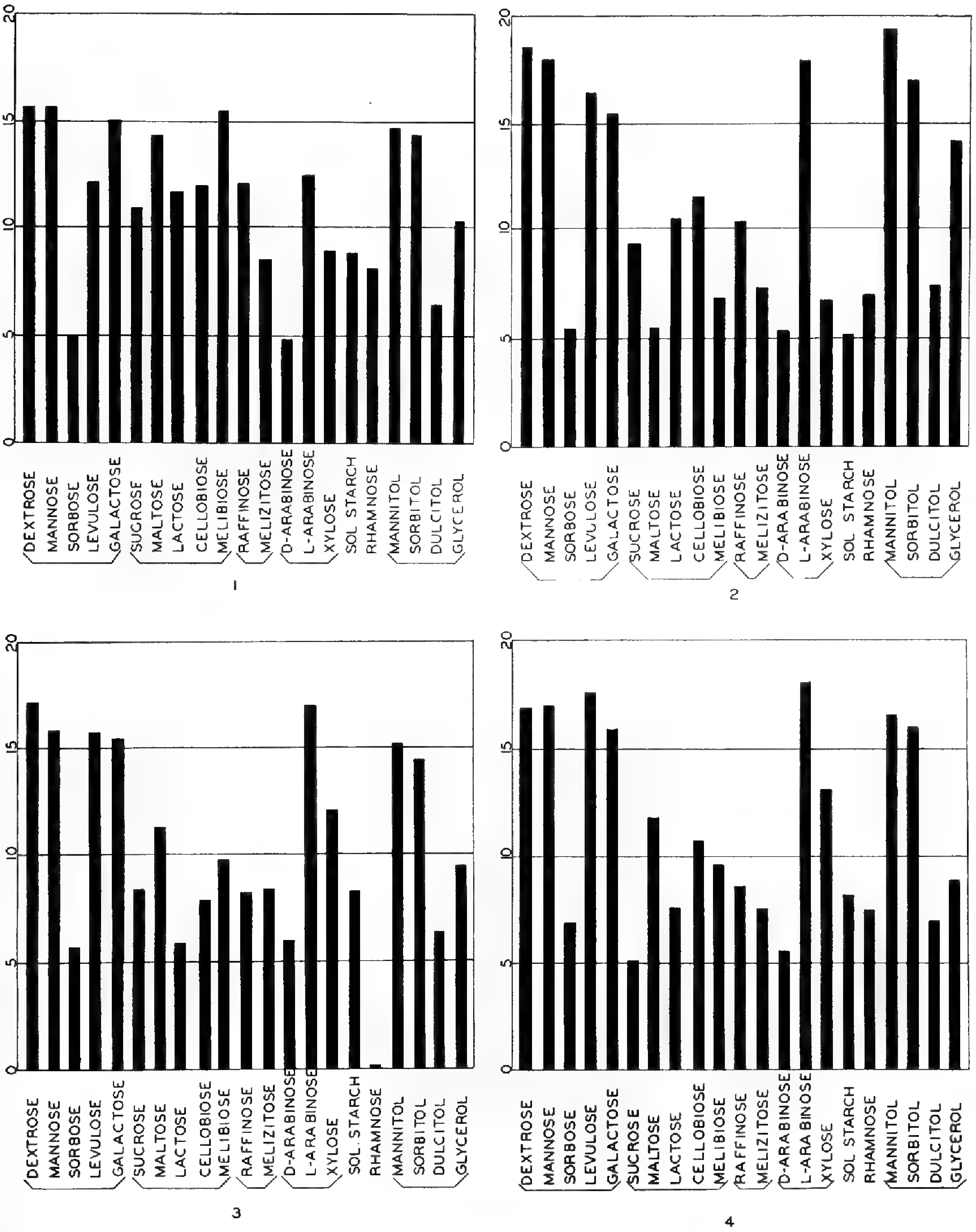

**Fig. 1.** Patterns 1, 2, 3, 4. Average growth in mms./24 hours for 144 hours on twenty-one carbon sources.

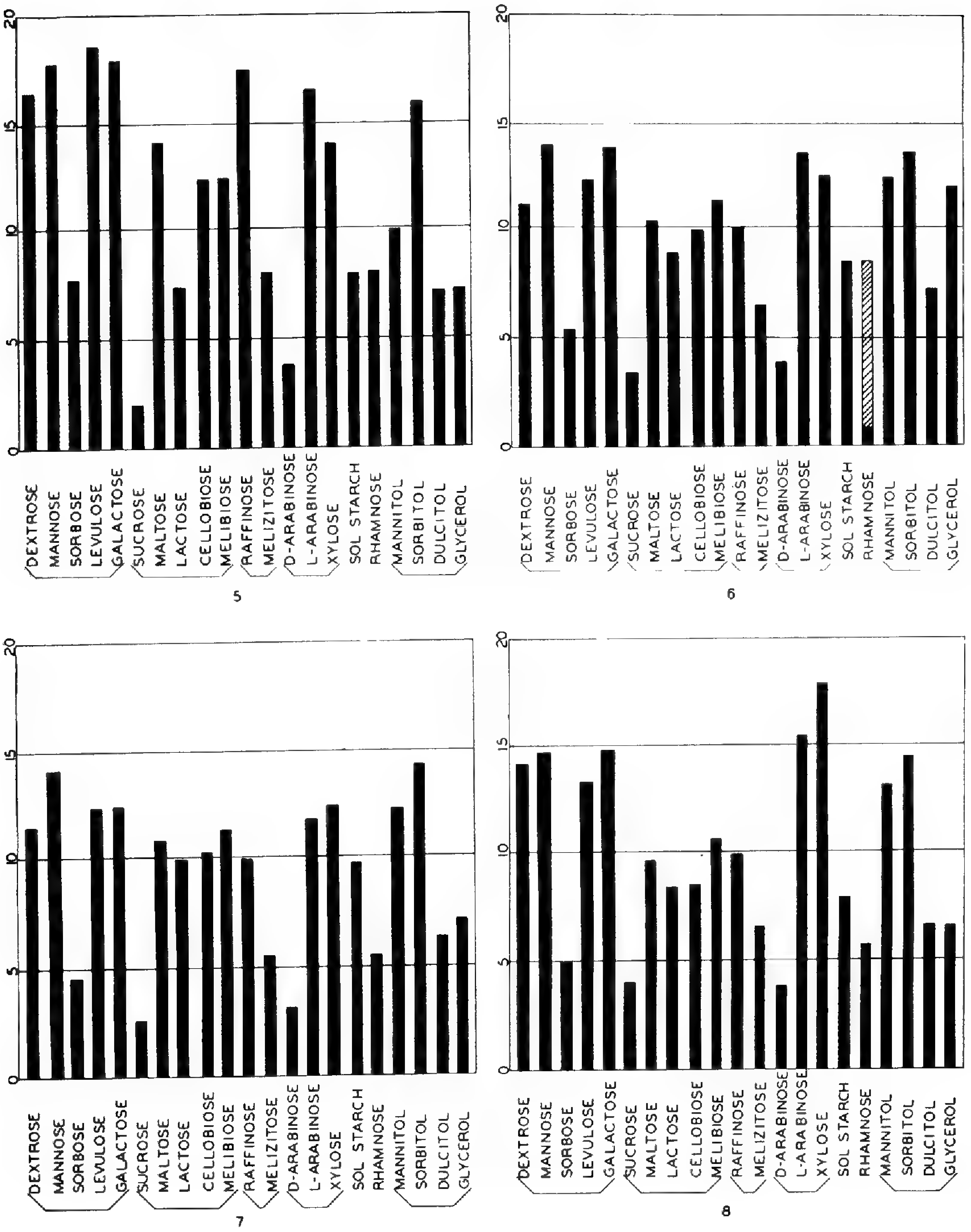

**Fig. 2.** Patterns 5, 6, 7, 8. Average growth in mms./24 hours for 144 hours on twenty-one carbon sources. In pattern 6 different rhamnose utilization levels indicated by cross hatching.

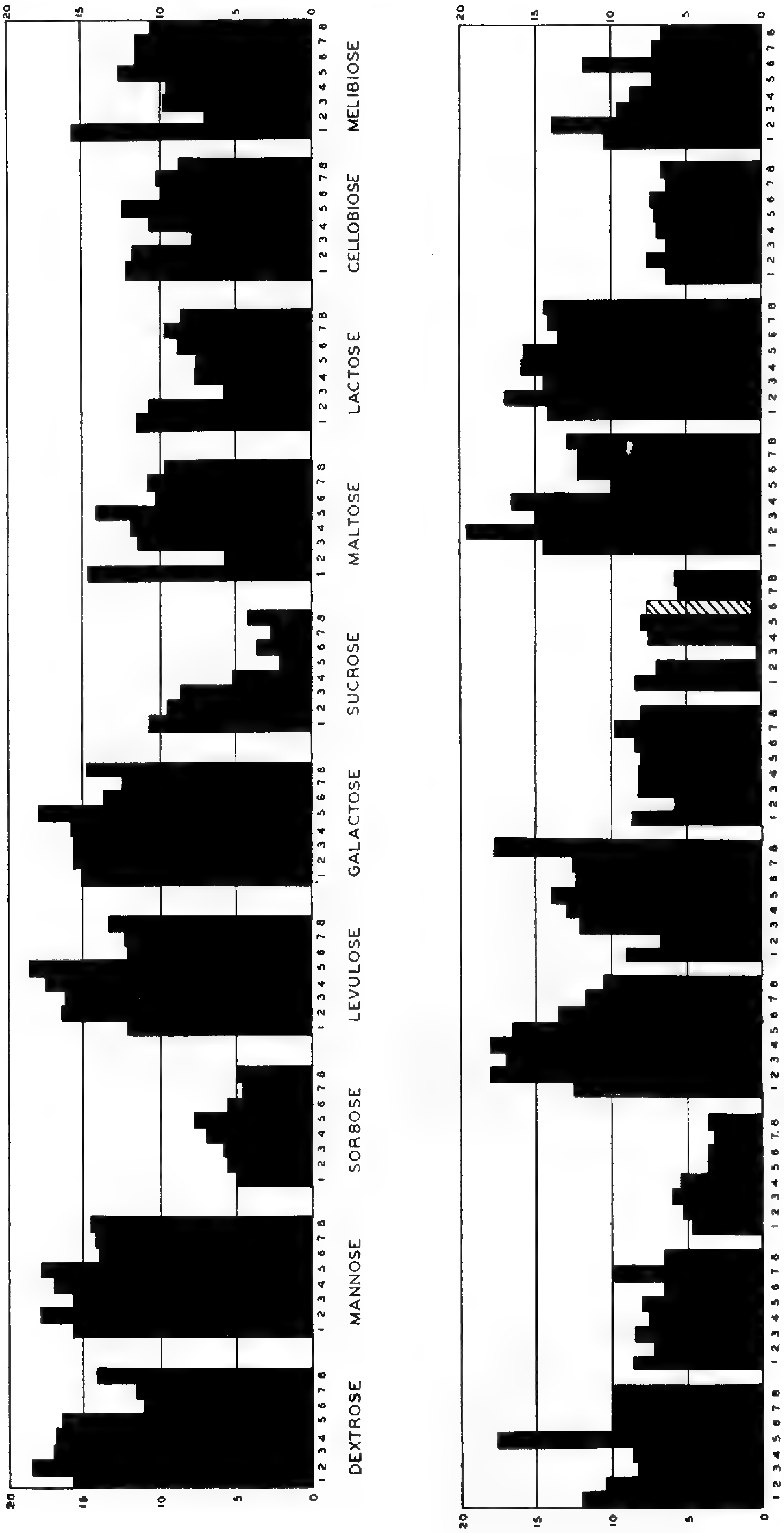

**Fig. 3.** Utilization of respective carbon sources by eight groups of isolates. Average growth in mms./24 hours for 144 hours.

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# NOMINA CONSERVANDA PROPOSITA AND NOMINA CONFUSA — FUNGI. SUPPLEMENT

DONALD P. ROGERS

An earlier series of notes (Rogers 1949) was prepared by the writer in an attempt to consider critically most of the proposals for conservation of generic names of fungi. As there stated in a footnote, two important papers by Donk (1949, 1949b) on the same subject arrived after those notes had been set in type, too late to introduce appropriate modifications. In order to preserve their (approximate) completeness this supplement is offered. Additional information, but no change in his previous decisions, is provided by Donk on *Agaricus* (p. 149), *Dictyolus* (p. 152), *Hypochnus* (p. 152), *Paxillus* (p. 154), *Podoscypha* (p. 154), and *Tomentella* (p. 158), which are not discussed here further. A recent paper by Bisby (1949) contains in brief notes much useful information on fungus nomenclature, and it is similarly referred to here in several places. While the present notes were in press an additional nomenclatorial paper by Donk was received; in it Donk has anticipated a number of the conclusions herein presented. He also reports (Donk 1949c) the discovery of two additional authors, Staude and Wünsche, who, in 1857 and 1877 respectively, preceded Quélet in the transformation of Friesian infrageneric groups into genera. Where these most recent conclusions have some bearing on nomina conservanda proposita they are referred to in these notes.

In the notes that follow the earlier discussion is not repeated, nor are the references appended to it. "Recommendation" means the recommendation of the writer; author- and literature-citations for proposals previously discussed will be found on the pages cited under "Rogers 1949." Again the principle has been followed that cases that can be dealt with by the Rules should not be made the subject of exceptions (i.e., conservation), and that the shorter the list of conserved names, the better.

## I. NOMINA CONSERVANDA

ACROTHECIUM VS. CORDANA and CACUMISPORIUM — Bisby 1949 pp. 4, 11; Rogers 1949 p. 428.

Bisby writes: "*Cacumisporium* evidently should not be rejected."

ALEURODISCUS VS. CYPHELLA — Donk 1949 p. 88; Rogers 1949 p. 433.

Donk retains his earlier proposal, changing only the citation for *Aleurodiscus*. His former citation was adequately supported (Donk 1941; Rogers & Jackson, Farlowia **1**:269), and the present writer's recommendation stands.

AMANITOPSIS ROZE VS. VAGINATA NEES EX GRAY — Donk 1949 p. 113.

In this proposal the nomen rejiciendum is ascribed to "S. F. Gray"; but since Gray ascribed it to "Esenbeck," it should, under Art. 48 and 49, when written in full be "Nees ex Gray." Since under the Rules Gray first published the name, any of his species is eligible as lectotype. Murrill designated *V. livida* and Singer & Smith (1946 p. 249) apparently concur. At least many of the combinations in *Vaginata* have already been published, and it seems doubtful that conservation of the newer name would "avoid disadvantageous changes in the nomenclature of genera." Since it is also far from certain that a genus distinct from *Amanita* will be maintained for these fungi, there is even less reason to attempt conservation. As in the earlier notes under *Volvaria* (q.v.), it is recommended that the proposal be rejected.

ASCHERSONIA VS. ASCHERSONIA — Bisby 1949 pp. 7, 8, 56; Rogers 1949 p. 434.

Bisby notes that *Underwoodina* OK. is at present the legitimate name for *Aschersonia* Mont.

AURICULARIA VS. AURICULARIA — Donk 1949 p. 89; Rogers 1949 p. 434.

Donk retains the substance of his earlier proposal but substitutes different citations for the nomen conservandum and n. rejiciendum. The recommendation stands.

It would be of interest to mycologists in general to learn the bases for Donk's reservation of judgment concerning the priority of Fries's Systema 1 to Gray's Natural Arrangement (p. 91, footnote 2). Fries's own assertion and the evidence of Hinrichs place the former no later than June 30, 1821. Gray's volumes themselves place the latter no earlier than Nov. 1, 1821. Surely such contemporary published evidence must be accepted where all contrary evidence is lacking.

CALOCERA VS. CORYNOIDES — Donk 1949 p. 114; Rogers 1949 p. 434.

Donk considers *C. cornea* the type of *Corynoides*; this selection would necessitate the conservation of *Calocera*. It is preferable to designate *C. fabarum* as lectotype, since this makes of *Corynoides* a nomen dubium, interfering with nothing; and this selection was made by Doty and the writer and published in 1948. The earlier discussion, according to which the present proposal is both unnecessary and impossible, stands.

CALODON VS. HYDNELLUM — Maire p. 35; Donk 1949 p. 151; Rogers 1949 p. 435.

The earlier recommendation, which agrees with Donk's, stands.

CANDIDA BERKHOUT, De schimmelgeslachten Monilia, Oidium, Oospora en Torula 41. 1923 — Type: *C. vulgaris* Berkh., l.c. p. 42 — vs. SYRINGOSPORA QUINQUAUD, Arch. Physiol. Norm. Path. **1**: 293. 1868.

The proposal has not yet been published (cf. A. & B. 1943 p. 47, 1945 p. 52), but was submitted to the Congress in multigraphed form by Dr. Rhoda Benham. Of the various names published for *Monilia* sensu medicorum non Pers. (Rogers 1949 p. 457) *Candida* is the only one now widely employed and the only one which seems to have any chance of acceptance by the non-mycological group who commonly deal with these fungi; *Syringospora* has no currency whatever. The genus is of considerable importance in human pathology and embraces a sufficient number of species (if they be such; at any rate, of specific names) that the conservation of *Candida* is abundantly justified.

*C. vulgaris* is the designated genotype. The fungi to which Berkhout gave that name were received by her as "*Monilia candida* Bon." Since she entertained some doubt whether they actually represented that species, since that doubt is amply justified, and since in any event there is no *M. candida* Bon., but only *M. candida* Pers., the name Berkhout gave to her material is here listed for the type rather than the dubious name under which she discussed that material; the basis for the genus is then Berkhout's description, figures, and (if still in existence) specimens.

Conservation of *Candida* automatically brings about the rejection of other names judged synonymous with it (Art. 21, Note 3). It is strongly recommended that the proposal be adopted.

CAPNODIUM MONT. vs. APIOSPORIUM FR., POLYCHAETON LÉV., and FUMAGO LÉV. — IR p. 122; IRA p. 39.

The chronology and citations for the nomina rejicienda are in need of correction. *Fumago* should be Pers., Mycol. Eur. **1**: 9. 1822; Léveillé had nothing to do with it. *Apiosporium* should be Kunze ex Fr., Syst. Orb. Veg. 156. 1825. *Polychaeton* should be (Pers.) Lév., Consid. Mycol. 125. 1846.

*Apiosporium Salicis* was designated by Kunze as the genotype (Myc. Hefte **1**: 8. 1817), and since it forms one of the three species treated in the genus by Fries in 1829 (Syst. Mycol. **3(1)**: 255,6) when he first listed species, must be the type of *Apiosporium* Kunze ex Fr. "*Fumago Citri* Turp. (vix Pers.) . . . in *Mém. des Sav. étr. de l'Inst. de Fr.*, t. VI, p. 240" is the designated type of *Capnodium* (Ann. Sc. Nat. Bot. iii **11**: 233. 1849). Since Montagne noted on publishing the genus that Turpin had failed to see the fructification, it is not a happy choice; nevertheless, to alter an author's choice of type (especially when he was in possession of the facts) is beyond the competence of any later worker or of the author himself. *Fumago* as Persoon first set it forth consisted of seven species, of which the first two, "conformatione aequali," were not set apart in a subgenus, while the remaining five were assigned to "** *Polychaeton*." It appears that the type should be chosen from the first two, *Polychaeton* having often been treated as a separate entity — (e.g., by Berkeley & Desmazières in Hort. Soc. Lond. Jour. **4**: 243–255. 1849); and since of these *F. Mali* is marked "An hujus generis?", the other, the first species listed, *F. vagans*, should be the type. The type of *Polychaeton* is one of the five species assigned to *Fumago* ** *Polychaeton* by Persoon in 1822.

The writer has no proper basis for a recommendation for action on the proposal — nor has anyone else not acquainted with the characters of *Fumago vagans*, *Apiosporium Salicis*, *Fumago* |subg.| *Polychaeton*, and *Fumago Citri* sensu Turp. as represented in the specimens (or at least descriptions) of their authors. One would suppose that at least *Fumago* Pers. was a genus of Fungi Imperfecti (see notes on *F. vagans* under discussion of nomina confusa), and at least some of the others were Ascomycetes, in which event it would be neither profitable nor possible to reject the first in favor of the latter. The matter should be tabled until information on the types is available.

CERATOSTOMA SACC., Syll. Fung. **1**: 215. 1882 — Type: ? — vs. CERATOSTOMA FR. (Obs. Mycol. **2**: 337. 1818) ex Fr., Summ. Veg. Scand. 396. 1849. — Mason 1933 pp. 42, 44; Bisby 1949 p. 13.

In 1848 Fries wrote, "Quando *S*[*phaeriam*] *chionaeam* legebam, mox pro novi generis typo habui = Ceratostoma *Obs. Myc. II*"; *C. chioneum* (or, as spelled in 1849, *chionaeum*) was the only species of the genus illustrated in 1818 and the first listed in 1849; by Fries's own designation it is the genotype. Meanwhile Corda had published *Melanospora* (Icon. Fung. **1**: 24. 1837), with three species, of which one was *M. chionea*; he discussed the characters and raison d'être of the genus at some length in a note under that species, thereby strongly implying that it was what he had chiefly in mind in describing the genus (ergo, was the type). *Ceratostoma* Fr. is then presumably an obligate synonym of *Melanospora*.

Bisby writes, "*Ceratostoma* Sacc. is in need of conservation." He does not give a citation for the publication of this name; in Syll. **1**: 215 one finds "*Ceratostoma* Fr. S. Veg. Scand. p. 392, p. min. parte." Since Fries designated his own type, Saccardo's selection of a "minor part" (three species, all listed in Syll. **1**: 220 as "species incertae") to bear the name has no validity. As Bisby has elsewhere written "Karsten did not propose a genus *Craterella*" (p. 18), so here one must say "Saccardo did not propose a genus *Ceratostoma*." It is, however, legally possible to conserve "*Ceratostoma* Sacc." provided the modification of Art. 47 adopted at Amsterdam is retained at Stockholm. See the earlier discussion under *Phoma*, and Mycologia **41**: 215–219. It is here recommended that no such conservation be attempted.

CLAVARIA VS. CLAVARIA — Donk 1949 p. 115; Rogers 1949 p. 436.

The proposals cited are in agreement.

CLITOPILUS (FR.) KUMMER VS. PLEUROPUS PERS. EX GRAY — Maire p. 82; Donk 1949 pp. 117, 154; Rogers 1949 p. 464 (*Panus*); Donk 1949b pp. 301, 394.

The earlier recommendation was that *Panus* be conserved against *Pleuropus*; this arose out of Singer & Smith's selection of *Pleuropus fornicatus* as the lectotype. If that be a "binding" designation of the lectotype, as both Donk and the writer believe it is, the recommendation stands. If, however, as Donk would prefer, the designation of *Agaricus orcellus* by Earle and Murrill as the type of the pre-Friesian *Pleuropus* Roussel be held to fix the type for *Pleuropus* Pers. ex Gray also, the present proposal is in order.

It is in order, but by no means acceptable. As Donk points out, *Agaricus* trib. *Clitopilus* Fr. 1821 is far from coextensive with *Agaricus* trib. *Clitopilus* Fr. as used in 1838. As a matter of fact, of the 20 original species 8 were in 1838 included in the trib. *Pluteus*, 8 in the trib. *Entoloma*, and one each in trib. *Clitocybe*, *Eccilia*, and *Tricholoma*; only *A. angustus* Pers. ex Fr. remained in *Clitopilus*. Donk thence reasons that "*Agaricus* trib. *Clitopilus* Fr. . . . 1838" is a new name, a homonym of the 1821 name; in which case it is illegitimate, and so is *Clitopilus* (Fr.) Kummer if that be indirectly based on it. If that is so, there would be every reason for retaining *Pleuropus* sensu Murrill and Donk, which is stated to be a synonym of *Clitopilus* as currently used. If a genus has long possessed a legitimate name, and if many of the component species have had the combinations with that name published — both true in this case — it seems scarcely a contribution to nomenclatorial stability to conserve against the legitimate name one which is not only invalid twice over but ambiguous (Art. 62). *Agaricus* trib. *Clitopilus* Fr. can of course be typified by almost any of its original species, but not, as proposed, by *Agaricus prunulus*, a species "not even mentioned at all among the members of [the tribe] of 1821 [and which] should, therefore, be disregarded" (Donk 1941 p. 180, in another connection). The obvious type is *Agaricus angustus* Pers. ex Fr. (*Clitopilus angustus* Kummer), the only original member of *Clitopilus* retained by Fries in his 1838 revision. It is hereby designated the lectotype of *Agaricus* trib. *Clitopilus* Fr., Syst. Mycol. **1**: 194. 1821, if that group be not already legitimately typified.

To return to *Pleuropus*: If Singer & Smith's typification stands, so does the earlier recommendation. If the typification of Earle & Murrill is judged applicable, it is strongly recommended that no conservation be attempted, and that Gray's name be allowed to prevail, as Murrill used it, for the genus later known as *Clitopilus*. In his most recent paper Donk (1949c) wishes to ascribe the name *Pleuropus* to "Gray" rather than "Pers. ex Gray." His argument, which depends on the typification of a section so named by Persoon in 1797, seems not to be in accord with the Rules or general usage. Art. 48 prescribes "Pers. ex Gray."

The authority cited for the proposed nomen conservandum necessitates consideration of a more general problem. Donk reports that it was his "fate" (perhaps "misfortune" would have been a better word) "to stumble on a popular booklet . . . in which Quélet was beaten by one year" in the self-imposed task of publishing genera for the earlier tribes and sub-genera of *Agaricus*. The book is Kummer, Paul, Der Führer in die Pilzkunde. pp. [ii]+146. Luppe, Zerbst, 1871. Donk correctly points out that in Kummer's work "there are no references or author citations after the scientific names. Thus all new names . . . owe their valid publication to the accompanying [key] descriptions." Donk says (p. 87) ". . . all new names and recombinations . . ."; but it is evident that strictly there can be no recombinations. That is, since there are no author- or literature-references, every binomial in the genera of gill-fungi not published as such by an earlier author is, strictly, typified only by Kummer's description or (if he had any) specimens. Donk refers also (p. 119, 139) to basinyms for generic names of Kummer's. But that author wrote in his introduction (p. 12, footnote): "Es sei hierbei bemerkt, dass ich die grosse Gruppe der Blätterpilze . . . , welche von den meisten Autoren als die einige grosse Gattung *Agaricus* aufgeführt werden, aus guten Gründen in viele Gattungen zerlegt, ihnen aber meist die Namen gegeben habe, mit denen man herkömmlich die Gattung *Agaricus* zu gruppiren pflegte." Kummer does not then say or imply that is is raising the former inferior groups to generic rank; he explicitly claims that he himself "divided . . . the large group of the gill-fungi . . . into several genera" — to which, almost (he would lead one to believe) fortuitously, he "mostly gave the names by which it was customary to classify the genus *Agaricus*." There is, then, no formal or necessary correspondence between, for example, *Clitopilus* Kummer, Führer Pilzk. 23, and *Agaricus* trib. *Clitopilus* Fr. 1821, *Agaricus* [trib.] *Clitopilus* Fr. sensu Fr. 1838, or *Agaricus* [group] *Hyporhodius* [group] *Clitopilus* Fr. sensu Rabenh. 1844 — nor between *Clitopilus Prunulus* Kummer, Führer Pilzk. 97 and *Agaricus Prunulus* Pers. ex Fr. 1821 or *Clitopilus Prunulus* ("Scop.") ex Quél. 1872. Strictly, Kummer's names are at best taxonomic synonyms of names of other authors, and at worst earlier homonyms of well established and universally accepted generic names or binomials.

Donk writes (p. 86) ". . . little shines through from [Kummer's] field experience and . . . his mycological library must have consisted of hardly more than one work: L. Rabenhorst 'Deutschlands Kryptogamen-Flora. Pilze.' [1.Aufl.] 1844. . . . a compilation based in the first place on Fries' Epicrisis. . . . It can be deduced that Kummer raised to generic rank — modified or not — Rabenhorst's tribus, which in turn are those — modified or not — of Fries' of 1838." Donk's deductions are confirmed by comparison of the works in question. In his key Kummer has 42 generic names in the gill-fungi. Of these four are used for genera in Rabenhorst, and of the remaining 38 only three are not exact duplicates of the latter's infrageneric names: *Leucopus* and *Rhaphanazon*, both new genera, and *Galorrheus*, which differs from the name in Rabenhorst by one *r*. The two new genera are described in the key on p. 22; but on p. 85, before any species have been assigned to them, are "combined as the following single genus: *Cortinarius*." Kummer's advance over Rabenhorst then consists, so far as these names are concerned, in a) the difference in rank attributed to them and b) the letter *r.* Of Kummer's generic names six are given to genera by Fries in the Epicrisis; 32 are there employed for infrageneric groups (rank unspecified); one (*Galorrheus*) stems from the Syst. Myc. and was changed to *Lactarius* in the Epicrisis; and one (*Rhymovis*) is Persoonian; *Cortinarius*, for which Kummer discarded his two new genera, makes a seventh Friesian generic name adopted by Kummer. As to species only one seems to have been intended as new: "Da er bisher nirgends von den Autoren angegeben ist, habe ich Ihn *R*[*ussula*] *narcotica* benannt" (p. 100). It may then be inferred that all other species had, in Kummer's opinion, been somewhere "indicated by the authors."

As Donk implies, the Kummer book is taxonomically worthless. The long list of new names is apt, however, to prove an embarrassment to students of the agarics. Since (except for assigned rank) it is abundantly clear that whatever his own evaluation of his work Kummer took over Rabenhorst's classification lock, stock, and barrel, and since he implied that all of his species but the one were those of earlier authors, it is strongly recommended that the difficulties presented by the existence of this book be avoided as they are in Donk's paper: All of Kummer's names not explicitly new are to be associated with names of genera or of infrageneric groups in Rabenhorst, Deutschlands Kryptogamen-Flora. 1 Bd. 1844. The precedent for such "association" exists in the last paragraph of Art. 20. For such a procedure the semblance, at least, of legality can be provided. Whatever Kummer says of his work, his innovations present little evidence of derivation from study of the fungi, and devastating evidence of derivation from Rabenhorst's book. It is therefore submitted that for many names (and can be stipulated that for all names except the two discarded new genera and the single new *Russula*) the type is not "a specimen or preparation" (Art. 18) but "a description . . . given by a previous author" — namely, Rabenhorst.

COLLYBIA (FR.) KUMMER VS. GYMNOPUS PERS. EX GRAY — Donk 1949 p. 120; Rogers 1949 p. 436; Donk 1949c pp. 322, 394.

The proposal embodies a typification of *Gymnopus* different from that earlier published by Singer & Smith (1946 p. 249). There seems to be no obstacle to the earlier typification; and unless it is discredited the present proposal is unnecessary. It should be rejected.

See notes on Kummer under *Clitopilus.* The existence in the Epicrisis of two collybias — 1) *Marasmius* [trib.] *Collybia* Fr., Epicr. 373, referred by Fries to "S. Orb. V. **1**: p. 73" (actually pp. 67 and 71), and there referred to *Agaricus* trib. *Collybia* Fr., "*S. M. I.* p. 129" and 2) *Agaricus* [trib.] *Collybia* Fr., Epicr. 81, without reference — confuses the problem of synonymy and typification. Are the two nomenclatorially distinct? and if so, which constitutes the basis of Rabenhorst's and Kummer's *Collybia? Collybia* in Kummer embraces 25 species of *Agaricus* [trib.] *Collybia* 1838 and 7 of *Marasmius* [trib.] *Collybia* 1838. Both the lectotype proposed by Singer & Smith (p. 260) and that of Donk (1949 p. 123) are members of *Agaricus* [trib.] *Collybia* Fr. 1821. If Fries's 1838 group of that name is the same as the 1821 tribe, *A. dryophilus* is not eligible as type; since it is not an original member thereof; if it is not the same, its name is a later homonym and the group is of no nomenclatorial consequence. Donk's choice, *A. tuberosus* Bull. ex Fr., may well be accepted.

In his latest paper Donk writes the nom. cons. prop. "*Collybia* (Fr.) Staude, Schwämme Mitteldeutschl. xxviii, 119. 1857." The page citations and quoted material are correct also for an issue or edition at hand dated 1858, which may be identical except for the title-page. Unlike Kummer (for whose work see the discussion under *Clitopilus*), Staude explicitly states (p. xxv, under Agaricini), "Die folgenden Gattungen und Untergattungen sind sämmtlich nach Fries. Vergl. Systema mycologicum etc.," and it might therefore be strictly correct to write the genera "(Fries) Staude." An anomaly should, however, be noted: that Staude lists all species under "G. [= Gattung] *Collybia*" with binomials in "*Ag.*" [ = *Agaricus*], a treatment that can be held to invalidate his generic name under Art. 37 as amended at Amsterdam, since it "is not validly published unless . . . definitely accepted by the author." It is submitted that Staude although referring to *Collybia* as a G[attung] did not definitely accept it as a genus, since he continued to refer species under it to *Agaricus*, thereby implying that it was only a subgenus or section; and that he therefore did not validly publish the genus *Collybia*. Since Donk (1949c p. 317) has only reluctantly drawn the attention of mycologists to Staude's forgotten popular work, it is to be hoped that he and other taxonomists will concur in this decision.

CONOCYBE VS. RADDETES, etc. — Donk 1949 p. 93; Rogers 1949 p. 437.

Donk's later decision is that "the proposal might better be suspended." If, as Donk now suggests, *Raddetes* can be considered a nomen dubium, this is the preferable disposition; otherwise the 1949 recommendation stands.

CORTICIUM VS. PHLEBIA and RICNOPHORA — Donk 1949 pp. 93, 140; Rogers 1949 p. 438.

The proposal has been amended by adding *Corticium* Gray, *Athelia* Pers., and *Hyphoderma* Wallr. to the nomina rejicienda. In 1944 I wrote (Mycologia **36**: 78), "It would be possible at this time to fix the application of Persoon's generic name by the formal designation of a lectotype for *Athelia*. It seems advisable, however, to refrain from making such a decision until the actual need arises for a generic name for some other species of that group." Donk reports that the type specimen of *Athelia epiphylla* Pers. is the fungus commonly known as *Corticium centrifugum* (Lév.) Bres., and designates *A. epiphylla* as the lectotype of Persoon's genus. Now the name *C. centrifugum* is untenable for the fungus in question on several grounds (Rogers & Jackson, Farlowia **1**: 286–288), and there seems to be no currently accepted generic name available for it and related forms. Donk has thus done a service to mycologists in supplying, by his typification, both a generic and a specific name for a fungus in need of both, and his decision should be gratefully accepted. It would be a pity to minimize it by enumerating *Athelia* among the nomina rejicienda, the more so that such enumeration would not, as he agrees, in any degree affect the status of *Athelia* for those who (like Donk and the writer) do not consider its type congeneric with the type of *Corticium*. It is therefore here recommended that *Athelia* be not listed among the rejicienda.

Donk similarly designates *H. spiculosum* as the lectotype of *Hyphoderma*. That species is a synonym of *Peniophora aspera* (Rogers & Jackson, Farlowia **1**: 282). Since *Hyphoderma* may be considered a later synonym of *Corticium* Gray and does not conflict with *Corticium* in the current sense, there is no occasion here for its formal rejection; since *P. aspera* and its relatives may well be in need of a generic name, there is every reason for not rejecting it. Therefore it is here recommended that it not be included among the nomina rejicienda.

The writer's 1949 recommendation stands.

CORTINARIUS VS. CORTINARIA — Donk 1949 p. 124; Rogers 1949 p. 440.

Donk and the writer agree that *Cortinarius* and *Cortinaria* are "variants of each other" — i.e., different spellings of the same name — but Donk would nevertheless "conserve the variant *spelling*." There is no provision in the Rules for this, and it seems in any case entirely pointless; the earlier recommendation stands.

CRATERELLUS PERS. VS. CRATERELLA GRAY — Donk 1949 p. 125, 154; Bisby 1949 p. 18; Rogers 1949 p. 471 (*Podoscypha*).

Since Gray wrote of "*Craterella* Pers.," in making a complete citation there is no option under the Rules but to cite the genus as "Pers. ex Gray." Donk correctly points out that *Cratarellus* Pers., Mycol. Eur. **2**: 4. 1825, is neither the same genus nor a homonym: "there is perhaps no necessity to conserve [*Cratarellus*]." It is recommended that the proposal be rejected.

Since the valid (Art. 70) spelling of *Cratarellus* (typified by *C. cornucopioides*) serves to differentiate it from *Craterella*, and since there is no provision in the Rules for conservation of a special orthography, it is urged that Persoon's spelling be left unaltered.

As Bisby notes (of the proposal in IR), "Karsten did not propose a genus *Craterella*"; what one finds in Bidr. Känned. Finl. Nat. Folk **37** (= Hattsv. **2**): 121 is "*Craterella* Pers." Although in the earlier recommendation it was indicated that Karsten's use of the name is illegitimate, the authorship was incorrectly stated.

CYSTOPUS BARY, Ann. Sci. Nat. Bot. iv **20**: 31. 1863 — Type: *C. candidus* Bary, l.c. p. 130 — *vs.* CYSTOPUS BLUME, Fl. Jav. Nov. Ser. 69. 1858. — Rogers 1949 p. 432 (*Albugo*); Shaw 1950.

The author of this proposal did not supply the typification nor citations of the names in question; presumably he had in mind those here given. De Bary's footnote on p. 31 is cited, rather than the treatment in his "Synopsis" (p. 129), since in the latter place De Bary did not find it necessary to mention oospores in describing the genus.

It is Shaw's contention that "the name 'given' to the perfect state . . . must be 'accompanied by a description . . . or by a reference to a previously and effectively published description' of that state"; and that "in the Oomycetes . . . the oogonium and its contents must be described." The implication is that the description, rather than the material described, determines the application of a name. The effect of this principle is to invalidate names published with inadequate descriptions. What in general constitutes a description of the perfect state is not specified, and must of course be determined for each name and by each student independently — without reference (under Shaw's interpretation) to the type specimen.

On this basis Shaw considers *Albugo* a "nomen provisorium"; and since the second name for the genus, *Cystopus* Lév., is a later homonym, he proposes its conservation. *Cystopus* Blume being the name of a genus of spermatophytes, adoption of the proposal would require the concurrence of the Special Committee for Phanerogams and Ferns. The present writer's earlier conclusion, that *Albugo* is not rejected by the existing Rules, stands, and it is here recommended that the proposal be rejected.

DICHAENA FR., Syst. Orb. Veg. 108. 1825. — Type: *Hysterina macularis* Ach. ex Gray, Nat. Arr. **1**: 505. 1821 — vs. HETEROGRAPHA FÉE, Meth. Lichenograph. xxxi. 1824. — Bisby 1949 p. 29.

Fries designated *H. macularis* as the type of his genus; the citation here given for that species is the earliest that appears after January 1, 1821. In 1828 he reduced that name to synonymy under *Hysterium* (*Dichaena*) *rugosum* (L.) ex Fr., El. **2**: 141, formally rejecting his genus *Dichaena* (near the middle of p. 142), and in the same paragraph (last line of p. 142) implying that it would nevertheless probably be used. In 1849 he again recognized *Dichaena*, again stating, "Typus generis est *Opegrapha macularis Ach.*," although listing that species under the name *D. rugosa* (Summ. Veg. Scand. 402.). In 1828 and 1849 *faginea* and *quercina* are given as infraspecific entities under *H. rugosum* or *D. rugosa.*

*Heterographa* was published the year before; according to Fée, the genus "est fondé sur deux opegraphes, *Opegrapha faginea* et *quercina*, de de Candolle, réunies en une seule espèce par Acharius, sous le nom de *macularis*." The name is therefore an obligate synonym of *Dichaena*. Bisby writes, "Presumably *Dichaena* should be conserved, if necessary." Whether the genus is of sufficient importance to make conservation necessary is doubtful. Bisby, who presents the status of the genus in Brit. Mycol. Soc. Trans. **25**: 135–6. 1941, lists two species from Great Britain; Ainsworth & Bisby 1945 p. 94 note "2 or 3."

Eriospora Berk. & Br., Eriospora Hochst. ex A. Rich., and Erispora Pat. — Bisby 1949 p. 24.

In Kew Bul. Mis. Inf. **1935**: 83 Dandy proposed the conservation of *Eriospora* Hochst. [1852] (for date see Soc. Bot. France Bul. **1**: 383. 1854), a name of a genus of Cyperaceae; the adoption of this proposal would under Art. 21, Note 4, automatically bring about the rejection of *Eriospora* Berk. & Br., Ann. Mag. Nat. Hist. ii **5**: 455. 1850, a name in use for fungi. Since Dandy withdrew the proposal for this very reason (Zesde Int. Bot. Congr. Proc. **1**: 359), the name *Eriospora* Berk. & Br. is not endangered. *Erispora* (not *Eriospora*) Pat., Soc. Mycol. France Bul. **38**: 84. 1922, is a name of obscure derivation; since the genus is "caractérisé . . . par des asques myriospores et par des spores brunes et uniseptées," it cannot mean "wooly-spored"; probably the prefix is ἐρι-, "much." In any event, Patouillard's name differs in spelling, in pronounciation, and in derivation, and is therefore not a homonym.

Flammula vs. Flammula — Donk 1949 p. 95; Rogers 1949 p. 443.

Donk's earlier proposal has been revised to list the nomen conservandum as *Flammula* (Fr.) Kummer 1871 and the type as *A. flavidus*. The proposed typification is acceptable. With substitution being made where appropriate of "Kummer" for "Quélet," the earlier discussion may stand.

Galera vs. Galera — Donk 1949 p. 96; Rogers 1949 p. 444.

Donk's former proposal is revised to make the nomen conservandum *Galera* (Fr.) Kummer 1871. He quotes a considerable body of opinion and evidence tending to show that *Galerula* Karst. is a nomen dubium, and supports *Agaricus hypnorum* Batsch ex Fr. as the lectotype of *Galera* (Fr.). It was earlier recommended that the decision, a taxonomic rather than a nomenclatorial one, should be left to the experts. It seems that in the light of his further evidence they will wish to support Donk's proposal.

Gautieria Vitt., Monogr. Tuber. 25. 1831 — Type: *G. morchelliformis* Vitt. — vs. Gautiera Raf., Med. Fl. **1**: 202. 1828.

Rafinesque's name, proposed for *Gaultheria* [Kalm ex Linn., Gen. Pl. 5 ed. 187] was superfluous and hence illegitimate (Art. 60 as modified at Amsterdam; Amst. Proc. **1**: 354; IRB p. 90; IRA p. 22) when published; nevertheless, *Gautieria* is an orthographic variant of Rafinesque's name (see Art. 70, "Examples of orthographic variants") and to be rejected under Art. 61 and Note. *Gautieria* is a well-known genus of some size (there are fifteen species listed by Zeller & Dodge in Mo. Bot. Gard. Ann. **21**: 692–705. 1934) which has never been known by its legitimate name *Usleria* Nieuwl., Am. Midl. Nat. **4**: 378. 1916. It originally included two species, of which Zeller & Dodge have designated the first and most minutely described, *G. morchelliformis* (for "*morchellaeformis*") as lectotype. It is therefore hereby proposed that *Gautieria* be conserved against *Gautiera*.

It appears that *Gautieria* (for Joseph Gautier) and *Gaultheria* (for Jean François Gaultier) are "different" under Art. 70 Note 3, and therefore the conservation of the former need not interfere with the continued use of the latter.

GOMPHUS VS. GOMPHORA — Donk 1949 p. 98; Rogers 1949 p. 445.

Withdrawn by Donk for the same reasons listed by the present writer.

GUEPINIA VS. GUEPINIA — Rogers 1949 p. 445; Nannfeldt 1947 p. 334.

Nannfeldt rejects this proposal, as do its author and the earlier recommendation.

GYROMITRA FR. VS. GYROCEPHALUS PERS. — Donk 1949b; Rogers 1949 p. 445. (*Guepinia*)

Donk notes that what seems to be the type of Persoon's genus, *Helvella sinuosa* Brond., is a *Gyromitra*, and proposes the conservation of that later name. *Gyromitra* is a relatively small genus, possibly insufficiently distinct from *Helvella*, and ordinarily would not be worth saving. However, the alternative, *Gyrocephalus*, has been so much used by the deluded followers of Brefeld in place of the legitimate *Phlogiotis* that its correct use would occasion endless confusion. It is therefore recommended that the proposal be adopted.

HERICIUM VS. HERICIUM — Donk 1949 p. 98; Rogers 1949 p. 447.

Withdrawn by its author for the same reasons given in the writer's earlier discussion.

HEXAGONA VS. SCENIDIUM — Rogers 1949 p. 447.

*Hexagona* is listed under Art. 70 as "an unintentional orthographic error for *Hexagonia*"; since Fries's spelling is consistent in Syst. Mycol. **1**: 344, Fl. Scan. 339, Gen. Hym. 11, Epicr. 496, Summ. Veg. Scand. 324, K. Vet. Ak. Handl. **1848**: 136 (Fung. Natal.), R. Soc. Sc. Upsala Nova Acta iii **1**: 100 (Nov. Symb.), and Hym. Eur. 589 — i.e., throughout his works — it appears that "unintentional" is gratuitous and unproved. Since Fries was free (under the current Rules) to adopt, discard, or alter any name he chose, there seems no reason to reject the form which he employed.

HYDROCYBE (FR.) WÜNSCHE VS. LEUCOPUS KUMMER — Donk 1949c pp. 361, 362, 365, 394.

As noted under *Clitopilus* (q.v.), Kummer separated *Leucopus* and *Rhaphanazon* in his key, but before treating any species "combined them as the . . . single genus *Cortinarius*." It is submitted that the generic name *Leucopus* was not "definitely accepted by the author" (Art. 37) and was not validly published. The proposal is therefore unnecessary, and its rejection is recommended.

HYMENOCHAETE VS. STEREUM and HYMENOCHAETA — Donk 1949 p. 98; Rogers 1949 p. 450.

Donk typifies *Stereum* by *Thelephora hirsuta,* as does the present writer, and deletes that genus from the list of rejicienda on the same grounds. The earlier opinion, that "*Hymenochaete*" Beauv. ex Nees is an inadvertent misspelling of *Hymenochaeta* and does not interfere with the use of *Hymenochaete* Lév., stands, as does the consequent recommendation.

HYPOLYSSUS VS. PERONA and CARIPIA — Rogers 1949 p. 451.

In the earlier notes it was stated that *Podostrombium* Kunze is the correct name for *Hypolyssus* sensu Berk. non Pers. In spite of extensive search no description has been found among G. Kunze's works. This is odd, because the name and the character of the genus seem to have been known to a number of the author's contemporaries; and Fries (Summ. Veg. Scand. 484) mentions a "schedula" of Kunze's. As early as 1828 Reichenbach, Conspect. 8, listed *Podostrombium* as "Fung. guian."

Since Léveillé's brief publication of *Podostrombium* in 1846 includes all the data supplied by O. Kuntze in his more prolix later publication of *Caripia,* there seems no basis but captiousness for rejecting the one and accepting the other. Anyone whose conscience still refuses the 1846 publication will cite *Podostrombium* Kunze ex Wittstein, Etym.-bot. Handwörterb. 711. 1856, where appears the statement "das Peridium is kreiselförmig und gestielt" — a meager, but legal, description.

It seems highly probable, although the material is not at hand for confirmation, that Kunze's name was proposed for one of Weigelt's exsiccati from Surinam. It is therefore worthy of note that Weigelt collected with Hering in Surinam, and, since much of Hering's material was sent to America and his fungi fell into Schweinitz's hands, that *Heringia* (for which see the earlier notes) and *Podostrombium* were based on the same collections. (Cf. Torrey Bot. Cl. Mem. **16**: 250. 1921.)

LACHNOCLADIUM VS. ERIOCLADUS — Singer 1944 p. 553; Donk 1949 p. 100; Rogers 1949 p. 453.

Revised by the author to list *Lachnocladium* Lév. as published in "Consid. Mycol. 1846" (the page is 108). Donk (1941) has made out a good case for *Clavaria furcellata* Fr. as the type, and Singer (a reference omitted from the earlier list of references) and Doty (p. 131) an equally good one for *E. brasiliensis* Lév.; Doty implies that *C. furcellata* is a nomen dubium. In the matter of conservation the 1949 recommendation stands.

MARASMIUS VS. MICROMPHALE — Donk 1949 p. 128; Rogers 1949 p. 454.

Although presented as a "new proposal," Donk's decision agrees with the earlier proposal of Singer & Smith and with the writer's recommendation.

MONILIA vs. MONILIA — Mason 1933 p. 11; Rogers 1949 p. 457.

Mason typifies *Monilia* by *M. cinerea* Bon. — a fact not noted in the earlier discussion. The recommendation stands.

MONOTOSPORA vs. MONOTOSPORA — Diehl p. 279; Rogers 1949 p. 459.

Diehl's comment is pertinent here. The recommendation stands.

MYCENA (PERS.) EX GRAY and PRUNULUS GRAY — Donk 1949 p. 85.

Donk notes that he regards the two names as synonyms, and elects under Art. 56 to retain the former. No proposal for conservation is offered or required.

MYCOLEPTODON vs. ODONTIA — Donk 1949 p. 100; Rogers 1949 p. 460.

Withdrawn by the author, for reasons similar to those advanced against the proposal by the present writer.

NUMMULARIA vs. BISCOGNIAUXIA — Bisby 1949 pp. 33, 40; Rogers 1949 p. 462.

In the writer's earlier discussion it was suggested that species now included in *Nummularia* Tul. non Trag. ex Gray might be "left without a generic name." Bisby lists two names published as substitutes for *Nummularia* Tul. — *Kommamyce* Nieuwl., Am. Midl. Naturalist **4**: 375. 1916, and *Numulariola* House, N. Y. State Mus. Bul. **266**: 49. 1925. The recommendation stands.

OMPHALINA QUÉL. vs. PERONA PERS. — Donk 1949 p. 131; Rogers 1949 p. 451 (*Hypolyssus*); Donk 1949c p. 326.

Singer & Smith (1946 p. 250) designated *O. adusta* (Pers. ex Fr.) Gray as the lectotype of *Omphalia* (Pers.) ex Gray. Their choice makes *Omphalia* a synonym of *Russula* Pers. ex Gray, and of these two synonyms of the same date they chose to retain *Russula* — a binding decision under Art. 56. It appears that their typification is binding also; Donk has chosen a different type, *Agaricus tardus*, from considerations of the pre-Friesian history of the name. But whereas a pre-Friesian typification may provide a cogent indication of the type species — as for *Phoma* Fr. (1819) ex Fr. (1823), for which see the writer's earlier notes — it cannot do more; and any of the subordinate groups included in the first legitimate publication is, other things being equal, eligible. The question whether *Omphalia* is a later homonym of *Omphalea* L. is one not resolved by the present Rules (see earlier notes under *Cyttaria*).

*Omphalia* (Fr.) Kummer is a later homonym of Gray's genus; if the citation in parentheses of Fries's name is justified, it must, directly or ultimately, be based on *Agaricus* Trib. *Omphalia* (Pers.) ex Fr., Syst. Mycol. **1**: 162. Of this tribe the type, designated by Donk, is *A. cyathiformis* Pers. ex Fr.; this species Fries in 1838 assigned to *Agaricus* V. *Clitocybe*. But whatever species Fries may have included in or excluded from the infrageneric group *Omphalia* in 1825, 1838, and 1874, its type is the same *A. cyathiformis*; and if there is a genus *Omphalia* (Fr.) Kummer (see notes under *Clitopilus*) its type is the same. That is implied by the type concept.

But whatever may be inferred concerning Quélet's possible motives in publishing the genus *Omphalina* in Ench. Fung. 42. 1886, he did not, as Donk notes, cite Fries (nor Kummer) in so doing. Strictly, then, *Omphalina* is not a nom. nov. but a gen. nov., and can be typified without reference to *Omphalia*. It should be noted in this connection that *A. cyathiformis*, Donk's lectotype for *Agaricus* trib. *Omphalia* Fr., is retained by Quélet in the genus *Omphalia* (Ench. 24). Murrill (N. A. F. 344. 1916) designated *O. hydrogramma* (Fr.) Quél. as the type of *Omphalina*.

Donk has now (1949c) withdrawn this proposal on the ground that *Perona* is already rejected as a later homonym of *Peronia* Laroche in Redouté, Les Liliacées **6**: 342. 1812 (Scitamin.). But the two names are not identical in spelling nor pronunciation; *Peronia* is named for Franz Peron and *Perona* quite surely derived from περονη, a pin; and there is no danger whatever of confusion between Persoon's fungus genus and the long-abandoned angiosperm name. Therefore the two are not, it is submitted, homonyms under Art 70. See earlier notes under *Cyttaria*.

The synonymy of *Perona* with *Omphalina* must be regarded as not proved; at least, no record is at hand of the assignment of a species of either to the other. It seems at least equally possible that *Perona* will be found to be a synonym of *Helotium* when the latter name is correctly typified. It is recommended that the proposal be rejected.

As earlier indicated, there is no *Perona* Fr.

Pactilia Fr. vs. Achitonium G. Kunze ex O. Kuntze — IR p. 126; IRA p. 41; Bisby 1949 p. 3.

*Pactilia* was described by Fries in Fl. Scan. 365 (not 363) 1835; the designated type, also described l.c., is *P. mycophila*. Fries later, in Summ. Veg. Scand. 472. 1849, cited Montagne's description and figure of *P. mycophila* (under the name *Tubercularia mycophila* Mont. & Fr.) published in Ann. Sc. Nat. Bot. ii **6:** 29. 1836; ibid. vol. 5 pl. 13 fig. 1. 1836; Fries also there listed as synonyms *Leucosporium* Corda in Sturm, Deutschl. Fl. III Abt. 3 Bändchen 13 Heft: 67. pl. 34. 1833, whose monotype, *L. vesiculiferum*, he renamed *Pactilia leucosporia*, and the name which Corda later substituted for the same genus, *Phymatostroma* Corda, Icon. Fung. **1:** 5. pl. 1, fig. 82, 83. 1837, with two additional species.

*Achitonium* Kunze ex Fries, Syst. Mycol. **3:** 470. 1832, is briefly described in a footnote, and again at the foot of p. [3] of the index, where *A. acicola* is given as its single species; it seems to be validly published. The genus was listed and *A. acicola* described by Sprengel in Linn. Syst. Veg. 16 ed. **4**(1): 580. 1827; the genus was again characterized by Fries in Fl. Scan. 367. 1835, and in Summ. Veg. Scand. 481. 1849 the single species *A. acicola* was again attributed to it.

There seem then to be four names available for the genus, in which Saccardo enumerates seven described species, and which Ainsworth & Bisby (1945 p. 225) judge to embrace "2 or 3" good ones. It appears then to be neither large nor of any great importance. The proposed lectotype is not eligible. It is recommended that the proposal be rejected.

PANAEOLUS (FR.) QUÉL. VS. COPRINARIUS (FR.) KUMMER — Donk 1949 p. 138.

*Agaricus* trib. *Coprinarius* Fr., Syst. Mycol. **1**: 300, embraced 18 species, one of which must be its type. Donk selects *A. papilionaceus* Bull. ex Fr. *A. campanulatus* Bull. ex Fr. is not eligible, since it was published (l.c. p. 295) as a member of trib. *Psilocybe* (in Epicr. 236 Fries published for it the synonym *A. ovalis*); there is of course no other legitimate *A. campanulatus*. *A. campanulatus* L. ex Fr., Epicr. 236, may be the type of *Agaricus* ser. *Coprinarius* [trib.] *Panaeolus* Fr., Epicr. 234, as Donk says, but certainly cannot be called by that binomial; according to Fries (p. 236) it is *A. papilionaceus* Bull. ex Fr., Syst. Mycol. **1**: 301. It is submitted that the lectotype for both names should be *A. papilionaceus* Bull. ex Fr. 1821, a name in turn typified by the "better part" of Bull. pl. 561 fig. II — i.e., as indicated by Fries in 1838, fig. II L.

There seem to be no obstacles to conservation of *Panaeolus*, and with the suggested alterations in naming of the type (but not in the fungus in question) adoption of the proposal is recommended.

PAXILLUS VS. RHYMOVIS — Maire 1937 p. 48; Rogers 1949 p. 465.

Maire's note should have been cited here; it does not alter the proposal nor the recommendation.

PENIOPHORA COOKE VS. CORTICIUM GRAY and HYPHODERMA WALLR. — Donk 1949 p. 140; Rogers 1949 p. 438 (*Corticium*).

*Hyphoderma* as typified by Donk, by *H. spiculosum* (= *Peniophora aspera* (Pers.) R. & J. = *P. setigera* (Fr.) H. & L.), is not necessarily synonymous with *Peniophora* as typified by *P. Quercina* (Pers. ex Fr.) Cke. (see discussion in these and the earlier notes under *Corticium*), even though, ad int., "the common tendency . . . is to admit a genus, universally called *Peniophora*, comprising both." The effect of overly zealous conservation here, as in many other cases, is merely to imply synonymy which actually is false; it cannot prevent the use of the nomen rejiciendum by those who do not regard the names as synonymous. The earlier recommendation stands.

PHELLINUS VS. PORIA — Donk 1949 p. 101; Rogers 1949 p. 466.

Withdrawn by the author on grounds presented with the former recommendation.

PHOLIOTA (FR.) KUMMER VS. DERMINUS (FR.) STAUDE — Donk 1949c pp. 324, 334, 394.

The remarks regarding Staude's work inserted under *Collybia* (q. v.) apply equally to *Derminus*. Since the latter name is held to be invalid under Art. 37, the proposal is unnecessary and should be rejected.

PISOMYXA CORDA VS. BRYOCLADIUM KUNZE — IR p. 122; IRA p. 41.

The genotype of *Pisomyxa* is *P. racodioides*, not "*rhacodioides*."

The nom. rejic. is listed (IR) as having appeared in "Flora (1830) 207"; there is no such name at the place cited; nor does it appear on p. 270, as given by Saccardo. In Flora **13**: 132. 1830 appears a short description of "*Bryocladium maculans*. Kz." There is no "combined generic and specific description" as exemplified under Art. 43, and *Bryocladium* is therefore a nomen nudum and conservation of *Pisomyxa* unnecessary. The proposal should be rejected.

Authors of proposals for conservation will earn the gratitude of their colleagues by verifying the citation, or at least the existence, of names which they submit for consideration.

PLEUROTUS VS. PTEROPHYLLUS and CREPIDOPUS — Donk 1949 p. 101; Rogers 1949 p. 470.

Revised to list *Pleurotus* as (Fr.) Kummer 1871, and to include as nomina rejicienda *Crepidopus* (as in Singer & Smith 1946), *Resupinatus* Nees ex Gray, *Pterophyllus* Lév., and *Hohenbühelia* Schulzer. Donk's reasons for enumerating the additional names appear adequate, and the former recommendation for adoption is extended to these additional rejicienda.

POLYSTICTUS FR. VS. COLTRICIA GRAY and STRIGLIA GRAY — Cooke pp. 86, 96; Donk 1949 p. 142.

Donk discusses the various essays at typification of the heterogeneous *Polystictus*, and gives as his opinion that Karsten first restricted the genus to one of its components in 1879 and in effect typified it by *P. perennis*. He accepts this as valid typification, and there appears no reason to differ from this decision. For the "Stirps" so chosen by Karsten to typify the genus is "A. stirps Polysticti perennis," whose type must be *P. perennis* even though that extra-tropical species is not described in Fries's Novae Symbolae. For a group so typified the legitimate name is *Coltricia* Gray, and that name has long been used, by Murrill and others who have not been willing to treat polypores in Fries's few and heterogeneous groups. *Polystictus* has also been widely employed, but frequently not for *P. perennis* and its allies; rather it has usually been the name for all coriaceous polypores, species as different as *P. versicolor*, *P. Tulipiferae* (not "*tulipiferus*") *P. conchifer*, and *P. cinnabarinus*. To conserve the name for such brown, stipitate forms as *P. perennis* will not, then, "avoid disadvantageous changes in the nomenclature of genera" (Art. 21); *Coltricia* is much better established *for the group in question* than is *Polystic-*

*tus*. It is therefore recommended that the legitimate name be allowed to stand, with *Polystictus* as a synonym, and that the proposal be rejected.

There seems to be under the Rules no alternative to citing *Coltricia* as "Mich. ex Gray" — except under the general clause (Art. 48, 2nd par.) which in any case permits omission of the author not actually the publisher of the name.

PORIA VS. PHYSISPORUS and PORIA — Donk 1949 pp. 103, 155; Rogers 1949 p. 471.

Withdrawn by Donk, in recognition of the priority of *Poria* Pers. ex Gray; he designates as lectotype *P. medullaris* Gray. This is in agreement with the earlier recommendation, which stands.

PSATHYRA VS. PSATHYRA — Donk 1949c p. 339.

The proposal is amended by citing the nom. cons. as *Psathyra* (Fr.) Kummer 1871 and by designating as the type *Agaricus fibrillosus* Pers. ex Fr.; the changes appear necessary and acceptable.

PTERULA FR. 1830 VS. PTERULA FR. 1825 — Doty p. 133; Donk 1949 p. 145.

As Doty notes, Fries wrote in Syst. Mycol. **1**: 464, "*Clavaria penicillata* Bull. est typus novi generis (*Pterula*)"; he chose not to describe it at that time, having only dried specimens. On p. 496 he referred the same species to a "genus inquirendum." His formal description of the genus, in 1825, refers to the latter page; in that year he added a second species. In 1830 Fries again described the genus and its two species, adding a third, *P. subulata* Fr. In 1832 he reduced *Pterula* to infrageneric rank under *Anthina*, retaining the same species, but marking the designated type "*A.* (*Pterula?*) *penicillata*." There can be no doubt from his successive citations that there is only the one *Pterula*, nor that *P. penicillata* is its type. "*Pterula* Fr. 1830" is therefore a nonentity, and the proposal an impossibility. It should be rejected.

RAMARIA VS. CLADARIA — Donk 1949 p. 106; Rogers 1949 p. 473.

Modified by the author to include *Ramaria* Holmsk. ex Gray among the rejicienda. The original description of *Cladaria* had previously been accessible neither to Donk nor to the present writer. The pertinent portion of Ritgen's article follows: "ASTKEULENSCHWÄMME. *Merisma* (149). Die astigen Clavarien müssen abgetheilt werden von den einfachkeulenförmigen, welches unter dem Namen *Cladaria* geschehn kann (150–153). KEULENSCHWÄMME. *Clavaria* (154. 155). *Spatularia* (256). *Geoglossum* (157–159). *Leotia* (160)." Ritgen's sentence is somewhat obscure, but from his center-headings (here printed in capitals) and the Nees illustrations to which his numbers refer there can be no doubt that *Cladaria* was published for the branched species of *Clavaria*. Donk designates *Clav.*

*corniculata* (Nees's no. 152) as lectotype; but Doty (p. 126) had earlier selected *Clav. amethystina* (Nees's no. 151); no obstacles to Doty's selection appear. It seems that the citations of both authors need revision. The copy of the Marburg publication at hand does not have a title-page or table of contents for the second volume, which consists of a number of sections separately paged. The Ritgen article in question forms pp. [39]–98 of one such section, and its first leaf is conjugate with a leaf of the preceding article (also by Ritgen), which is dated, on its title-page, 1828. What follows in brackets is the result of inference, but the date and page are unquestionable; the correct citation is *Cladaria* Ritgen, [Gesell. Beförd. gesammt. Naturwiss. Marburg Schr. **2**(3):] 54. 1828.

In the matter of conservation Doty pp. 126, 128, 134 should be consulted. The earlier recommendation — for rejection — stands. Doty's lectotypes for *Cladaria* and *Ramaria* are acceptable and valid; there is no place for the substitution of others by a subsequent author. *Ramaria* has been used by more than one author but, as anyone can discover by examining recent general treatments of the Clavariaceae, has no real currency.

RHODOPHYLLUS VS. ACURTIS, etc. — Donk 1949 p. 156, 157 (*Entoloma*); Rogers 1949 p. 474; Smith 1950.

Donk corrects the proposal by substituting "Kummer 1871" for "Quélet," by citing *Claudopus* as "(W. G. Smith)" rather than "(Fr.)," and by adding to the rejicienda *Latzinaea* OK. He then rejects it on the grounds advanced for the earlier recommendation. Finally, he accepts the responsibility conferred by Art. 56, choosing *Entoloma* (Fr.) Kummer from among the earlier synonyms of *Rhodophyllus* as the valid name for the group. This is in accord with Singer & Smith's earlier typification. All of this, which is in agreement with the earlier recommendation, seems quite acceptable.

Smith remains of the opinion earlier expressed by Singer and by Singer & Smith that stability of names will be favored by conservation of *Rhodophyllus* against the five generally-accepted earlier genera of which it is composed. The matter is settled, however, by the existence of *Rhodophyllis* Kütz., Bot. Zeit. **5**: 23. 1847; *Rhodophyllus* cannot be conserved without displacing the earlier homonym (Art. 21, Note 4) in current use by algologists.

The foregoing leaves out of account Fries's curious name *ACurtis*. It was earlier stated that *Clavaria gigantea* Schw., a species based on the characteristic abortive carpophores of what is usually called *Clitopilus abortivus* B. & C., and the basis of the genus *ACurtis*, is an imperfect state. Smith seems to regard it as the "fruiting stage" of the fungus, and because of that, as the perfect state. The biological function of the *ACurtis* stage seems not to be known; but intergrades between it and the completely different basidium-bearing fructifications, if they exist, must be rare and abnormal, and its nearest analogue in other fungi would seem to be the bulbils of *Trechispora Brinkmanni* (cf. Biggs, Mycologia **29**: 696–697) or the *Ptychogaster* stage of some polypores (except that these are both reproductive). Schweinitz's type as represented in the Farlow Herbarium is certainly sterile and without so much as a pileus. It might be noted that if the abortive structures in question were the perfect stage the fungus should be called not *Rhodophyllus abortivus* (B. & C.), as by Singer & Smith, nor *Clitopilus abortivus*, but *Rhodophyllus giganteus* (Schw.) or *Clitopilus giganteus*. The fact that neither name seems to be employed, even by such conscientious mycologists as the authors in question, is evidence that the structures are generally regarded as imperfect. Ergo, the name *ACurtis* does not conflict with *Clitopilus* — nor with *Entoloma* nor *Rhodophyllus*.

SCOPULARIA and SCOPULARIA — Rogers 1949 p. 476.

*Scopularia* Preuss, the later homonym, was long ago renamed *Lindavia* by Nieuwland, Am. Midl. Naturalist **4**: 385. 1916.

SEPTOBASIDIUM vs. GLENOSPORA and GAUSAPIA — Donk 1949 p. 108; Rogers 1949 p. 476.

An additional nomen rejiciendum is introduced — *Campylobasidium* Lagerh. ex Ludw. From Ludwig's characterization that name would be either a nomen dubium or a synonym of *Cystobasidium;* but because Patouillard cites it under *Septobasidium* it appears that Lagerheim's name (Lagerheim was a collaborator of Patouillard's) really belongs there. There being at hand no evidence on the relative dates of Patouillard's article and Ludwig's Lehrbuch (both dated 1892), it is recommended that this addition be incorporated in and adopted with the earlier proposal. Donk now accepts the typification of *Septobasidium* published by Martin. The earlier recommendation stands.

STEREUM vs. AURICULARIA and STEREUM — Donk 1949 p. 110; Rogers 1949 p. 480.

Withdrawn, for reasons given in the earlier recommendation.

TELAMONIA (FR.) WÜNSCHE vs. RAPHANAZON KUMMER — Donk 1949c pp. 361, 362, 364, 368, 394.

It is submitted that *Rhaphanazon*, like *Leucopus* (for which see the earlier paragraph under *Hydrocybe*), is invalid under Art. 37, and that the proposal is unnecessary and should be rejected.

TREMATOSTOMA vs. CLYPEOTHECIUM — Rogers 1949 p. 483; Nannfeldt 1947 p. 324.

Nannfeldt rejects the proposal, and points out that Petrak in Ann. Mycol. **27**: 401 united his *Clypeothecium* with *Exarmidium* Karst., Bidr. Känned. Finl. Nat. Folk **23**: 222. 1873 (which Clements & Shear accept as autonomous).

TREMELLA VS. TREMELLA and GYRARIA — Rogers 1949 p. 483.

Donk (1949 p. 87) considers *Gyraria* "impriorable." This decision arises out of his interpretation of Art. 20(f) — an interpretation which has much to commend it, but which does not accord with the Rules as understood by the present writer. The 1949 proposal stands.

TREMELLODON VS. HYDNOGLOEA — Donk 1949 p. 110; Rogers 1949 p. 483.

*Pseudohydnum* Karst. is added to the n. rejicienda proposita. The earlier recommendation stands.

TRICHOLOMA VS. TRICHOLOMA — Donk 1949 p. 110; Rogers 1949 p. 484; Donk 1949c p. 326.

*Tricholoma* is now cited as (Fr.) Kummer 1871, although in his most recent paper Donk states that the correct citation is "(Fr.) Staude, Schwämme Mitteldeutschl. xxviii, 125. 1857." What is said of Staude's work under *Collybia* applies here.

If the BMS selection of *T. rutilans* as the lectotype be regarded as the valid one (as it well may be, earlier choices having apparently been of species for one reason or another ineligible), *Tricholomopsis* Sing. would appear to be a nomen superfluum, illegitimate under Art. 60(1) as modified at Amsterdam (IRB p. 90; IRA p. 22). Otherwise, Donk's lectotype, *T. imbricatum*, should be accepted. The earlier recommendation stands.

VOLVARIA VS. VOLVARIA — Donk 1949 p. 112; Rogers 1949 p. 488.

Modified by the citation of the nomen conservandum as *Volvaria* (Fr.) Kummer 1871. Donk designates *Agaricus volvaceus* as the lectotype. The earlier recommendation was for rejection, on the ground that the name *Volvariopsis* had already been used for most of the species, and therefore conservation would not "avoid . . . changes." Donk now indicates the possibility that *Volvariella* Speg., Mus. Nac. Buenos Aires Anal. **6**: 118. 1899, may be a synonym and necessitate a whole new set of binomials. If in the judgment of students of agarics this synonymy is considered established, the present proposal should be adopted.

XEROCOMUS QUÉL. VS. VERSIPELLIS QUÉL. — Donk 1949 p. 147.

Snell (Mycologia **34**: 407) has proposed to get rid of the unwanted name *Versipellis* Quél., Enchir. 157. 1886, by considering it a nomen ambiguum. The Rule under which his proposal was offered is Art. 62: "A name . . . must be rejected if, owing to its use with different meanings, it becomes a permanent source of confusion or error." It is submitted that because of the wide use of *Boletus* II. *Derminus* 2. *Versipelles* Fr., Epicr. 423, the use of *Versipellis* for a segregate of the same genus but a different group of species would be "a permanent source of confusion or error." On this point Snell, Donk, and the writer are in agreement. The only question is whether *Versipelles* and *Versipellis* are "a name" — i.e., the same name. It seems that as the plural and singular of the same word they incontestably are. It is therefore submitted that the case comes entirely under Art. 62, that Snell's rejection of Quélet's name is valid, and that in consequence the proposed conservation of *Xerocomus* is unnecessary. It is recommended that the proposal be rejected.

The case is quite different where a name is repeated for infrageneric groups within two or more genera — e.g., *Agaricus* VI. *Collybia* and *Marasmius* I. *Collybia*, in Epicr. 81, 373 — perhaps to suggest similarities. The latter practice is to be avoided (Rec. XI (c)), but past instances can be rejected only if conflict with some other Rule exists. The essence of the case against *Versipellis* is the likelihood of confusion.

The case is also different where the infrageneric name has less currency. With a little more mental agility the unwanted name *Pellicularia* Cke. (cf. Farlowia **1**: 95) might similarly have been disposed of, and the preferable *Botryobasidium* retained; the writer deeply regrets his failure to examine that possibility. But *Corticium* sect. *Pellicularia* Bourd. & Galz., Hym. Fr. 191, although well established, had little currency, and the probability of serious confusion seems slight. It is even less now that *Pellicularia* Cke. is well established and the section of *Corticium* has its own generic name *Athele* (for which see on a preceding page notes under *Corticium*).

## II. NOMINA CONFUSA

The names are here listed as in the notes to which these are supplementary. Most were taken from Bisby's (1949) paper. In these lists, as in the earlier ones, where no question or objection is noted the cited evidence appears satisfactory, and it is recommended that the names be inserted in Appendix V of the Rules.

### NOMINA SPECIFICA CONFUSA

ARCHILEGNIA LATVICA (APIN.) APIN., Hort. Bot. Univ. Latv. Acta **8**: 106. [1935 (Mar. 1)] (nom. nud.; cf. note under *Archilegnia*.) Cf. Sparrow, Aquat. Phycom. 514. 1943.

BYSSOTHECIUM CIRCINANS FUCKEL, Bot. Zeit. **19**: 251. 1861. Cf. Fuckel, Nassau. Ver. Naturk. Jahrb. **23**, **24**: 142 [1870].

CERATOCLADIUM CLAUTRIAVII PAT., Soc. Mycol. Fr. Bul. **14**: 196. 1898. Cf. *Xylocladium Clautriavii.*

CHAETASPIS STENOCHLAENAE SYD., Ann. Mycol. **15**: 219. 1917. Syn.: *Parmulina Stenochlaenae* (Syd.) Petr., Ann. Mycol. **27**: 377. 1929. Cf. Petrak, l.c.

COCCIDIOPHTHORA VARIABILIS SYD., Ann. Mycol. **11**: 263. 1913. Cf. Hara, Bot. Mag. Tokyo **28**: 339, 350. 1914; Petch, Brit. Mycol. Soc. Trans. **10**: 198. 1925.

CORTICIUM KOMABENSIS [!] P. HENN., Bot. Jahrb. **32**: 38. 1902. Syn.: *Peniophora corticalis* var. *komabensis* (P. Henn.) Höhn. & Litsch., Ak. Wiss. Wien Sitzungsber. Math.-Naturw. Kl. **116, 1**: 744. 1907. Cf. Höhnel & Litschauer, l. c.

CYSTOTHYRIUM MAGELLANICUM SPEG., Cordoba Acad. Nac. Cienc. Bol. **11**: 300. 1887. Petrak & Sydow, Ann. Mycol. **33**: 159. 1935, state that the type material is immature and the spore-characters incorrectly described. They do not, however, suggest that more than the one fungus is present. Spegazzini published two new species with the genus, and gave no indication that *C. magellanicum* was, as Petrak & Sydow state, the "Typusart."

DECAMPIA HOOKERI (BORRER) MASSAL., Sulla Lecidea Hookeri di Schaerer 7. 1853. Syn.: *Verrucaria Hookeri* Borrer in Engl. Bot. Suppl. **1**: [text for] pl. *2622* (fig. 2). 1831. Cf. Kiessler in Rabenh. Kryptogamen-Fl. 2 Aufl. **8**: 503. 1930, where also will be found two pages and a half of synonyms, most (but not all) likewise nomina confusa.

EURYACHORA SEDI * RUMICIS KARST., Bidr. Känned. Finl. Nat. Folk **23**: 228. 1873. Syn.: *Dothidella Rumicis* (Karst.) Sacc., Syll. Fung. **2**: 630. 1883; *Dictyochora Rumicis* (Karst.) Theiss. & Sydow, Ann. Mycol. **12**: 274. 1914. Petrak & Sydow, Ann. Mycol. **21**: 383. 1923, report that Karsten's species is a synonym of *E. thoracella* Karst. and his name is not a nomen confusum, but that the diagnosis of *Dictyochora* included the characters both of the *Euryachora* and a *Pleospora*. They therefore declare *Dictyochora* a nomen confusum. Since "the type . . . of a generic name is a species" (Art. 18), it would appear that *Dictyochora* is rather a synonym of whatever genus *D. Rumicis* belongs to.

FUMAGO VAGANS PERS., Mycol. Eur. **1**: 9. 1822. Bisby 1949 p. 11 writes that *Fumago* "was considered [by Woronich] a nomen confusum." Woronich (Ann. Mycol. **24**: 261–4) gives it as his opinion and that of earlier authors (cf. Berkeley & Montagne, Hort. Soc. Lond. Jour. **4**: 244 1849), that "the whole first section of the genus *Fumago* Pers. is no more than a mixture of *Cladosporium herbarum* Link and other fungi, such as *Mystrosporium*, *Triposporium*, etc."; he states that only by examination of authentic material can this tangle be straightened out. Now this is not evidence, nor even an assertion, that "the characters of the group were derived from two or more entirely discordant elements . . . erroneously supposed to form part of the same individual" (Art. 64). Persoon lists six genera as hosts of *F. vagans*, thereby implying at least as many occurrences (individuals). It has been argued (in Mycologia **40**: 635–637) that the intent and essence of Art. 64, the nomen-confusum rule, is not that the author applied one name to different elements (as, for example, Fries did in describing the genus *Agaricus* and the species *Hypochnus olivaceus* (El. **1**: 197; cf. Mycologia **31**: 299)), but that the author supposed discordant elements to form part of the same individual. Otherwise any name applied to a group from which subsequent authors detached segregates could be a nomen confusum. Quite likely Persoon lumped a number of sooty growths in his *F. vagans*, as did all his contemporaries dealing with fungi whose differential characters are revealed only by the microscope. But until a type specimen has been found, established as such, and shown not merely to bear two fungi but to have had their characters combined in Persoon's diagnosis, the name is not, it is submitted, a nomen confusum. The name is of little consequence; the conflicting principles can have an important effect in all botanical nomenclature. See under *Capnodium* among nom. cons. prop.

HELICOBASIDIUM HYPOCHNOIDEUM (HÖHN.) HÖHN., Ak. Wiss. Wien Sitzungsb., Math.-Naturw. Kl. **116**, **1**: 85. 1907. Syn.: *Stypinella hypochnoides* Höhn., Ann. Mycol. **3**: 324. 1905. The type specimen consists of a fructification of *Pellicularia flavescens* (Bon.) Rogers overgrown by a minute species of *Helicobasidium*. Since the former fungus supplies many of the characters (and the specific epithet) published by Höhnel, both of his names are nomina confusa.

HENNINGSOMYCES PULCHELLUS SACC., Syll. Fung. **17**: 689. 1907. Listed as a nomen confusum by Bisby (p. 29), with reference to Hansford. Hansford, however, in Imp. Mycol. Inst. Mycol. Papers **15**: 60. 1946, appears to consider the genus autonomous and the species valid but of doubtful position, implying that the three types of fructification present in the type may belong to the life cycle of one species.

HYALODOTHIS CLAVUS PAT. & HAR., Soc. Mycol. France Bul. **9**: 210. 1893. Cf. Theissen & Sydow, Ann. Mycol. **12**: 186. 1914. These authors do not reject *H. clavus* as a nomen confusum, preferring to retain the name for one of the components. According to their account, however, the generic and specific names must be rejected under Art. 64.

LUCIDIUM PYTHIOIDES LOHDE, Ges. deutsch. Naturf. Aertzte Tagebl. Versamml. **47**: 205. 1874. Cf. Butler, India Dept. Agr. Mem. Bot. Ser. **1** (5): 88. 1907.

MELANOMYCES QUERCINUS SYD., Ann. Mycol. **15**: 196. 1917. Cf. Petrak, Sydowia **1**: 188. 1947.

METASPHAERELLA SUBANTARCTICA SPEG., Cordoba Acad. Nac. Cienc. Bol. **27**: 376. 1924. Cf. Petrak & Sydow, Ann. Mycol. **34**: 42. 1936.

MYRIOBLEPHARIS PARADOXA THAXT., Bot. Gaz. **20**: 484. 1895. Cf. Waterhouse, Brit. Mycol. Soc. Tr. **28**: 94. [1946].

MYRIOCARPA CYTISI FUCKEL, Nassau. Ver. Naturk. Jahrb. **23**, **24**: 116. 1870. Syn. *Anthostomella Cytisi* (Fuckel) Sacc., Syll. Fung. **1**: 290. 1882. Cf. Höhn., Ak. Wiss. Wien Math.-Naturw. Kl. **116**, **1**: 621. 1907.

PERIASTER STRONGYLODONTIS THEISS. & SYD., Ann. Mycol. **14**: 452. 1916. Cf. Petrak, Ann. Mycol. **29**: 390. 1931.

PERONOSPORA NICOTIANAE SPEG., Rev. Argent. Hist. Nat. **1**: 36. 1891. Cf. Clayton & Stevenson, Phytopath. **25**: 516–521. 1925; ibid. **33**: 106–7, 111. 1943; Shaw, ibid. **39**: 675. 1949. Since "none of the four Spegazzinian specimens studied by Clayton and Stevenson possesses both 'oospores' and conidia" (Shaw), the "discordant elements" were presumably not "supposed to form part of the same individual" (Art. 64); *P. Nicotianae* would then seem not to be a nomen confusum, as Shaw would have it, unless *all* names exemplified by several collections in which more than one taxonomic group is represented are nomina confusa. Since the only specimen in Spegazzini's herbarium collected before the date of publication of his name shows only oospores (Clayton & Stevenson 1935 p. 516), that specimen and its oospores would normally be held to be the type of *P. Nicotianae.* Clayton & Stevenson judge that it is not a peronospora.

PHAEODOTHIS TRICUSPIDIS SYD., Ann. Mycol. **2**: 166. 1904. Cf. Sydow, Ann. Mycol. **37**: 192. 1939.

PHAEOMARSONIA YERBAE SPEG., Buenos Aires Mus. Nac. Anal. iii **10**: 138. 1908. Petrak & Sydow, Ann. Mycol. **34**: 32. 1936, report that "a fungus corresponding to the description of the author is quite non-existent," but that the spores and perithecia found in the type specimen belong together. According to their account the generic and specific names are nomina dubia and not n. confusa.

PHRAGMOCARPELLA ICHNANTHI (HENN.) THEISS. & SYD., Ann. Mycol. **13**: 601. 1915. Syn.: *Roumegueria Ichnanthi* Henn., Hedwigia **47**: 256. 1908. Cf. Petrak, Ann. Mycol. **29**: 349. 1931.

PIPTOSTOMUM DOMINGENSE LÉV., Ann. Sci. Nat. Bot. iii **3**: 65. 1846. Cf. Petrak & Sydow, Ann. Mycol. **27**: 109. 1929.

PSILOTHECIUM INNUMERABILE FUCKEL, Fung. Rhen. Exs. 1571. 1865. Syn.: *Septoria innumerabilis* (Fuckel) Sacc., Syll. Fung. **1**: 290. 1882; *Stagonospora innumerabilis* (Fuckel) Sacc., Syll. Fung. **3**: 446. 1884. Cf. Höhnel, Ak. Wiss. Wien Math.-Naturw. Kl. Sitzungsb. **116**, **1**: 621. 1907; BMS 2 p. 290.

SCIRRHIOPSIS HENDERSONIOIDES P. HENN., Bot. Ver. Prov. Brandenb. Verh. **47:** XII. 1906. Cf. Höhnel. Ak. Wiss. Wien Sitzungsb. Math.-Naturw. Kl. **120**, **1**: 409. 1911.

STEREUM GUADELUPENSE PAT., Soc. Mycol. Fr. Bul. **15**: 201. 1899. Cf. Höhnel & Litschauer, Ak. Wiss. Wien Sitzungsber. Math.-Naturw. Kl. **116**, **1**: 753. 1907.

THEISSENULA CLAVISPORA SYD., Ann. Mycol. **12**: 198. 1914. Cf. Petrak, Ann. Mycol. **26**: 410. 1928; Hansford, Imp. Mycol. Inst. Mycol. Papers **15**: 91. 1946.

TRECHISPORA ONUSTA KARST., Hedwigia **29**: 147. 1890. Bresadola implied that there were two fungi present in the type collection, but did not state that the name was based on both "elements . . . erroneously supposed to form part of the same individual" (Art. 64). After study of the type Rogers declared that the alien mycelium whose presence Bresadola had noted was not included in Karsten's description of the species (cf. Mycologia **36**: 75–76. 1944). Lundell & Nannfeldt, Fung. Exs. Suec. Praes. Upsal. Fasc. XXIX–XXX. no. 1415a. 1947, state that "Karsten's name . . . seems to be a *nomen confusum*"; the basis for their opinion is not given, but probably is the material presented by Bresadola and Rogers.

VERMICULARIELLA ELYMI OUD., Nederl. Kruidk. Arch. iii **1**: 495. 1898. Cf. Petrak, Ann. Mycol. **42**: 62. 1944.

VOLVOBOLETUS VOLVATUS (PERS.) P. HENN. in E. & P., Nat. Pflanzenfam. **1**, **1** **: 196. 1898. Syn.: *Boletus volvatus* Pers., Mycol. Eur. **2**: 124. 1825; *Gyrodon volvatus* (Pers.) Opat., Comm. Fam. Fung. Boletoid. 5. 1836; *Uloporus volvatus* (Pers.) Quél., Fl. Mycol. France 411. 1888. Cf. Lloyd, Myc. Writ. **3**, M. N. 444. 1909; Höhn., Ak. Wiss. Wien Sitzungsb., Math.-Naturw. Kl. **119**, **1**: 881. 1910; Ulbrich, Deutsch. Bot. Ges. Ber. **57**: 389. 1939; Neuwirth, Stud. Bot. Čech. **9**: 128. [1949]. — Quélet and Höhnel opined that Persoon's species was based on a bolete parasitized by *Hypomyces*. The weight of the evidence presented by Ulbrich indicates that it was rather a teratological *Amanitopsis*. In that case *B. volvatus* and the other names based on it are illegitimate under Art. 65, but are not nomina confusa.

XYLOCLADIUM CLAUTRIAVII (PAT.) SYD. in E. & P., Nat. Pflanzenfam. **1**, **1** **: 494. 1900. Syn.: *Ceratocladium Clautriavii* Pat. Cf. Höhn., Ak. Wiss. Wien Sitzungsb., Math.-Naturw. Kl. **118**, **1**: 418. 1909.

## NOMINA GENERICA CONFUSA

ARCHILEGNIA APIN. Monotype: *A. latvica* (Apin.) Apin. The number of the journal in which this name was printed is marked as having been issued March 1, 1935. *Archilegnia* was not validly published (Art. 38), and therefore need not be placed on the list of nomina confusa.

ASCOPHORA TODE EX FR. — Listed by Bisby (1949 p. 8) as "apparently a nomen confusum," but without reference or evidence.

BYSSOTHECIUM FUCKEL. Monotype: *B. circinans* Fuckel.

CERATOCLADIUM PAT., non *Ceratocladium* Corda, Prachtfl. 41. 1839. Cf. *Xylocladium* Syd.

CHAETASPIS SYD. Monotype: *C. Stenochlaenae* Syd.

CHAOS L., Syst. Nat. 12 ed. **1**: 1326. 1766.—Listed by Bisby (1949 p. 14) as "a nomen confusum . . . rejected by Fries." The genus originally included five species, of which one, *C. Prometheus*, was published in Syst. Nat. 10 ed. **1**: 821. 1758, as *Volvox Chaos*, characterized as "Prometheo inconstantior." Since that species furnished the generic name for *Chaos*, it should be regarded as the type. To attempt to settle the application of the name *V. Chaos* would be to invite engulfment in a recent extensive and spirited controversy among zoologists about a zoological entity known as *Chaos Chaos*. It is enough here to say that the species and genus are widely accepted as amoebae. Relying on reports of some of Baron Munchausen's researches, Linnaeus included *C. Ustilago*, a name for a number of smuts, and *C. fungorum*, a name for the "seeds" of many fungi. Fortunately, *Chaos* pertains to zoological rather than mycological nomenclature.

COCCIDIOPHTHORA SYD. Monotype: *C. variabilis* Syd.

CYSTOTHYRIUM SPEG. Cf. *C. magellanicum* Speg.

DECAMPIA MASSAL. Monotype: *D. Hookeri* (Borrer) Massal.

DIBLEPHARIS LAGERH., K. Svensk. Vet.-Akad. Handl. Bih. **25, Afd. 3**(8): 39. 1900, was based on *Monoblepharis insignis* Thaxt. and *M. fasciculata* Thaxt., one of which must be its type. Neither is known to be a nomen confusum. Lagerheim ascribed to these species and to his genus biflagellate zoospores, which Sparrow (Aquat. Phycom. 467. 1943) thinks possibly "extraneous, parasitic." Whether or not they are, the status of *Diblepharis* is determined by its type species, and the name is presumably a synonym of *Monoblepharis* rather than a nomen confusum.

DICTYOCHORA THEISS. & SYD. Monotype: *Euryachora* [*Sedi* *] *Rumicis* Karst.

FUMAGO PERS. Lectotype: *F. vagans* Pers.

HENNINGSOMYCES SACC. (non OK., Rev. Gen. Pl. **3(2)**: 483. 1898). Monotype: *H. pulchellus* Sacc.

HYALODOTHIS PAT. & HAR. Type: *H. clavus* Pat. & Har. (of two original species the other was assigned here "with doubt.")

LUCIDIUM LOHDE. Monotype: *L. pythioides* Lohde.

MELANOMYCES SYD. Monotype: *M. quercinus* Syd.

MELIOLOPSIS (SACC.) SACC. Bisby (1949 p. 37) says, "nomen confusum or dubium," referring to the comments of Theissen & Sydow in Ann. Mycol. **15**: 465. [1918]. The latter authors state that "*Meliolopsis* (Syll. Fung. I p. 68), originally a subgenus of *Meliola*, was later (Syll. IX), with all the species earlier named, elevated to generic rank." This is only partly true; in Syll. IX none of the species in the subgenus is transferred to the genus *Meliolopsis*. They then state, "M. *microthecia* Thuem. is therefore to be considered the type." This is completely a non sequitur; *M. microthecia* is no more than one of the six original species. Finally, of that form they write, "the species needs reexamination." *Meliolopsis* may be a nomen dubium; there is no evidence at hand that it is a nomen confusum.

METASPHAERELLA SPEG. Monotype: *M. subantarctica* Speg.

MYCODERMA PERS., Mycol. Eur. **1:** 96. 1822. Persoon's name was published for four species, constituted by the tough pellicle formed on the surface of as many vegetable infusions. Ciferri & Redaelli discuss in Ann. Mycol. **27**: 271–278 the application of this name by various later authors — all, of course, entirely irrelevant. Of Persoon's own use of the genus, they write (p. 273), "these microorganisms . . . might have been true *Mycoderma* mixed with other Torulopsidaceae and Schizomycetes" — i.e., there is a "true *Mycoderma*," but Persoon may not have had pure cultures — and further (p. 277), "the complete morphological characters of [Persoon's *Mycoderma*] cannot be laid down precisely because of the impossibility of tracing the types" — i.e., *Mycoderma* is a nomen dubium. Evidence is needed to determine whether such pellicles as Persoon described are produced by a single organism (contaminants being of no importance here unless they furnished some of the rather sketchy characters published by Persoon); in its absence, *Mycoderma* and its species are better regarded as nomina dubia, subject to reestablishment (Rec. XXXVII) than as nomina confusa.

MYRIOBLEPHARIS THAXT. Monotype: *M. paradoxa* Thaxt.

MYRIOCARPA FUCKEL. Lectotype (species treated in greater detail, and showing all characters): *M. Cytisi* Fuckel.

PERIASTER THEISS. & SYD. Type: *P. Strongylodontis* Theiss. & Syd.

PHAEODOTHIS SYD. Type: *P. Tricuspidis* Syd.

PHAEOMARSONIA SPEG. Monotype: *P. yerbae* Speg.

PHRAGMOCARPELLA THEISS. & SYD. *P. Ichnanthi* (q.v.) is the type according to Petrak; but no type is designated in the original publication. The genus originally included three species, of which the third is aberrant (in spore-septation) and hardly eligible. Since *P. Ichnanthi* received the most attention from the authors, Petrak's selection may well be accepted.

PHYLLONOCHOETA FRAG. & CIF. Type: *P. Solani* Frag. & Cif. The references to the species were given in Rogers 1949 p. 490, but the n. conf. gen. omitted from the list.

PIPTOSTOMUM LÉV. Monotype: *P. domingense* Lév.

PSILOTHECIUM FUCKEL. Monotype: *P. innumerabile* Fuckel.

SCIRRHIOPSIS P. HENN. Monotype: *S. hendersonioides* P. Henn.

THEISSENULA SYD. Monotype: *T. clavispora* Syd.

TRECHISPORA KARST. Monotype: *T. onusta* Karst.

TRICHOCHORA THEISS. & SYD. Type: *Ophiodothis marginata* Theiss. The references to the species were given (under *T. marginata*) in Rogers 1949 p. 490, but the generic name was inadvertently omitted from the list.

VERMICULARIELLA OUDEM. Type: *V. Elymi* Oudem.

VOLVOBOLETUS HENN. Monotype: *V. volvatus* (Pers.) P. Henn.

XYLOCLADIUM SYD. Type: *Ceratocladium Clautriavii* Pat.

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# QUARTERMASTER CULTURE COLLECTION

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The fundamental nature of the fungal and bacterial deterioration of materiel constituted one of the first pioneering problems with which the Quartermaster Research and Development Laboratories were directly concerned. Today, it continues to be one of our emphasized areas of investigational activity.

Through the far-sighted research vision of General Georges F. Doriot and Dr. Edwin L. Gustus, former Chief and former Technical Director respectively, of the Military Planning Division of the Office of The Quartermaster General, Professor William H. Weston, Jr. of Harvard University was invited in 1943 to propose, implement and direct a basic approach to the prevention of deterioration of cotton textiles. This program was executed to complement the applied empirical research program already under way.

Professor Weston's long-range plan evolved around three phases. The first two were a determination of the causal organisms and a study of their mechanism of action. Based on the information garnered from these two phases, pioneering work was initiated on the third phase, a development of new and improved methods of prevention. This approach set the pattern for subsequent Quartermaster research on the biological deterioration not only of cotton but of other military items, such as leather, wool, paper, and plastic products.

A monograph (35) painting an integrated picture of the microbiological attack on cellulose and on cotton textiles is nearing completion. Other publications and reports listed in the appendix provide a general review of our activities in the biological deterioration of materiel. The present paper by Reese, Levinson, Downing, and White treats in some detail one phase of our pertinent investigational interests. In it are listed all of the cultures being maintained in our collection of fungi, bacteria, actinomycetes and yeasts isolated by our own and by collaborating laboratories from exposed and deteriorating materiel. With the help of many specialists we have conscientiously followed the spirit of Professor Weston in guarding against ill-defined and taxonomic errors, unfortunately frequent in the literature, which have vitiated many of the results of microbiological research.

Contributors to this culture collection were many, selfless and capable. The signal efforts of Professor Weston were supplemented by the late Dr. D. H. Linder, Dr. W. L. White, Dr. K. B. Raper, Dr. N. R. Smith, Dr. G. W. Martin and others who provided the keen judgment which established the sound taxonomic position of the collection. Drs. E. S. Barghoorn, G. F. Weber, H. W. Reuszer, and W. G. Hutchinson have been responsible for most of the isolation and field observations. The U. S. Army Chemical Corps and the U. S. National Defense Research Committee have been most generous in requesting the amalgamation of their respective collections with our own. The resultant collection is the most complete and dependable one for experimental microbiology associated with deterioration of materiel. We wish to acknowledge the valuable and unstinting contributions of these and the hundreds of others who have participated in the joint effort. We wish particularly to point out the expeditious coordination by Mr. Richard Wells, a member of Dr. S. J. Kennedy's Quartermaster team of textile experts. It was mainly through Mr. Wells' effort that the many laboratories were able to operate effectively with a minimum of administrative synapses during the hectic war days.

It has been the established policy of our laboratories to share our scientific tools with those of our colleagues collaborating with United States Departments of the Army, Navy and Air Force. In the case of the culture collection, this has been a *de facto* service. Thousands of cultures have been furnished during the past years to laboratories in this country and those of our allies for use in research and procurement testing. The Quartermaster Corps joins me in extending an invitation to scientific collaborators of the U. S. National Military Establishment for continued use of our culture collection.

RALPH G. H. SIU
*Research Director*
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## GENERAL CONSIDERATIONS

This report summarizes that phase of the Tropical Deterioration program dealing with the isolation and determination of microorganisms involved in the deterioration of materiel. This program was sponsored by the U. S. National Defense Research Committee and The Office of the Quartermaster General. The present authors wish to emphasize the fact that their role has been primarily the collation of loose ends. In doing so, the authors have reduced the collection of actively growing cultures to a size (830 cultures) which, it was felt, would not impose too great a burden on the present staff. The reduction was made by eliminating replications. For instance, of 30 *Aspergillus fumigatus* isolates, five were selected for maintenance in the active collection. Several criteria were used as a basis for the selections:

(a) Frequency with which the isolate has been used in studies carried on here and elsewhere
(b) Morphological or physiological variation within the species
(c) Authenticity of identification
(d) Nature of the substratum from which the organism was isolated
(e) Locality of isolation

The collection contains a wide variety of organisms, and sufficient numbers within a species to exhibit whatever variation exists. None of the original isolates, however, was discarded. Those not actively maintained on agar have been lyophilized, or kept under mineral oil. In the desiccated state most of these will remain viable for several years, and will be available for future study.

This is a collection of microorganisms of tropical and subtropical origin. The isolations from deteriorating materiel were made in Florida and in Panama at the site of the exposure tests, and at the Jeffersonville and Philadelphia Quartermaster Depots from samples carefully wrapped and sent in from the South Pacific and from Asiatic regions. All samples were carefully unwrapped in a sterile room and precautions taken to prevent contamination by the local air borne flora. Sterile instruments were used to tease out fibers from decomposing areas. The fibers were then plated out on various media. In Philadelphia, the following substrata were used:

(a) cellulose dextrin agar,
(b) nutrient agar,
(c) potato dextrose agar,
(d) acidified potato dextrose agar, and
(e) filter paper strips in nutrient salts solution.

The Jeffersonville laboratory used an equally wide, but different, set of conditions, the favorite medium there being grass agar. Transfers were made from the incubated plates as soon as growth was visible. Isolated fungi were maintained on potato dextrose agar and bacteria on Difco nutrient agar. The method of isolation used in Panama was similar to that described above, but in most cases potato dextrose agar was the only medium used. In Florida, and occasionally in Panama, the techniques included washing of samples followed by plating out.

The type of samples examined included cotton and wool fabrics, paper, leather, and plastic. Since these are complex entities, the isolated organism may have been growing on any one of the constituent compounds. From the isolation data alone, it is impossible to say that the isolates from cotton were degrading cellulose, and not starch, waxes, or other chemical compounds in the cloth. For many of the isolates, data have been gathered relative to their ability to attack cellulose (47) and wool (49) in pure culture. If an isolate from decomposing cotton, for example, were found capable of attacking cellulose, the organism might well be considered the agent active in the field.

Investigators concerned with protecting materiel against microbial attack should know which organisms are most likely to be encountered. The data in the various reports — and particularly that of Barghoorn — have been summarized below (table 1). It is apparent that most of the organisms are of wide occurrence, and that the same species are found in Florida, in Panama and in the South Pacific area. Even the frequency with which many species were isolated is similar for the three areas (*Aspergillus versicolor* group, *Trichoderma viride*, *Penicillium citrinum*). There are,

TABLE 1. THE MOST FREQUENT ISOLATES OF QM CULTURE COLLECTION ARRANGED ACCORDING TO FREQUENCY

| Southwest Pacific | | Panama | | Florida | |
|---|---|---|---|---|---|
| Organism | % of isolates | Organism | % of isolates | Organism | % of isolates |
| *Aspergillus niger* group | 5.8 | *Trichoderma viride* ** | 11.1 | *Penicillium luteum* series * | 5.4 |
| *Memnoniella echinata* ** | 4.4 | *Penicillium citrinum* | 8.1 | *Penicillium funiculosum* series | 5.1 |
| *Aspergillus versicolor* group | 4.4 | *Botryodiplodia theobromae* | 5.5 | *Penicillium citrinum* | 4.6 |
| *Chaetomium globosum* ** | 4.0 | *Pullularia pullulans* | 4.6 | *Aspergillus versicolor* group | 4.3 |
| *Trichoderma viride* ** | 3.7 | *Aspergillus versicolor* group | 3.2 | *Aspergillus niger* group | 3.6 |
| *Aspergillus flavus-oryzae* group | 3.6 | *Fusarium solani* * | 3.0 | *Aspergillus flavus-oryzae* group | 3.5 |
| *Penicillium citrinum* | 3.1 | *Fusarium moniliforme* ** | 3.0 | *Chaetomium globosum* ** | 3.5 |
| *Aspergillus nidulans* group | 2.4 | *Pestalotia virgatula* * | 1.8 | *Trichoderma viride* ** | 3.4 |
| *Botryodiplodia theobromae* | 2.1 | *Fusarium javanicum* ** | 1.6 | *Paecilomyces varioti* | 1.9 |
| *Aspergillus terreus* ** | 2.0 | *Gliocladium roseum* * | 1.6 | *Fusarium solani* * | 1.6 |
| *Chaetomium funicolum* ** | 1.8 | *Fusarium diversisporum* | 1.3 | *Aspergillus terreus* ** | 1.4 |
| *Cladosporium herbarum* * | 1.5 | *Aspergillus niger* group | 1.1 | *Penicillium chrysogenum* series | 1.4 |
| *Pullularia pullulans* | 1.5 | *Phialophora lignicola* | 1.1 | *Cylindrocephalum aureum* | 1.4 |
| *Aspergillus ustus* | 1.5 | *Fusarium semitectum* * | 1.0 | *Fusarium moniliforme* ** | 0.7 |
| *Aspergillus fumigatus* ** | 1.4 | *Pestalotia copernica* | 0.9 | *Pullularia pullulans* | 0.4 |
| *Aspergillus tamarii* | 1.3 | *Paecilomyces varioti* | 0.8 | *Gliocladium roseum* * | 0.4 |
| *Thielavia sepedonium* ** | 1.3 | *Curvularia lunata* ** | 0.7 | *Curvularia lunata* ** | 0.4 |
| *Phoma terrestris* ** | 1.1 | *Penicillium luteum* series * | 0.5 | *Memnoniella echinata* ** | 0.3 |
| *Syncephalastrum racemosum* | 1.0 | *Aspergillus flavus-oryzae* group | 0.4 | *Pestalotia virgatula* | 0.2 |
| *Paecilomyces varioti* | 0.9 | *Memnoniella echinata* ** | 0.3 | *Phialophora lignicola* | 0.2 |

* Cellulolytic — less than 50% loss in tensile strength of 3.3 oz. cotton sheeting in two weeks.

** Strongly cellulolytic — 50–100% loss in tensile strength of 3.3 oz. cotton sheeting in two weeks.

on the contrary, some differences in the frequency of occurrence of a few species. *Memnoniella echinata,* the second most common isolate from S. W. Pacific samples, is found also in Florida and Panama, but is much less often isolated. *Pullularia pullulans,* common in Panama, is less frequent in the other two zones. *Botryodiplodia theobromae,* third in frequency in Panama, and ninth in S. W. Pacific, does not appear among the Florida collections. Other points of similarity and of divergence are obtainable by an examination of the table. In any case, if one were to become familiar with but 25 fungi, he would be able to recognize about 50 per cent of the isolates made from deteriorating materials such as those listed above. More detailed information on frequency is available by careful examination of the catalogue.

For an intelligent approach to mildew control, the part played by each of these common organisms should be determined. Our present results cover only the ability of the organisms to attack cellulose in pure culture. This information has been incorporated into table 1, one asterisk denoting weak, two asterisks strong, cellulolytic activity. Since only one half of the organisms listed are capable of growth on cellulose, the others are either growing at the expense of some other component of the fabric, or are air borne contaminants. The presence of sizing would be sufficient to account for development of most of the other fungi, since starch is readily utilized by very many microorganisms. It is interesting to note the absence from the Panama list of *Chaetomium globosum,* a fungus commonly used in fungicide testing.

A note of caution should be inserted relative to the weight to be given the above data. Much effort has been expended by our staff in examining fabrics undergoing decomposition for evidence of actual *fruiting* of the fungus on the fabric. White (52) has particularly noted the frequent occurrence of *Memnoniella echinata* in the tropics, and of *Stachybotrys atra* in temperate climes. We have not seen fruiting structures of *Trichoderma viride, Penicillium* or *Aspergillus.* It may be that the latter organisms do not grow on the cloth, but are isolated with great frequency only because their air-borne spores are abundant on all substrata in that vicinity. On the other hand, it may well be that the hyaline conidiophores of *Trichoderma, Aspergillus* and *Penicillium* rapidly disappear, whereas the colored conidiophores of *Memnoniella* and *Stachybotrys* are more persistent. The black aspect of the latter also makes them more obvious.

The data on frequency of bacterial species are much more limited. Only information relative to the S. W. Pacific samples is available. Slightly more than 50 per cent of the bacteria have been identified. The genus *Bacillus* was segregated and the isolates identified by Dr. N. R. Smith (40). This genus accounts for 40 per cent of all bacterial isolates, *Bacillus cereus* and *Bacillus megatherium* being the most common. None of the isolated members of the genus *Bacillus* attacks cellulose, but the majority of them can degrade autoclaved wool. The Actinomycetes make up only 5 per cent of the total bacterial isolates. A few of these are cellulolytic. The unidentified bacteria, chiefly gram negative non-cellulolytic rods, make up roughly 50 per cent. The cellulose decomposing schizomycetes, bacteria and Actinomycetes, are relatively few in number accounting for only 3 per cent of the total isolates.

For most of the organisms in our collection, relatively few experimental data are available. On the other hand, some have been the subjects of detailed study. On the basis of the knowledge accumulated, it is possible to suggest various organisms for studies dealing with various substrata.

(a) *Electrical insulation*: Members of the *Aspergillus glaucus* group and particularly *Aspergillus repens* (QM *360*, *361*), frequently develop well on insulation (E. A. Weaver). It has been found that these organisms can withstand high osmotic concentrations in the substratum, and will develop under conditions in which the relative humidity is as low as thirty per cent. Some strains fail to grow on agar unless the osmotic concentration is increased considerably above that found in the usual media.

(b) *Paints*: A few fungi appear to grow on and to blemish painted surfaces. Among the most common are:

1. *Pullularia pullulans* (QM *279c*)
2. *Cladosporium herbarum* (QM *489*)

(c) *Nylon*: To our knowledge the only organism isolated from nylon is *Tritirachium roseum* (QM *494*) received from Wright Field. It is quite possible that growth here was on the plasticizer or on contaminating organic matter, and not on the nylon itself. W. D. Gray (4) of the Jeffersonville Depot tested 101 microorganisms of various genera for their ability to grow on nylon (Type 2, duPont). Six isolates were claimed to be able to use nylon as a nitrogen source: *Botryodiplodia* sp. (2) (QM *603*), *Monascus* sp., *Trichothecium* sp., *Spegazzinia tessarthra* (QM *840*), *Blennoria* sp. (QM *590*). None was able to use nylon as a carbon source.

(d) *Wool*: As has been pointed out (49), few of the fungi, except the dermatophytes, are capable of attacking *non-autoclaved* wool. Two such non-pathogenic organisms are *Myrothecium verrucaria* (QM *460*) and *Actinomyces* sp. (QM *B1477*). The dermatophytes studied most completely in our laboratories have been *Microsporum gypseum* (QM *196*), and *Trichophyton mentagrophytes* (QM *253*). It cannot be stated too emphatically that such organisms should be handled only by personnel familiar with the pathogenicity of these fungi. Many additional microorganisms can grow on *autoclaved* wool. Those most active in our tests include:

*Bacillus megatherium* (QM *B1193*)
*Bacillus cereus* (QM *B476*)
*Aspergillus flavus* (QM *70a*)
*Aspergillus terreus* (QM *82j*)
*Alternaria tenuis* (QM *26a*)
*Fusarium moniliforme* (QM *427*)

(e) *Cellulose*: Many microorganisms can degrade cellulose. Some of the more active representatives of the different groups are indicated below:

1. *Myrothecium verrucaria* (QM *460*), one of the most active of cellulolytic microorganisms, yet rarely isolated from exposed cotton fabrics.
2. *Aspergillus fumigatus* (QM *45h*) } These two fungi grow
3. *Aspergillus terreus* (QM *82j*) } actively at 40°C.
4. *Memnoniella echinata* (QM *1c*), an active cellulose destroying fungus of frequent occurrence; requires biotin.
5. *Sporocytophaga myxococcoides* (QM *B490*), represents an active bacterial cellulose destroyer of frequent occurrence on buried samples. In experiments where filtrates are required, the mucilaginous substance produced often makes filtration difficult.
6. *Actinomyces* sp. (QM *B814*), an active cellulolytic organism representing the Actinomycetes.
7. *Trichoderma viride* (QM *6a*), one of the most frequent cellulolytic isolates; of moderate cellulolytic activity.
8. *Cellvibrio vulgaris* (QM *B4*), an active cellulolytic bacterial organism isolated in the Canal Zone with a fair degree of frequency.
9. *Gliomastix convoluta* (QM *4c*)

(f) *Fabrics*: The following organisms have been used widely in specifications set up by government agencies for procurement testing:

1. *Chaetomium globosum* (QM *459*, USDA *1042.4*)
2. *Myrothecium verrucaria* (QM *460*, BPI *1334.2*)
3. *Aspergillus niger* (QM *458*, TC *215–4247*)
4. *Aspergillus ustus* (QM *891*, JQMD *272*)
5. *Trichoderma viride* (QM *365*, BPI *T–1*)

(g) *Leather*: Many organisms especially Aspergilli and Penicillia have been isolated from leather but the damage done is of a questionable nature.

1. *Aspergillus niger* (QM *458*)

(h) *Plastics*: Dr. J. V. Harvey (21) has devised a method for evaluating fungus resistance of plastic coated fabrics which involves an estimate of the amount of visible growth, coupled with a measure of stiffness. An increase in stiffness accompanies fungal degradation. He recommends that the following test organism be used:

1. *Aspergillus versicolor* (QM *4g*)

The reports on which the list is based are not generally available but may be obtained on loan from our laboratories. They are listed below under "Contractual Reports." A second group of reports is also appended. These are included because they deal with the microorganisms in the collection, and because they are pertinent to the subject of deterioration of materiel.

## CONTRACTUAL REPORTS

1. **Barghoorn, E. S.** 1945. Studies of the deterioration of textiles under tropical conditions in the Canal Zone. OSRD Rept. 4807.

2. ————. 1946. Field studies of the deterioration of textiles under tropical conditions. Textile Series Rept. 24. Microbiological Series Rept. 4 of Res. & Dev., OQMG.
3. ————. 1948. Methods of isolation of fungi studied in QM Corps research in tropical deterioration. Rept. uncirculated.
4. **Gray, W. D.** 1945. History of the Biological Laboratory: Isolation and identification of fungi involved in tropical deterioration. Jeffersonville QM Depot — Rept. 303.
5. ————. 1946. Isolations of microorganisms from equipment forwarded from New Guinea. Jeffersonville QM Depot — Rept. 312.
6. ————. 1946. Isolations of microorganisms from equipment forwarded from Guadalcanal. Jeffersonville QM Depot — Rept. 323.
7. **Heimsch, C.** 1946. Tropical Deterioration of Equipment and Materials. OSRD Rept.
8. **Hutchinson, W. G., S. H. Davis, and J. A. Jump.** 1945. The tropical deterioration testing station at Barro Colorado Island. OSRD Rept. 5690.
9. **Linder, D. H.** 1946. Rept. at AAAS in St. Louis in March 1946.
10. **Reuszer, H. W.** 1945. Studies on the role of bacteria in the deterioration of cotton duck. OSRD Rept. 4806.
11. ————. 1945. Bacteria culture collection, OSRD Rept. 5682.
12. ————. 1946. Maintenance and identification of bacterial cultures isolated from material subjected to tropical deterioration. QMC Rept. 59.
13. **Smith, Nathan R., and Marie E. Wenzel.** 1947. Identification of spore-forming bacteria for the OQMG, Army Service Forces. Special Rept. 22. Div. of Soils, Fertilizers, & Irrigation. USDA. Jan. 6, 1947.
14. **Weston, W. H.** 1945. Tropical Fungus Culture Collection. OSRD Rept. 5681.
15. ————. 1949. Tropical deterioration: Preparation and preservation of fungus cultures of military importance. QMC Rept. 60.

## RESEARCH AND PUBLISHED REPORTS

16. **Buell, C. B., and W. H. Weston.** 1947. Application of the mineral oil conservation method to maintaining collections of fungous cultures. QM General Lab. Topical Rept. 18, 1–3.
17. **Burkholder, P. R., and R. G. H. Siu.** 1947. Studies on degradation of cellulose and derivatives by microorganisms. QM General Lab. Topical Rept. 23, 1–22.
18. **Darby, R.** 1949. Resistance of some cellulose derivatives to the fungus *Myrothecium verrucaria*. QM General Lab. Res. Rept., Microbiological Series 10.
19. **Gray, W. D., and G. W. Martin.** 1946. Improvements on the soil burial testing method. QM General Lab. Topical Rept. 14, 1–17.
20. ————, **and** ————. 1947. The growth of fungi on asphalt-treated paper. Mycologia **39**(5): 587–601. 7 fig.
21. **Harvey, James V.** 1949. Testing the fungal resistance of plastic coated fabrics and plastic films. QM General Lab. Res. Rept., Microbiological Series 13.
22. **Levinson, H. S.** 1948. Bacteria involved in cellulose degradation. QM General Lab. Res. Rept., Microbiological Series 9.
23. ————, **and R. DiLello.** 1947. Assay for cellulolytic activity of cultures of bacteria in the QM Bacteria Collection. QM General Lab. Topical Rept. 25, 1–9.
24. **Mandels, G. R., and A. Norton.** 1948. Physiology of spores of the cellulolytic fungus *Myrothecium verrucaria*. QM General Lab. Res. Rept., Microbiological Series 11.
25. ————, **and** ————. 1949. Invertase of *Myrothecium verrucaria* spores. QM General Lab. Res. Rept., Microbiological Series 12.
26. ————, **W. H. Stahl, and H. S. Levinson.** 1948. Structural changes in wool degraded by the ringworm fungus *Microsporum gypseum* and other microorganisms. Text. Res. Journ. **18**(4): 224–231. 14 fig.

27. **Reese, E. T.** 1947. On the effect of aeration and nutrition on cellulose decomposition by certain bacteria. J. Bact. **53**(4): 389–400. 7 fig.

28. **Saunders, P., R. G. H. Siu, and R. N. Genest.** 1948. A cellulolytic enzyme preparation from *Myrothecium verrucaria*. J. Biol. Chem. **174**(2): 697–703. 1 fig.

29. **Sinden, J. W., A. J. Mix, and R. G. H. Siu.** 1946. Effect of pH on cellulolytic action of fungi. QM General Lab. Topical Rept. 10, 1–20.

30. ————, ————, **and** ————. 1946. Relation of temperature to decomposition of cellulose by fungi. QM General Lab. Topical Rept. 11, 1–2.

31. ————, ————, **and** ————. 1948. Effect of environment and mineral nutrition on cellulolytic activity of fungi. QM General Lab. Res. Rept., Microbiological Series 8.

32. **Siu, R. G. H.** 1946. Prevention of the microbiological degradation of cotton fabrics. QM General Lab. Topical Rept. 7, 1–7.

33. ————. 1946. Resistance of cyanoethylated cellulose and cotton fabric to microorganisms. QM General Lab. Topical Rept. 8, 1–6.

34. ————. 1947. Fundamental aspects of the prevention of the microbiological degradation of cotton textiles. Amer. Dyestuff Reptr. **36**: 320–323.

35. ————. 1949–50. Microbial action on cellulose. (Book in preparation)

36. ————, **P. R. Saunders, R. Genest, and J. Dagney.** 1946. Effects of sugars on the cellulolytic activity of *Metarrhizium glutinosum*. QM General Lab. Topical Rept. 1, 1–10.

37. **Skoog, F., and M. Hopkins.** 1946. Biotin as a growth factor for *Memnoniella echinata*. QM General Lab. Topical Rept. 12, 1–7.

38. ————, **and** ————. 1946. A tube-culture method for studying growth rates of fungi. QM General Lab. Topical Rept. 9, 1–27.

39. ————, **and** ————. 1947. Sand culture method for fungi. QM General Lab. Topical Rept. 16, 1–13.

40. **Smith, N. R., H. S. Levinson and R. DiLello.** 1947. Identification and examination for cellulolytic activity of sporeforming bacteria in the QM Bacteria collection. QM General Lab. Topical Rept. 21, 1–16.

41. **Stahl, W. H., and B. McQue.** 1949. Microbiological degradation of wool. III. Digestion of normal and modified fibrillar proteins. QM General Lab. Res. Rept., Biochem. Series 3.

42. ————, ————, **G. R. Mandels, and R. G. H. Siu.** 1949. Studies on the microbiological degradation of wool. I. Sulfur metabolism. Arch. Biochem. **20**: 422–432.

43. **Wagner, R. P., H. H. Webber, and R. G. H. Siu.** 1947. The effect of ultraviolet light on cotton cellulose and its influence on subsequent degradation by microorganisms. Arch. Biochem. **12**(1): 35–50. 3 fig.

44. **White, W. L.** 1946. Mycological factors. *In* Report of the Army Air Forces Tropical Science Mission 25–46, 16 fig. (Wright Field, Ohio). 15 May. (Revised as QM General Lab. Topical Rept. 13: 1–44, 29 fig. 29 Nov.).

45. ————. 1946. Deterioration of Quartermaster fabrics in the Tropics. Quartermaster Review **26** (3): 63–64, 67, 4 figs. Nov.–Dec.

46. ————. 1948. Activities and interrelationships of microorganisms responsible for the deterioration of industrial and military materials. Amer. Journ. Bot. **35**: 804.

47. ————, **R. T. Darby, Gladys M. Stechert, and Kathryn Sanderson.** 1948. Assay of cellulolytic activity of molds isolated from fabrics and related items exposed in the tropics. Mycologia **40**(1): 38–84. 3 fig.

48. ————, **and Mary H. Downing.** 1947. The identity of "*Metarrhizium glutinosum*." Mycologia **39**(5): 546–555, 2 fig.

49. ————, **G. R. Mandels, and R. G. H. Siu.** 1950. Fungi in relation to the deterioration of woolen fabrics. Mycologia **42**: 199–223.

50. ————, **and R. G. H. Siu.** 1947. Resistance of resin-impregnated cotton fabrics to microorganisms. Ind. Eng. Chem. **39**: 1628–1632 1 fig.

51. ————, **R. G. H. Siu, and E. T. Reese.** 1948. The black Aspergilli in relation to cellulosic substrata. Bul. Torrey Bot. Club **75**(6): 604–632. 11 fig.

52. ————, **C. C. Yeager, and Helen Shotts.** 1949. History, distribution and economic significance of the cellulose-destroying fungus *Memnoniella echinata.* Farlowia **3**(4): 399–423, 5 pl., 1 text fig.

## THE LIST

A few notes are necessary for understanding the following catalogue of cultures.

1. *Penicillium*: It will be observed that no cultures of *Penicillium* have been selected at the present listing for the permanent collection. Isolates of all the species indicated are being maintained but sufficient data are not yet available on which a wise selection can be made. It is expected that this group will be carefully examined during the next year.

2. *Arrangement*: The fungi are placed first, followed by the bacteria including actinomycetes and yeasts. The order is alphabetically by genus and species.

3. *Frequency*: The number of times each species has been isolated is placed in parenthesis after the species name. A "(0)" indicates that the organism was not isolated here, but reached us from some other source.

4. *Cultures on agar*: These are listed by QM number under the species. Bacterial numbers are preceded by a "B," as "QM *B12*."

5. *Activity*: C = cellulose; W = wool; + = active in reducing tensile strength of cloth; − = inactive. Cellulose activities are based on loss in tensile strength of grey cotton duck. The wool has been autoclaved, and is much more susceptible to microbial attack than the natural product.

6. *Identifications*: The names of those who have identified the cultures are listed. Many of the Jeffersonville and Philadelphia cultures included in the list were named by individuals in the respective laboratories.

7. *Substrate and locality*: These are listed specifically in case one wishes organisms from a particular substratum or locality for investigation. Most of the isolates are of tropical or sub-tropical origin. Organisms received from other sources are indicated by their previous number, or source.

8. *Culture identification numbers*: Many of our cultures have been distributed previously as "PQMD" numbers. The "P" and the "D" have now been dropped and a culture formerly designated as "PQMD *4c*," is now "QM *4c*," i.e., the actual number is unchanged.

Numerous cultures that had been isolated at other agencies and sent to us have been accessioned under our own QM numbers. Where this is the case, our QM number appears first, directly followed by the original culture number. The following categories are those directly concerned with this change:

(a) Cultures isolated at Jeffersonville Quartermaster Depot (4, 5, 6) and sent to us as "JQMD" numbers; for instance *Aspergillus ustus*, JQMD *272*, appears in the present list as "QM *891* (JQMD *272*)."

(b) Cultures isolated by Dr. G. F. Weber at the University of Florida from Quartermaster items exposed experimentally in Florida, listed as "QM *877* (Fla *A–2*)."

(c) Cultures sent to us by Dr. W. H. Weston (14, 15) at Harvard which had been isolated mostly by Dr. E. S. Barghoorn (1, 2) and Dr. W. G. Hutchinson (8) under wartime OSRD contracts. Most of them were made in Panama or were from Panama materials. A culture by Barghoorn appearing in Harvard Reports as "*B–66E*" is here listed "QM *663* (Pan *B–66E*)." Cultures from Hutchinson may be designated as "CZ" or "UP."

(d) BPI = cultures obtained from the Division of Cotton and other Fiber Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, as "QM *365* (BPI *T–1*)." Cultures in this series have been widely distributed from the Bureau of Plant Industry under such designations as "*T–1*" or "*1334.2*." Recipients have generally added the letters "USDA" as "USDA T–1," etc. Dr. Marsh advises that, with the exception of ***Chaetomium globosum***, USDA *1042.4*, all such cultures should be designated "BPI."

(e) AMP = isolates made by the Australian Mycological Panel in 1944; also previously (47) referred to as "Aust." or more commonly as "SN," which translates simply "Serial Number."

(f) MIT = isolates made by W. L. White in 1944 at the Chemical Warfare Service Development Laboratory, Massachusetts Institute of Technology.

(g) 42nd Chem. = isolates made in the southwest Pacific by the 42nd Chemical Laboratory Co. of the Chemical Warfare Service in 1943 and sent to Chemical Warfare Service Development Laboratory, M.I.T.

(h) NIH = National Institute of Health, Bethesda, Md.

(i) NRRL = Northern Regional Research Laboratory, U. S. Department of Agriculture, Peoria, Ill.

(j) BOL = British Ordnance Laboratory, Cawnpore, India.

(k) ATCC = America Type Culture Collection, Washington, D. C.

FUNGI

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Absidia capillata** van Tieghem (1) | | | | |
| QM *8b* | C− W− | V. M. Cutter | Cotton shirt | New Guinea |
| **Absidia** sp. (1) | | | | |
| QM *579* (Fla *D-75*) | C− W− | | Cot fabric | Florida |
| **Acladium** sp.? (2) | | | | |
| QM *45f* | C+ W+ | | Shoe | India |
| QM *49c* | C+ W+ | | Cartridge belt | India |
| **Acremoniella** sp. (1) | | | | |
| QM *580* (JQMD *454*) | C+ W+ | G. W. Martin | Trousers | New Guinea |
| **Acremonium** sp. (9) | | | | |
| QM *1b* | C+ W+ | | Tent canvas | Bougainville |
| QM *89c* | C+ W+ | W. L. White | Canvas legging | New Guinea |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| QM *581* (JQMD *365*) | C+ W+ | G. W. Martin | Belt | New Guinea |
| QM *582* (JQMD *1117*) | C+ W+ | J. V. Harvey | Tent | New Guinea |
| QM *583* (JQMD *1168*) | C+ W+ | L. G. Isfort | Tent | New Guinea |
| **Acrostalagmus albus** Preuss (1) | | | | |
| QM *663* (Pan *B-66E*) | C+ W+ | K. B. Raper | Leaves | Canal Zone |
| **Acrostalagmus cinnabarinus** Corda (8) | | | | |
| QM *320e* | C+ W+ | W. L. White | Cardboard | Maryland |
| **Acrostalagmus** sp. (1) | | | | |
| **Aegerita** sp. (2) | | | | |
| QM *566* (Pan *B-217I*) | C+ W− | D. H. Linder | Canvas | Canal Zone |
| Agaricaceae? (1) | | | | |
| **Alternaria oleraceae** Milbrath (0) | | | | |
| QM *280* | C− W+ | | Tomato transplants | Georgia USA |
| **Alternaria solani** (Ellis & Martin) Jones & Grout (0) | | | | |
| QM *281* (Main Exp. Sta. *52*) | C+ W+ | | Potato | Maine USA |
| **Alternaria tenuis** Nees (14) | | | | |
| QM *26a* | C+ W+ | J. W. Groves | Canvas | Russell Is. |
| QM *73b* | C+ W+ | W. L. White | Plastic canteen | New Guinea |
| QM *85i* | C+ W+ | J. W. Groves | Canvas tent | Italy |
| QM *120m* | C+ W+ | “ | Tarpaulin | Canal Zone |
| QM *584* (Fla *B-7*) | C+ W+ | “ | Tent | Florida USA |
| QM *585* (Fla *B-47*) | C+ W+ | “ | Canvas | Florida USA |
| QM *586* (Fla *B-48*) | C+ W+ | “ | Canvas | Florida USA |
| **Alternaria** sp. (30) | | | | |
| QM *15a* | C+ W+ | W. L. White | Shoe leather | New Hebrides |
| QM *298* | C+ W+ | M. H. Downing | Electric wiring | Penna. USA |
| QM *587* (Fla *F-11*) | C+ W+ | D. H. Linder | Nylon net | Florida USA |
| **Antennaria** sp. (1) | | | | |
| **Aposphaeriopsis** n. sp. (1) | | | | |
| QM *668* (Pan *52A7A*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Arthrobotrys arthrobotryoides** (Berlese) Lindau (3) | | | | |
| QM *669* (Pan *B-63A (II)*) | C+ W− | D. H. Linder | Tentage | Canal Zone |
| **Arthrobotrys superba** Corda (1) | | | | |
| QM *670* (Pan *51A2A*) | C+ W+ | D. H. Linder | Textile | Canal Zone |
| **Arthrobotrys superba** Corda var. **oligospora** Coemans (1) | | | | |
| QM *671* (Pan *B-741A*) | C+ W− | D. H. Linder | Tarpaulin | Canal Zone |
| **Arthrobotrys** sp. (1) | | | | |
| **Arthrosporium** sp. (1) | | | | |
| **Ascobolus saccoboloides** Seaver ex Dodge & Seaver (1) | | | | |
| QM *899* (JQMD *637*) | C+ W+ | F. J. Seaver | Socks | New Guinea |
| **Aspergillus awamori** Nakazawa (1) | | | | |
| **Aspergillus caespitosus** Raper & Thom (1) | | | | |
| QM *961* | C− W+ | Reese & Downing | Shoe | New Guinea |
| **Aspergillus candidus** Link (1) | | | | |
| **Aspergillus carbonarius** (Bainier) Thom (0) | | | | |
| QM *331* (NRRL *369*) | C− W− | | | |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Aspergillus chevalieri** (Mangin) Thom & Church (16) | | | | |
| QM *52b* | C− W− | K. B. Raper | Khaki shirt | New Guinea |
| QM *64c* | C− W− | Reese & Downing | Poplin shirt | New Guinea |
| QM *112a* | C− W− | W. L. White | Synthetic buttons | Florida USA |
| QM *312* | C− W− | Reese & Downing | Cork gasket | Penna. USA |
| **Aspergillus chevalieri** (Mangin) var. **intermedius** Thom & Raper (4) | | | | |
| QM *58b* | C− W− | K. B. Raper | Leatherette | New Guinea |
| **Aspergillus clavatus** Desmazieres (4) | | | | |
| QM 862 (JQMD *239*) | C− W+ | G. W. Martin | Tarpaulin | New Guinea |
| QM *872* (JQMD *206*) | C− W+ | K. B. Raper | Tarpaulin | New Guinea |
| **Aspergillus conicus** Blochwitz (2) | | | | |
| **Aspergillus fischeri** Wehmer (9) | | | | |
| QM *864* (JQMD *589*) | C+ W+ | G. W. Martin | Paper | Georgia USA |
| QM *865* (Fla *A-11*) | C+ W+ | K. B. Raper | Canvas cot | Florida USA |
| QM *866* (Fla *B-21*) | C+ W+ | " | Canteen cover | Florida USA |
| QM *867* (Fla *B-26*) | C+ W+ | " | Sample cloth | Florida USA |
| **Aspergillus flavipes** (Bainier & Sartory) Thom & Church (10) | | | | |
| QM *24a* | C+ W− | K. B. Raper | Grey netting | Russell Is. |
| QM *868* (Fla *A-14*) | C+ W+ | " | Canvas cot | Florida USA |
| QM *869* (Fla *B-67*) | C+ W+ | " | Canvas legging | Florida USA |
| **Aspergillus flavus** Link (89) | | | | |
| QM *4m* | C− W+ | K. B. Raper | Shoe | Bougainville |
| QM *10e* | C− W+ | " | Canvas | New Guinea |
| QM *63c* | C− W+ | W. L. White | Cotton rope | New Guinea |
| QM *70a* | C− W+ | W. L. White | Shoe | New Guinea |
| QM *138f* | C− W+ | | Shoe | New Guinea |
| QM *380* | C− W+ | K. B. Raper | Shoe | New Guinea |
| QM *870* (Fla *C-2*) | C− W+ | K. B. Raper | Web belt | Florida USA |
| **Aspergillus flavus-oryzae** group (4) | | | | |
| QM *871* (Fla *C-57*) | C− W+ | K. B. Raper | Sock | Florida USA |
| **Aspergillus foetidus** Thom & Raper (0) | | | | |
| QM *328* (NRRL *341*) | C− W− | | | |
| **Aspergillus fonsecaeus** Thom & Raper (1) | | | | |
| QM *330* (NRRL *67*) | C− W− | | | |
| **Aspergillus fumigatus** Fresenius (30) | | | | |
| QM *6b* | C+ W+ | K. B. Raper | Shelter half | Bougainville |
| QM *45h* | C+ W+ | " | Shoe | India |
| QM *445* (MIT *10*) | C+ W+ | W. L. White | Chair glue | Mass. USA |
| QM *497* | C+ W+ | E. T. Reese | Compost | Penna. USA |
| **Aspergillus giganteus** Wehmer (1) | | | | |
| QM *620* (Pan *V4CE3AII*) | C+ W− | K. B. Raper | Textile sample | Canal Zone |
| **Aspergillus luchuensis** series (36) | | | | |
| QM *21e* | C+ W− | | Tarpaulin | New Hebrides |
| QM *102d* | C+ W− | | Leather liner | New Guinea |
| QM *155e* | C+ W− | Reese & Downing | Shelter half | New Georgia |
| QM *873* (JQMD *190*) | C+ W− | G. W. Martin | Tent | New Guinea |
| QM *874* (JQMD *745*) | C+ W− | " | Tent | New Guinea |
| **Aspergillus melleus** Yukawa (2) | | | | |
| **Aspergillus miyakoensis** Nakazawa (1) | | | | |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Aspergillus montevidensis** Talice & Mackinnon (1) | | | | |
| QM *401* (AMP *81*) | C− W− | D. H. Linder | Electric equipment | New Guinea |
| **Aspergillus nidulans** (Eidam) Winter (7) | | | | |
| QM *25b* | C− W+ | Reese & Downing | Shoe leather | Russell Is. |
| QM *87c* | C+ W+ | “ | Cotton rope | New Guinea |
| QM *875* (JQMD *942*) | C− W+ | K. B. Raper | Tent rope | Guadalcanal |
| QM *876* (Fla. *A-13*) | C+ W+ | “ | Canvas cot | Florida USA |
| **Aspergillus nidulans** group (2) | | | | |
| **Aspergillus niger** van Tieghem (49) | | | | |
| QM *458* (TC *215–4247*) | C− W− | | | |
| QM *877* (Fla *A-2* | C+ W− | D. H. Linder | Canvas cot | Florida USA |
| QM *878* (Fla *C-78*) | C− W− | | Typewriter ribbon | Florida USA |
| **Aspergillus niger** mut. **cinnamomeus** (Schiemann) Thom & Raper (0) | | | | |
| QM *326* (NRRL *348*) | C− W− | K. B. Raper | | |
| **Aspergillus niger** mut. **schiemanni** (Thom) Thom & Raper (0) | | | | |
| QM *327* (NRRL *361*) | C+ W− | K. B. Raper | | |
| **Aspergillus niger** group (81) | | | | |
| QM *4j* | C− W− | W. L. White | Shoe | Bougainville |
| QM *38b* | C− W− | “ | Tent canvas | India |
| QM *45d* | C− W− | “ | Shoe | India |
| QM *50c* | C− W− | “ | Tent lines | Hawaii |
| QM *154a* | C− W− | “ | Musette bag | New Georgia |
| QM *198b* | C− W− | W. L. White | Cotton twill | Eastern USA |
| QM *386* (AMP *26*) | C− W− | D. H. Linder | Wireless set | Australia |
| QM *861* (Fla *D-120*) | C− W− | Reese & Downing | Cot fabric | Florida USA |
| **Aspergillus niveus** Blochwitz (2) | | | | |
| QM *879* (JQMD *1148*) | C+ W+ | Reese & Downing | Tent | New Guinea |
| **Aspergillus ochraceus** Wilhelm (0) | | | | |
| QM *26b* | C+ W+ | W. L. White | Canvas | Russell Is. |
| QM *58c* | C+ W+ | K. B. Raper | Leatherette | New Guinea |
| QM *880* (JQMD *1014*) | C− W+ | “ | Mattress cover | Guadalcanal |
| *QM* 881 (JQMD *1080*) | C+ W+ | L. G. Isfort | Wool overcoat | Guadalcanal |
| **Aspergillus oryzae** (Ahlburg) Cohn (3) | | | | |
| QM *22b* | C− W+ | K. B. Raper | Canvas | Russell Is. |
| QM *82i* | C− W+ | W. L. White | Haversack | New Guinea |
| **Aspergillus ostianus** Wehmer (1) | | | | |
| **Aspergillus panamensis** Raper & Thom (1) | | | | |
| QM *882* (JQMD *515*) | C− W− | Reese & Downing | Shoe | New Guinea |
| **Aspergillus parasiticus** Speare (2) | | | | |
| QM *883* (Fla *A-7*) | C− W+ | K. B. Raper | Cot fabric | Florida USA |
| QM *884* (Fla *A-8*) | C− W+ | “ | Cot fabric | Florida USA |
| **Aspergillus phoenicis** (Corda) Thom & Currie (0) | | | | |
| QM *329* (NRRL *1956*) | C− W− | K. B. Raper | | |
| **Aspergillus repens** (Corda) deBary (22) | | | | |
| QM *44c* | C− W− | | Tobacco | S. W. Pacific |
| QM *56f* | C− W− | K. B. Raper | Tent rope | New Guinea |
| QM *59g* | C− W− | | Canvas kit | New Guinea |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| QM *210* | C− W− | W. L. White | Ham | Virginia USA |
| QM *360* | C− W− | Reese & Downing | Electric wire | Penna. USA |
| QM *361* | C− W− | " | Electric wire | Penna. USA |
| QM *364* | C− W− | " | Electric wire | Penna. USA |
| QM *564* | | E. T. Reese | Contaminant | Penna. USA |
| **Aspergillus restrictus** G. Smith (6) | | | | |
| QM *496* | C− W− | E. T. Reese | Wooden stock | Penna. USA |
| QM *885* (JQMD *1213*) | C− W− | L. G. Isfort | Canvas legging | New Guinea |
| **Aspergillus rugulosus** Thom & Raper (0) | | | | |
| QM *886* (JQMD *729*) | C+ W+ | K. B. Raper | Tent | New Guinea |
| **Aspergillus sclerotiorum** Huber (2) | | | | |
| QM *661* (Pan *51A3C*) | C− W+ | K. B. Raper | Textile sample | Canal Zone |
| **Aspergillus sulphureus** (Fresenius) Thom & Church (3) | | | | |
| **Aspergillus sydowi** (Bainier & Sartory) Thom & Church (93) | | | | |
| QM *4d* | C− W− | K. B. Raper | Shoe | Bougainville |
| QM *31c* | C− W− | " | Canvas bag | New Guinea |
| QM *41a* | C− W− | " | Tent rope | India |
| QM *54a* | C− W− | " | Tentage | New Guinea |
| QM *96a* | C− W− | W. L. White | Cellophane | Florida USA |
| QM *103g* | C− W− | Reese & Downing | Canvas tent | New Guinea |
| **Aspergillus tamarii** Kita (23) | | | | |
| QM *50b* | C− W+ | K. B. Raper | Tent lines | Hawaii |
| QM *75b* | C− W+ | Reese & Downing | Cellophane | New Guinea |
| QM *887* (JQMD *949*) | C− W+ | K. B. Raper | Shoe leather | Guadalcanal |
| QM *888* (Fla *A-6*) | C− W+ | " | Canvas cot | Florida USA |
| **Aspergillus terreus** Thom (53) | | | | |
| QM *72f* | C+ W+ | W. L. White | Leather scabbard | New Guinea |
| QM *82j* | C+ W+ | " | Haversack | New Guinea |
| QM *91c* | C+ W+ | " | Canvas | New Guinea |
| QM *106g* | C+ W+ | | Canvas legging | New Guinea |
| QM *442* (MIT *7*) | C+ W+ | W. L. White | Wood shelf | Mass. USA |
| QM *889* (Fla *B-19*) | C+ W+ | K. B. Raper | Canteen cover | Florida USA |
| **Aspergillus unguis** Emile-Weil & Gaudin (28) | | | | |
| QM *8f* | C− W− | K. B. Raper | Cotton undershirt | New Guinea |
| QM *30b* | C− W− | W. L. White | Shoe | Hawaii |
| QM *45e* | C− W− | K. B. Raper | Shoe | India |
| QM *53c* | C− W− | " | Leather strap | New Guinea |
| QM *890* (Fla *F-8*) | C− W− | " | Nylon hammock | Florida USA |
| **Aspergillus ustus** (Bainier) Thom & Church (43) | | | | |
| QM *29c* | C+ W+ | K. B. Raper | Tarpaulin | Hawaii |
| QM *89d* | C+ W+ | W. L. White | Canvas legging | New Guinea |
| QM *133f* | C+ W− | | Canteen cover | New Georgia |
| QM *137d* | C+ W− | | Shoes | New Guinea |
| QM *891* (JQMD *272*) | C+ W− | G. W. Martin | | Indiana USA |
| QM *892* (JQMD *673*) | C+ W+ | Reese & Downing | Case liner | Georgia USA |
| **Aspergillus ustus** (Bainier) var. **laevis** Blochwitz (14) | | | | |
| QM *24a-2* | C− W− | K. B. Raper | Netting | Russell Is. |
| QM *893* (Fla *F-17*) | C− W− | " | Nylon hammock | Florida USA |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Aspergillus versicolor** (Vuillemin) Tiraboschi (98) | | | | |
| QM *4g* | C− W− | W. L. White | Shoe leather | Bougainville |
| QM *17d* | C− W− | K. B. Raper | Tentage | New Hebrides |
| QM *432* (MIT *1c*) | C− W− | “ | Cellophane | India |
| QM *894* (Fla *D-77*) | C− W− | “ | Cot fabric | Florida USA |
| **Aspergillus versicolor** group (2) | | | | |
| **Aspergillus violaceo-fuscus** Gasperini (3) | | | | |
| QM *335* (NRRL *360*) | C− W− | K. B. Raper | | |
| **Aspergillus wentii** Wehmer (1) | | | | |
| QM *44a* | C− W− | K. B. Raper | Tobacco | S. W. Pacific |
| **Aspergillus** sp. (3) | | | | |
| Basidiomycetes (48) | | | | |
| QM *588* (Fla *B-44*) | C+ W− | W. L. White | Canvas | Florida USA |
| QM *589* (Fla *B-75*) | C+ W+ | “ | Shoe | Florida USA |
| **Blakeslea trispora** Thaxter (12) | | | | |
| **Blakeslea** sp. (11) | | | | |
| **Blennoria** sp. (1) | | | | |
| QM *590* (JQMD *991*) | C− W− | G. W. Martin (?) | Nylon plate | Indiana USA |
| **Botryella** sp. (3) | | | | |
| **Botryodiplodia theobromae** Patouillard (157) | | | | |
| QM *78a* | C+ W+ | W. L. White | Tent canvas | New Guinea |
| QM *145h* | C+ W+ | | Tarpaulin | New Georgia |
| QM *166a* | C+ W+ | | Citrus | Trinidad |
| QM *898* (JQMD *891*) | C+ W+ | G. W. Martin | Tent | New Guinea |
| **Botryodiplodia** sp. (4) | | | | |
| **Botryophialophora** sp. (1) | | | | |
| QM *571* (Pan *V58B3AIII*) | C− W+ | D. H. Linder | Textile | Canal Zone |
| **Botryosphaeria** sp. (1) | | | | |
| **Botryosporium** sp. | | | | |
| QM *907* | C− W− | | Paper | from Dr. Sinden |
| **Botrytis cinerea** Persoon (0) | | | | |
| QM *520* | C+ W− | C. L. Fergus | Poinsettia | Penna. USA |
| **Botrytis** sp. (7) | | | | |
| QM *344* | C+ W− | W. L. White | Green pepper | Penna. USA |
| QM *578* | C+ W− | E. T. Reese | *Maclura pomifera* | Penna. USA |
| QM *592* (JQMD *540*) | C+ W+ | L. G. Isfort | Tent | New Guinea |
| QM *594* (JQMD *781*) | C+ W− | G. W. Martin | Tent | Pacific |
| **Brachysporium oosporum** (Corda) Saccardo (7) | | | | |
| QM *665* (Fla *G-128*) | C+ W+ | D. H. Linder | Water proof bag | Florida USA |
| **Brachysporium** sp. (21) | | | | |
| QM *38d* | C+ W+ | | Tentage | India |
| QM *63b* | C+ W+ | | Cotton rope | New Guinea |
| QM *70g* | C+ W+ | | Shoe | New Guinea |
| QM *595* (Fla *B-57*) | C+ W+ | J. W. Groves | Tent | Florida USA |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Byssochlamys** sp. (1) | | | | |
| **Cephaliophora tropica** Thaxter (1) | | | | |
| QM *596* (JQMD *956*) | C+ W+ | W. L. White | Shoe leather | Guadalcanal |
| **Cephalosporium acremonium** Corda (2) | | | | |
| QM *611* (Pan *B-212C*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Cephalosporium curtipes** Saccardo (1) | | | | |
| **Cephalosporium** sp. (30) | | | | |
| QM *107a* | C+ W+ | | Trousers | New Guinea |
| QM *124h* | C+ W+ | | Cotton duck | Canal Zone |
| QM *127e* | C+ W+ | | Tarpaulin | New Georgia |
| QM *597* (JQMD) *297*) | C− W+ | G. W. Martin | Tent | New Guinea |
| QM *598* (Fla *B-5*) | C+ W+ | D. H. Linder | Tent | Florida USA |
| **Cephalothecium roseum** Corda (1) | | | | |
| QM *599* (Fla B-50) | C− W+ | | Canvas | Florida USA |
| **Cephalothecium** sp. (5) | | | | |
| QM *600* (JQMD *380*) | C+ W+ | G. W. Martin | Tarpaulin | New Guinea |
| **Cercosporella** sp. (1) | | | | |
| QM *601* (JQMD) *786* | C+ W+ | G. W. Martin | Tent | New Guinea |
| **Cercosporidium** sp. (1) | | | | |
| QM *602* (JQMD *257*) | C+ W+ | G. W. Martin | Tarpaulin | New Guinea |
| **Chaetodiplodia** sp. (1) | | | | |
| QM *603* (JQMD *197*) | C+ W+ | | Tent | New Guinea |
| **Chaetomella** sp. (1) | | | | |
| QM *40c* | C+ W+ | | Canvas | India |
| **Chaetomium atrobrunneum** Ames (1) | | | | |
| QM *626* (JQMD *1041*) | C+ W+ | L. M. Ames | Mattress cover | Guadalcanal |
| **Chaetomium cochliodes** Palliser (1) | | | | |
| QM *604* (JQMD *131*) | C+ W+ | L. M. Ames | | Tropical America |
| **Chaetomium elatum** Kunze & Schmidt (9) | | | | |
| QM *382* (AMP *11*) | C+ W+ | | Sandbag | Australia |
| QM *605* (JQMD *776*) | C+ W− | L. M. Ames | Tent | Pacific area |
| QM *606* (JQMD *1082*) | C+ W− | L. G. Isfort | Wool overcoat | Guadalcanal |
| **Chaetomium funicolum** Cooke (31) | | | | |
| QM *33c* | C+ W− | D. H. Linder | Pistol belt | New Guinea |
| QM *34d* | C+ W− | W. L. White | Canteen cover | New Guinea |
| QM *35e* | C+ W− | " | Tent | New Guinea |
| QM *42a* | C+ W− | L. M. Ames | Cap | India |
| QM *383* (AMP *12*) | C+ W+ | " | Pea seed | Australia |
| QM *607* (Fla *B-12*) | C+ W− | D. H. Linder | Tent | Florida USA |
| **Chaetomium globosum** Kunze (93) | | | | |
| QM *32b* | C+ W+ | L. M. Ames | Tent | New Guinea |
| QM *38f* | C+ W+ | " | Canvas tent | India |
| QM *85n* | C+ W+ | " | Canvas tent | Italy |
| QM *104a* | C+ W+ | " | Rubber boot | New Guinea |
| QM *459* (USDA *1042.4*) | C+ W+ | | | |
| QM *608* (Fla *C-12*) | C+ W+ | D. H. Linder | Shower curtain | Florida USA |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Chaetomium indicum** Corda (8) | | | | |
| QM *46b* | C+ W− | L. M. Ames | Tent rope | India |
| QM *47c* | C+ W− | " | Wax paper | India |
| QM *156f* | C+ W− | " | Barracks bag | New Georgia |
| QM *621* (JQMD *810*) | C+ W− | W. L. White | Tent | New Guinea |
| **Chaetomium spirale** Zopf (1) | | | | |
| QM *622* (JQMD *135*) | C+ W+ | G. W.Martin | | Tropical America |
| **Chaetomium tortile** Bainier (1) | | | | |
| QM *895* (JQMD *477*) | C+ W+ | E. T. Reese | Trousers | New Guinea |
| **Chaetomium velutinum** Ames (1) | | | | |
| QM *623* (JQMD *359*) | C+ W+ | L. M. Ames | Tent | New Guinea |
| **Chaetomium** n. sp. of Ames (8) | | | | |
| QM *624* (JQMD *486*) | C+ W+ | L. M. Ames | Greenhouse soil | Indiana USA |
| QM *625* (JQMD *647*) | C+ W− | " | Case liner | Georgia USA |
| **Chaetomium** sp. (15) | | | | |
| QM *145k* | C+ W− | | Tarpaulin | New Georgia |
| QM *155b* | C+ W− | | Shelter half | New Georgia |
| QM *627* (JQMD *1105*) | C+ W+ | L. G. Isfort | Wool overcoat | Guadalcanal |
| **Chloridium** sp. (2) | | | | |
| QM *567* (Pan *54A3R*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Choanophora simsonii** Cunningham (1) | | | | |
| **Choanophora** sp. (20) | | | | |
| QM *565* (Pan *10A4B*) | | V. M. Cutter | Textile sample | Canal Zone |
| **Chromosporium** sp. (2) | | | | |
| QM *628* (Fla *C-73*) | C+ W+ | D. H. Linder | Cotton cord | Florida USA |
| **Circinella spinosa** van Tieghem & Le Monnier (0) | | | | |
| QM *537* (Schneidau *760*; ATCC *9025*) | C− W− | | | |
| **Circinella sydowi** Lendner (1) | | | | |
| QM *629* (JQMD *672*) | C− W− | V. M. Cutter | Litter | Florida USA |
| **Circinella** sp. (1) | | | | |
| QM *672* (Fla *I-A245*) | C− W− | D. H. Linder | Poplin | Florida USA |
| QM *902* (Fla *C-13*) | C− W− | E. T. Reese | Shower curtain | Florida USA |
| **Citromyces musae** Bainier & Sartory (4) | | | | |
| **Cladosporium herbarum** Link (31) | | | | |
| QM *17b* | C− W+ | W. L. White | Tentage | New Hebrides |
| QM *52a* | C− W+ | | Khaki shirt | New Guinea |
| QM *55b* | C+ W− | | Leather band | New Guinea |
| QM *71d* | C+ W+ | | Canvas glove | New Guinea |
| QM *120g* | C− W+ | W. L. White | Tarpaulin | Canal Zone |
| QM *121k* | C+ W+ | " | Tarpaulin | Canal Zone |
| QM *122e* | C+ W+ | " | Duck | Canal Zone |
| QM *279a* | C− W− | " | Painted wood | Costa Rica |
| QM *489* | C− W− | Reese & Downing | Floor | Penna. USA |
| **Cladosporium** sp. (73) | | | | |
| QM *122c* | C+ W+ | W. L. White | Duck | Canal Zone |
| QM *146h* | C− W− | | Tarpaulin | New Georgia |
| QM *236* | | W. L. White | Shower curtain | |
| QM *279b* | C− W− | " | Painted wood | Costa Rica |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Clasterosporium** sp. (1) | | | | |
| **Coccobolus** sp. ? (2) | | | | |
| QM *534* (Pan *X 23A2A*) | C+ W+ | D. H. Linder | Textile | Canal Zone |
| **Coccosporium** sp. (0) | | | | |
| QM *230* (Higinbotham *46-1-4*) | C+ W+ | | | |
| **Colletotrichum** sp. (2) | | | | |
| QM *533* (UP *139A*) | C+ W+ | | Decayed leaves | Canal Zone |
| **Collonaemella** sp. (1) | | | | |
| QM *568* (Pan *B-C61*) | C+ W+ | | Leather, cowhide | Canal Zone |
| **Coniothyrium** sp. (2) | | | | |
| **Coprinus radians** (Desmazières) Fries (1) | | | | |
| **Coprinus** sp. (3) | | | | |
| QM *149e* | C− W+ | | Tent | New Georgia |
| QM *630* (JQMD *351*) | C+ W+ | G. W. Martin | Greenhouse soil | Indiana USA |
| **Corynespora** sp. (2) | | | | |
| QM *569* (Pan *B-52BI*) | C+ W+ | D. H. Linder | Duck | Canal Zone |
| **Ctenomyces serratus** Eidam? (0) | | | | |
| QM *256* (NIH *1902*) | C− W+ | C. W. Emmons | Bird's nest | England |
| **Ctenomyces** sp. ? (7) | | | | |
| QM *199* | C− W+ | C. W. Emmons | Wool shallie | Penna. USA |
| QM *287* (BOL *D-381*) | C− W+ | W. L. White | Wool serge | India |
| QM *774* (JQMD )*1070* | C+ W− | “ | Tent | New Guinea |
| QM *845* (JQMD *1277*) | C− W+ | “ | Wool overcoat | Guadalcanal |
| **Cunninghamella bertholletiae** Stadel (1) | | | | |
| **Cunninghamella blakesleeana** Lendner (2) | | | | |
| QM *631* (JQMD *885*) | C− W+ | V. M. Cutter | Tent | New Guinea |
| **Cunninghamella echinulata** (Thaxter) Saccardo (6) | | | | |
| QM *35c* | C− W+ | V. M. Cutter | Tent | New Guinea |
| QM *154f* | C− W+ | | Musette bag | New Georgia |
| QM *632* (JQMD *927*) | C− W− | V. M. Cutter | Tent rope | Guadalcanal |
| **Cunninghamella elegans** Lendner (8) | | | | |
| QM *633* (JQMD *181*) | C− W+ | V. M. Cutter | Greenhouse soil | Indiana USA |
| QM *634* (Fla *B-4*) | C− W+ | D. H. Linder | Tent | Florida USA |
| QM *635* (Fla *C-88*) | C− W+ | “ | Typewriter ribbon | Florida USA |
| **Cunninghamella** sp. (5) | | | | |
| QM *636* (JQMD *1035*) | C− W+ | L. G. Isfort | Canvas cot | Guadalcanal |
| **Curvularia brachyspora** Boedijn (6) | | | | |
| QM *93b* | C+ W+ | J. W. Groves | Tarpaulin | New Guinea |
| QM *637* (Fla *A-19*) | C+ W+ | “ | | Florida USA |
| QM *638* (Fla *B-8*) | C+ W+ | “ | Tent | Florida USA |
| QM *639* (Fla *B-46*) | C+ W+ | W. L.White | Tent | Florida USA |
| **Curvularia falcata** (Tehon) Boedijn (5) | | | | |
| QM *77a* | W+ | J. W. Groves | Tent | New Guinea |
| QM *120h* | C+ W+ | “ | Tarpaulin | Canal Zone |
| QM *640* (JQMD *590*) | C− W+ | “ | Tent | New Guinea |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Curvularia fallax** Boedijn (2) | | | | |
| QM *561* (Pan *B-663*A) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Curvularia geniculata** (Tracy & Earle) Boedijn (2) | | | | |
| QM *562* (Pan *C1A4A*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Curvularia intermedia** Boedijn ? (1) | | | | |
| QM *563* (Pan *B-711A*) | C+ W+ | D. H. Linder | Textile | Canal Zone |
| **Curvularia lunata** (Wakker) Boedijn (33) | | | | |
| QM *34b* | C+ W+ | J. W. Groves | Canteen cover | New Guinea |
| QM *120L* | C+ W+ | " | Tarpaulin | Canal Zone |
| QM *641* (JQMD *569*) | C+ W+ | " | Raincoat | New Guinea |
| QM *642* (Fla *D-90*) | C+ W+ | D. H. Linder | Cot fabric | Florida USA |
| **Curvularia maculans** (Bancroft) Boedijn (8) | | | | |
| QM *666* (Pan *B-210F*) | C+ W+ | D. H. Linder | Textile | Canal Zone |
| **Curvularia** sp. (22) | | | | |
| QM *371d* | C+ W+ | White & Downing | Cardboard | Florida USA |
| QM *535* (Pan *58A8B*) | C+ W+ | E. T. Reese | Textile | Canal Zone |
| QM *643* (JQMD *627*) | C− W+ | G. W. Martin | Tent | New Guinea |
| QM *674* (Pan *81H*) | C+ W+ | D. H. Linder | Cotton thread | Canal Zone |
| **Cylindrocarpon album** (Saccardo) Wollenweber (1) | | | | |
| QM *673* (Pan *51C20I*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| **Cylindrocarpon candidum** (Link) Wollenweber (1) | | | | |
| QM *530* (Pan *8B5DI*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| **Cylindrocarpon janthotele** Wollenweber (2) | | | | |
| **Cylindrocarpon olidum** Wollenweber (0) | | | | |
| QM *538* (Schneidau *850*; ATCC *6679*) | C+ W+ | | | |
| **Cylindrocarpon soparium** n.var. (1) | | | | |
| QM *557* (UP *151*) | C+ W+ | C. D. Sherbakoff | Decaying leaves | Canal Zone |
| **Cylindrocarpon** sp. (30) | | | | |
| **Cylindrocephalum aureum** (Corda) Bonorden (16) | | | | |
| QM *523* (Fla E-*9*) | C+ W+ | D. H. Linder | Canvas cot | Florida USA |
| QM *610* (Fla *B-116*) | C+ W+ | " | Nylon hammock | Florida USA |
| QM *644* (Fla *D-158*) | C+ W+ | " | Rope | Florida USA |
| **Cylindrocephalum** sp. (25) | | | | |
| **Cylindrocladium scoparium** Morgan (4) | | | | |
| **Cylindrocladium** n. sp. (3) | | | | |
| **Cylindrocladium** sp. (3) | | | | |
| **Cylindrophora** sp. ? (1) | | | | |
| **Cytospora?** sp. (1) | | | | |
| QM *570* (Pan *B-227C*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Cytosporina?** sp. (2) | | | | |
| QM *713* (Pan *B-209T*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Dactylium dendroides** (Bulliard) Fries (1) | | | | |
| QM *508* | C− W+ | E. T. Reese | Agaricus | Penna. USA |
| QM *513* | C− W+ | " | Mushroom bed | Penna. USA |
| **Daedalea quercina** Fries (0) | | | | |
| QM *510* (C. L. Fergus *24780-S*) | | | | |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| Dematiaceae mycelium non-sporulating (29) | | | | |
| QM *69d* | C− W− | | Canvas | New Guinea |
| QM *646* (JQMD *890*) | C+ W+ | G. W. Martin | Tent | New Guinea |
| **Dematium** sp. (2) | | | | |
| QM *647* (JQMD *1193*) | C+ W+ | | Tent | New Guinea |
| **Dendrodochium** sp. (1) | | | | |
| QM *714* (Pan *4CA3LI*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Dendryphium** sp. (4) | | | | |
| QM *675* (Fla *H-185*) | C+ W+ | D. H. Linder | Cotton socks | Florida USA |
| **Dicoccum** sp. (1) | | | | |
| QM *572* (Pan *CZ131*) | C− W− | | Telescope | Canal Zone |
| **Diplodia** sp. (3) | | | | |
| QM *648* (Fla *D-19*) | C+ W+ | | Cot strap | Florida USA |
| **Diplodiella** sp. (1) | | | | |
| **Diplodiopsis** sp. (1) | | | | |
| QM *715* (Pan *7PA4C*) | C− W− | | Textile | Canal Zone |
| **Diploplenodomopsis?** sp. (3) | | | | |
| QM *573* (Pan *LI6A2BI*) | C+ W+ | D. H. Linder | Textile | Canal Zone |
| **Dothiorella** sp. (2) | | | | |
| QM *676* (Pan *B-200F*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Endoconidiophora** n. sp. (1) | | | | |
| QM *677* (Pan *1TD2F*) | C− W− | D. H. Linder | Textile | Canal Zone |
| **Endoconidium** sp. (1) | | | | |
| **Endogloea?** sp. (1) | | | | |
| QM *574* (Pan *X1A1A*) | C+ W+ | D. H. Linder | Textile | Canal Zone |
| **Endomyces** sp. (3) | | | | |
| QM *577* (Pan *BC-87*) | C− W− | D. H. Linder | Photo film | Canal Zone |
| Endomycetales (5) | | | | |
| QM *678* (Pan *7PA61I*) | C+ W− | D. H. Linder | Textile | Canal Zone |
| **Epicoccum** sp. (3) | | | | |
| QM *284e* | C+ W+ | W. L. White | Cardboard | Penna. USA |
| QM *649* (JQMD *790*) | C+ W+ | | Tent | New Guinea |
| **Epidermophyton floccosum** (Harz) Langeron & Milochevitch (0) | | | | |
| **Epistigme** sp. (1) | | | | |
| **Eurotium** sp. (2) | | | | |
| QM *650* (JQMD *1130*) | | | Tent | New Guinea |
| QM *651* (JQMD *1250*) | | | Tarpaulin | Guadalcanal |
| **Exophoma** sp. ? (1) | | | | |
| QM *716* (Pan *V7MA5AII*) | C+ W+ | D. H. Linder | Textile | Canal Zone |
| **Fomes pinicola** (Fries) Cooke (0) | | | | |
| QM *511* (C. L. Fergus *24719-S*) | C− W− | | | |
| **Fusarium acuminatum** Ellis & Everhart (1) | | | | |
| QM *525* (Pan *51A2B*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| **Fusarium avenaceum** (Fries) Saccardo (5) | | | | |
| QM *552* (Pan *C1A5EII*) | C− W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| **Fusarium bulbigenum** Cooke & Massee (2) | | | | |
| QM *553* (Pan *51B6F*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Fusarium camptoceras** Wollenweber & Reinking (3) | | | | |
| QM *679* (Pan *B-209D*) | C+ W+ | C. D. Sherbakoff | Cotton duck | Canal Zone |
| **Fusarium decemcellulare** Brick (7) | | | | |
| QM *613* (Pan *B-647A*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| **Fusarium diversisporum** Sherbakoff (34) | | | | |
| QM *77g* | C+ W+ | C. D. Sherbakoff | Tent canvas | New Guinea |
| QM *88a* | C+ W+ | “ | Rope | New Guinea |
| **Fusarium equiseti** (Corda) Saccardo (1) | | | | |
| QM *29a* | C+ W+ | C. D. Sherbakoff | Tarpaulin | Hawaii |
| **Fusarium graminum** Corda (3) | | | | |
| QM *680* (Pan *B-25D*) | C− W+ | C. D. Sherbakoff | Duck | Canal Zone |
| **Fusarium heterosporum** Nees n. var. (1) | | | | |
| QM *51d* | C+ W+ | C. D. Sherbakoff | Tentage | Hawaii |
| **Fusarium javanicum** Koorders (41) | | | | |
| QM *23d* | C+ W+ | C. D. Sherbakoff | Rope | Russell Is. |
| **Fusarium javanicum** Koorders var. **ensiforme** (Wollenweber & Reinking) Wollenweber (5) | | | | |
| QM *524* (Pan *B-233AI*) | C+ W+ | C. D. Sherbakoff | Canvas | Canal Zone |
| **Fusarium javanicum** Koorders var. **radicicola** Wollenweber (8) | | | | |
| QM *529* (Pan *V51F1B*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| **Fusarium lactis** Pirotta & Riboni (1) | | | | |
| QM *612* (Pan *B65DII*) | C+ W+ | C. D. Sherbakoff | Dead leaf | Canal Zone |
| **Fusarium lateritium** Nees (5) | | | | |
| QM *120d* | C+ W+ | W. C. Snyder | Tarpaulin | Canal Zone |
| **Fusarium melanochlorum** (Caspary) Saccardo (1) | | | | |
| QM *652* (Fla *A-23*) | C+ W+ | C. D. Sherbakoff | Cot fabric | Florida USA |
| **Fusarium merismoides** Corda (1) | | | | |
| QM *555* (Pan *51A4F*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| **Fusarium moniliforme** Sheldon (81) | | | | |
| QM *427* (42nd Chem. *70d*) | C+ W+ | | | India |
| QM *527* (Fla *E-209*) | C+ W+ | C. D. Sherbakoff | Food can | Florida USA |
| QM *653* (Fla *B-13*) | C+ W+ | W. C. Snyder | Tent | Florida USA |
| QM *654* (Fla. *D-145*) | C+ W+ | C. D. Sherbakoff | Rope | Florida USA |
| **Fusarium moniliforme** Sheldon var. **anthophilum** (A.Br.) Wollenweber (1) | | | | |
| QM *717* (Pan *7MB5BII*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| **Fusarium moniliforme** Sheldon var. **minus** Wollenweber (2) | | | | |
| QM *556* (Pan *C1A5EI*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| **Fusarium moniliforme** Sheldon var. **subglutinans** Wollenweber & Reinking (1) | | | | |
| QM *526* (Pan *C1A5EI*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| **Fusarium orthoceras** Appel & Wollenweber (4) | | | | |
| QM *655* (Fla *D-101*) | C+ W+ | C. D. Sherbakoff | Cot fabric | Florida USA |
| QM *681* (Pan *V51F4A*) | C+ W+ | “ | Textile sample | Canal Zone |
| **Fusarium oxysporum** Schlechtendahl (33) | | | | |
| QM *21c* | | C. D. Sherbakoff | Tarpaulin | New Hebrides |
| QM *23e* | C+ W+ | “ | Rope | Russell Is. |
| QM *47e* | C+ W+ | W. C. Snyder | Wax paper | India |
| QM *656* (Fla *B-61*) | C+ W+ | “ | Tent | Florida USA |
| QM *657* (Fla *C-8*) | C+ W+ | “ | Web belt | Florida USA |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Fusarium redolens** Wollenweber (1) | | | | |
| QM *682* (Fla *E-13*) | C+ W+ | C. D. Sherbakoff | Canvas cot | Florida USA |
| **Fusarium reticulatum** Montagne (7) | | | | |
| QM *658* (Fla *B-14*) | C+ W+ | C. D. Sherbakoff | Tent | Florida USA |
| QM *706* (Fla *D-99*) | C+ W+ | " | Cot fabric | Florida USA |
| **Fusarium roseum** Link (9) | | | | |
| QM *38a* | C+ W+ | W. C. Snyder | Canvas tent | India |
| QM *38g* | C+ W+ | " | Canvas tent | India |
| QM *659* (Fla *B-24*) | C+ W+ | " | Canteen cover | Florida USA |
| **Fusarium sambucinum** Fuckel (1) | | | | |
| QM *662* (Pan *B-65C*) | C+ W+ | C. D. Sherbakoff | Dead leaf | Canal Zone |
| **Fusarium scirpi** Lambotte & Fautrey (3) | | | | |
| QM *660* (Fla *C-75*) | C+ W+ | D. H. Linder | Cotton cord | Florida USA |
| **Fusarium scirpi** Lambotte & Fautrey var. **compactum** Wollenweber (1) | | | | |
| **Fusarium scirpi** Lambotte & Fautrey var. **filiferum** (Preuss) Wollenweber (1) | | | | |
| QM *528* (Pan *B-52A*) | C+ W+ | C. D. Sherbakoff | Cotton duck | Canal Zone |
| **Fusarium scirpi** Lambotte & Fautrey var. **longipes** (Wollenweber & Reinking) Wollenweber (3) | | | | |
| QM *50f* | C+ W+ | C. D. Sherbakoff | Tent | Hawaii |
| QM *398* (AMP *68*) | C+ W+ | | Tent canvas | New Guinea |
| **Fusarium semitectum** Berkeley & Ravenel (7) | | | | |
| QM *66b* | C+ W+ | C. D. Sherbakoff | Web strap | New Guinea |
| QM *122a* | C+ W+ | " | Cotton duck | Canal Zone |
| **Fusarium semitectum** Berkeley & Ravenel var. **majus** Wollenweber (21) | | | | |
| QM *121c* | C+ W+ | C. D. Sherbakoff | Tarpaulin | Canal Zone |
| **Fusarium solani** (Martius) Appel & Wollenweber (41) | | | | |
| QM *21d* | C+ W+ | C. D. Sherbakoff | Tarpaulin | New Hebrides |
| QM *745* (Fla *D-102*) | C+ W+ | " | Cot fabric | Florida USA |
| QM *746* (Fla *D-106*) | C+ W+ | " | Cot fabric | Florida USA |
| **Fusarium solani** (Martius) Appel & Wollenweber var. **eumartii** (Carpenter) Wollenweber (6) | | | | |
| QM *530* (Pan *8B5DI*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| QM *554* (Pan *52A3L*) | | " | Textile sample | Canal Zone |
| QM *683* (Pan *B-23*) | C+ W+ | " | Canvas | Canal Zone |
| **Fusarium solani** (Martius) Appel & Wollenweber var. **martii** (Appel & Wollenweber) Wollenweber (36) | | | | |
| QM *747* (Fla *D-9*) | C+ W+ | C. D. Sherbakoff | Cot strap | Florida USA |
| QM *748* (Fla *F-28*) | C+ W+ | " | Nylon net | Florida USA |
| **Fusarium solani** (Martius) Appel & Wollenweber var. **minus** Wollenweber (18) | | | | |
| QM *127h* | C+ W+ | C. D. Sherbakoff | Tarpaulin | New Georgia |
| QM *749* (Fla *C-13b*) | C+ W+ | " | Shower curtain | Florida USA |
| QM *750* (*Fla B-50*) | C+ W+ | " | Cot strap | Florida USA |
| QM *751* (Fla *F-148*) | C+ W+ | " | Pistol belt | Florida USA |
| **Fusarium** sec. **Elegans** (15) | | | | |
| QM *106b* | C+ W+ | C. D. Sherbakoff | Canvas legging | New Guinea |
| QM *120e* | C+ W+ | " | Tarpaulin | Canal Zone |
| QM *752* (Fla *D-70*) | C+ W+ | " | Cot fabric | Florida USA |
| **Fusarium** sec. **Martiella** (22) | | | | |
| QM *125b* | C+ W+ | C. D. Sherbakoff | Cotton duck | Canal Zone |
| QM *129g* | C+ W+ | " | Tent rope | New Georgia |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Fusarium** sec. **Sporotrichoides** (1) | | | | |
| QM *753* (Fla *C-66*) | C+ W+ | C. D. Sherbakoff | Socks | Florida USA |
| **Fusarium** sp. (57) | | | | |
| QM *70f* | C+ W+ | | Shoe | New Guinea |
| QM *197* | C+ W+ | M. H. Downing | Wool | Penna. USA |
| QM *754* (Fla *D-97*) | C+ W+ | C. D. Sherbakoff | Cot fabric | Florida USA |
| **Fusidium** sp. (3) | | | | |
| QM *755* (JQMD *1108*) | C+ W+ | | Wool overcoat | Guadalcanal |
| **Fusoma** sp. (2) | | | | |
| **Galactinia** sp. (*Botrytis* stage) (0) | | | | |
| QM *345* (Korf *SS-3*) | C+ W+ | R. P. Korf | Greenhouse soil | New York USA |
| **Gelatinosporium** sp. (5) | | | | |
| QM *684* (Pan *B-212H*) | C+ W+ | D. H. Linder | Cotton duck | Canal Zone |
| **Geotrichum** sp. (2) | | | | |
| QM *532* (Fla *F-113*) | C− W− | D. H. Linder | Hammock, mesh | Florida USA |
| **Gibberella saubinetii** (Montagne) Saccardo (1) | | | | |
| QM *685* (Pan *51A3JII*) | C+ W+ | C. D. Sherbakoff | Textile sample | Canal Zone |
| **Gliobotrys** sp. (1) | | | | |
| QM *220* | C+ W+ | | Canvas bag | |
| QM *756* (JQMD *924*) | C+ W− | L. G. Isfort | Tent | New Guinea |
| **Gliocladium catenulatum** Gilman & Abbott (0) | | | | |
| QM *177* (NRRL *1093*) | C+ W+ | W. L. White | | |
| QM *178* (Brian *222*) | C+ W+ | | | |
| QM *372* (Brian *224*) | C+ W+ | | | |
| **Gliocladium deliquescens** Olsen-Sopp (3) | | | | |
| QM *169* (BOL *191*) | W+ | W. L. White | | India |
| **Gliocladium fimbriatum** Gilman & Abbott (1) | | | | |
| QM *560* (Pan *V51B3A*) | C+ W+ | K. B. Raper | Textile sample | Canal Zone |
| **Gliocladium glaucum** (15) | | | | |
| QM *559* (Fla *H-163*) | C− W+ | D. H. Linder | O. D. poplin | Florida USA |
| **Gliocladium lignicolum** Grove (1) | | | | |
| **Gliocladium penicilloides** Corda (9) | | | | |
| **Gliocladium roseum** Bainier (43) | | | | |
| QM *243* | C+ W+ | W. L. White | | Penna. USA |
| QM *757* (Fla *B-34*) | C+ W+ | D. H. Linder | Cloth | Florida USA |
| **Gliocladium** (the species that produces gliotoxin and viridin) (5) | | | | |
| QM *3a* | C+ W+ | W. L. White | Tent rope | Bougainville |
| QM *170* (BOL *63*) | C+ W+ | " | Tent | India |
| QM *354* (Brian *218*) | C+ W+ | " | Greenhouse soil | Jealott's Hill, England |
| QM *355* (Brian *3*) | C− W+ | " | Soil | Southern Rhodesia |
| QM *357* (Brian *208*) | C+ W+ | " | Manured soil | Jealott's Hill, England |
| QM *365* (ATCC *9645*; | C+ W+ | | | |
| BPI *T*-1) | C+ W+ | " | | Maryland, USA |
| QM *758* (JQMD *348*) | C+ W+ | " | Belt | New Guinea |
| **Gliocladium** sp. (29) | | | | |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Gliomastix convoluta** (Harz) Mason (11) | | | | |
| QM *4c* | C+ W+ | W. W. Diehl | Shoe | Bougainville |
| QM *124c* | C+ W+ | W. L. White | Cotton duck | Canal Zone |
| QM *367h* | C+ W+ | White & Downing | Cardboard | Florida USA |
| QM *452* (MIT *16*) | C+ W+ | W. L. White | Cotton webbing | Mass. USA |
| QM *759* (Fla *F-121*) | C+ W+ | " | Jungle pack | Florida USA |
| **Gloeosporium** sp. (3) | | | | |
| **Gloiosphaera globuligera** v. Höhnel (2) | | | | |
| QM *686* (Fla *H-72*) | C− W+ | D. H. Linder | Coated raincoat | Florida USA |
| **Gloiosphaera** sp. (1) | | | | |
| **Graphium rubrum** Rumbold (0) | | | | |
| QM *539* (Schneidau *1600*; ATCC *6505*) | C− W− | | | |
| **Graphium** sp. (2) | | | | |
| QM *687* (Fla *F-184*) | C+ W+ | D. H. Linder | Socks | Florida USA |
| Gymnoascaceae (1) | | | | |
| **Haplaria grisea** Link (4) | | | | |
| QM *320k* | C− W+ | W. L. White | Cardboard | Maryland |
| **Haplographium** sp. (1) | | | | |
| **Haplosporella** sp. (3) | | | | |
| QM *688* (Fla *E-105*) | C+ W+ | D. H. Linder | Food cans | Florida USA |
| **Harknessia** sp. (3) | | | | |
| QM *614* (Pan *B-68A*) | C− W− | D. H. Linder | Dead leaf | Canal Zone |
| **Helicoma** sp. (1) | | | | |
| QM *760* (JQMD *959*) | C+ W+ | | Tent | New Guinea |
| **Helicosporium lumbricoides** Saccardo (1) | | | | |
| QM *761* (Fla *B-48*) | C+ W− | D. H. Linder | Cot straps | Florida USA |
| **Helminthosporium** sp. (15) | | | | |
| QM *392* (AMP *44*) | C+ W+ | D. H. Linder | Canvas | Australia |
| QM *762* (JQMD *853*) | C+ W+ | | Tent | New Guinea |
| QM *763* (Fla *D-7*) | C+ W+ | | Cot strap | Florida USA |
| **Hemispora** sp. (0) | | | | |
| QM *322* | C− W− | | | From Conant, Duke U. |
| **Herpocladiella** sp. (1) | | | | |
| QM *689* (Fla *G-30*) | C− W− | D. H. Linder | Haversack | Florida USA |
| **Heterosporium tschawytachii** Doty (0) | | | | |
| QM *540* (*Schneidau 2600*) | C− W− | | | |
| **Heterosporium** sp. (2) | | | | |
| QM *70b* | C+ W+ | | Shoe | New Guinea |
| QM *764* (JQMD *397*) | C− W− | J. W. Groves | Trousers | New Guinea |
| **Hormiactella** sp. (4) | | | | |
| QM *765* (JQMD *854*) | C+ W− | L. G. Isfort | Tent | New Guinea |
| QM *766* (JQMD *1050*) | C+ W+ | " | Tent | New Guinea |
| **Humicola grisea** Traaen (1) | | | | |
| QM *228* | C+ W+ | E. W. Mason | Compost heap | Penna. USA |
| QM *498* | C+ W+ | " | Compost heap | Penna. USA |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Humicola** sp. (43) | | | | |
| QM *34e* | C+ W+ | W. L. White | Canteen cover | New Guinea |
| QM *71c* | C+ W+ | | Canvas glove | New Guinea |
| QM *73d* | C+ W+ | | Plastic canteen | New Guinea |
| **Hypomyces ipomoeae** (Halsted) Wollenweber (4) | | | | |
| QM *767* (Fla *F-86*) | C+ W+ | C. D. Sherbakoff | Canteen | Florida USA |
| **Isaria** sp. (2) | | | | |
| QM *4f* | C− W+ | W. L. White | Leather | Bougainville |
| **Karlingia rosea** (deBary & Woronin) Johanson (0) | | | | |
| QM *517* (Haskins *45–7*) | C+ W− | J. S. Karling | | |
| **Lasiostroma** sp. (1) | | | | |
| QM *690* (Pan *B-202B*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Lichtheimia regneri** (Lucet & Costantin) Vuillemin (1) | | | | |
| QM *45b* | C− W− | V. M. Cutter | Shoe | India |
| **Macrophoma** sp. (2) | | | | |
| QM *692* (Pan *C1A3M*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Macrophomopsis** sp. (2) | | | | |
| QM *693* (Pan *B-721AI*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Macrosporium** sp. (6) | | | | |
| QM *768* (JQMD *996*) | C+ W+ | | Tent | New Guinea |
| QM *769* (JQMD *1057*) | C+ W+ | | Tent | New Guinea |
| **Memnoniella echinata** (Rivolta) Galloway (88) | | | | |
| QM *1c* | C+ W+ | W. L. White | Tent canvas | Bougainville |
| QM *50d* | C+ W+ | " | Tent canvas | Hawaii |
| QM *72i* | C+ W+ | " | Leather scabbard | New Guinea |
| QM *82d* | C+ W+ | " | Haversack | New Guinea |
| QM *176* | C+ W+ | | Fabric | India |
| QM *770* (Fla *B-66*) | C+ W+ | D. H. Linder | Canvas legging | Florida USA |
| QM *771* (Fla *F-141*) | C+ W+ | W. L. White | Pistol belt | Florida USA |
| **Metarrhizium anisopliae** (Metschnikoff) Sorokin (0) | | | | |
| QM *192* (NRRL *1945*) | C− W+ | W. L. White | Wire worms | Oregon, USA |
| **Metarrhizium brunneum** Petch (0) | | | | |
| QM *191* (NRRL *1944*) | C− W+ | White, conf. Petch | Wire worms | Oregon, USA |
| **Microascus** sp. (2) | | | | |
| QM *859* (Pan *52B4D*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Micropera** sp. (1) | | | | |
| QM *684* (Pan *B-804AIII*) | C+ W+ | D. H. Linder | Fabric | Canal Zone |
| **Microsporum audouini** Gruby (0) | | | | |
| QM *247* (NIH 243) | C− W+ | H. Kittredge | Scalp | Washington, D.C. |
| **Microsporum canis** Bodin (0) | | | | |
| **Microsporum gypseum** (Bodin) Guiart & Grigorakis (1) | | | | |
| QM *196* | C− W+ | S. B. Salvin | Wool | Penna. USA |
| QM *245* (NIH *235*) | C− W+ | C. W. Emmons | Human face | Maryland USA |
| **Monascus purpureus** Went (0) | | | | |
| QM *541* (Schneidau *9340*; ATCC *6405*) | C− W− | | | |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Monascus** sp. (2) | | | | |
| QM *85g* | C+ W+ | | Canvas tent | Italy |
| **Monilia** sp. (16) | | | | |
| QM *772* (JQMD *394*) | C+ W− | G. W. Martin | Blanket | New Guinea |
| QM *773* (JQMD *753*) | C+ W+ | “ | Tent | New Guinea |
| Moniliales (1) | | | | |
| **Monosporium** sp. (2) | | | | |
| **Monotospora daleae** Mason (0) | | | | |
| QM *542* (Schneidau *3240*) | C+ W− | | | |
| **Monotospora lanuginosa** (Griffon & Maublanc) Mason (0) | | | | |
| QM *225* (Reese *14PS*) | C− W− | E. W. Mason | Hot compost | Penna. USA |
| QM *226* (Reese *16PS*) | C− W− | E. T. Reese | Hot compost | Penna. USA |
| QM *227* (Reese *21*) | C− W− | | Compost heap | Cal. USA |
| **Monotospora** sp. (5) | | | | |
| **Mortierella** sp. (1) | | | | |
| QM *695* (Fla *E-72*) | C− W− | D. H. Linder | Rope | Florida USA |
| Mortierellaceae (5) | | | | |
| **Mucor fumosus** Naumov (1) | | | | |
| QM *436* (MIT *3B*) | C− W− | | Gas mask | Mass. USA |
| **Mucor genevensis** Lendner (1) | | | | |
| QM *549* (Pan *C1B5FII*) | C− W+ | V. M. Cutter | Textile sample | Canal Zone |
| **Mucor heterosporus** Fischer (10) | | | | |
| QM *615* (Pan B-*213C*) | C− W− | D. H. Linder | Canvas | Canal Zone |
| **Mucor hiemalis** Wehmer (14) | | | | |
| QM *775* (Fla *D-36*) | C− W− | V. M. Cutter | Cot strap | Florida USA |
| **Mucor microsporus** Namyslowski (1) | | | | |
| QM *551* (Pan *B-C8*) | C− W− | V. M. Cutter | Twill | Canal Zone |
| **Mucor mucedo** Brefeld (1) | | | | |
| QM *550* (Pan *B-38DII*) | C− W− | V. M. Cutter | Tent | Canal Zone |
| **Mucor murorum** Naumov (1) | | | | |
| QM *776* (Fla *C-61*) | C− W+ | V. M. Cutter | Socks | Florida USA |
| **Mucor racemosus** Fresenius (4) | | | | |
| QM *79J* | C− W− | V. M. Cutter | Shoe | New Guinea |
| QM *777* (Fla *C-29*) | C− W− | D. H. Linder | Sewing string | Florida USA |
| **Mucor varians** Povah (8) | | | | |
| QM *778* (Fla *D-52*) | C− W− | V. M. Cutter | Cot fabric | Florida USA |
| QM *779* (Fla *D-164*) | C− W− | “ | String | Florida USA |
| **Mucor** sp. (11) | | | | |
| QM *155a* | C− W− | | Tent | New Georgia |
| QM *490* | C− W− | E. T. Reese | Egg | Eastern USA |
| Mucorales, undetermined (3) | | | | |
| **Myceliophthora lutea** Costantin (0) | | | | |
| QM *514* | C+ W− | E. T. Reese | Mushroom bed | Penna. USA |
| **Mycogone perniciosa** Magnus (0) | | | | |
| QM *516* | C− W− | E. T. Reese | Mushroom bed | Penna. USA |
| **Myrothecium inundatum** Tode ex Fries (0) | | | | |
| QM *206* (Preston *XV*) | C− W+ | | *Russula adusta* | England |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Myrothecium roridum** Tode ex Fries (3) | | | | |
| QM *188* | C+ W+ | W. L. White | Tomato | Mexico |
| QM *201* (Preston *1*) | C+ W+ | | *Asclepias* sp. | W. Africa |
| QM *780* (Fla *B-11*) | C+ W+ | W. L. White | Tent | Florida USA |
| **Myrothecium verrucaria** (Albertini & Schweinitz) Ditmer ex Fries (10) | | | | |
| QM *34f* | C+ W+ | W. L. White | Canteen cover | New Guinea |
| QM *70h* | C+ W+ | " | Shoe | New Guinea |
| QM *185* | C+ W+ | G. Smith | Canvas shoe | England |
| QM *460* (BPI *1334.2*) | C+ W+ | W. L. White | Cotton bale | Washington, D.C. |
| QM *781* (Fla *C-35*) | | " | String | Florida USA |
| **Myrothecium** sp.? (3) | | | | |
| QM *375* | C+ W+ | | Chestnut | Penna. USA |
| **Myxofusicoccum** sp.? (1) | | | | |
| QM *575* (Pan *B-210M*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Myxosporium** sp. (1) | | | | |
| **Myxotrichella** sp. (3) | | | | |
| QM *782* (JQMD *814*) | C+ W+ | G. W. Martin | Tent | New Guinea |
| QM *783* (JQMD *906*) | C+ W+ | " | Tent | New Guinea |
| QM *784* (JQMD *1183*) | C+ W+ | L. G. Isfort | Tent | New Guinea |
| Nectrioidaceae (1) | | | | |
| **Neosphaeropsis** sp. (1) | | | | |
| QM *616* (Pan *54C2L*) | C+ W− | D. H. Linder | Textile | Canal Zone |
| **Nigrospora sphaerica** (Saccardo) Mason (9) | | | | |
| **Nigrospora** sp. (5) | | | | |
| QM *785* (JQMD *428*) | C+ W+ | W. L. White | Sock | New Guinea |
| QM *786* (JQMD *925*) | | | Tent | New Guinea |
| **Nodulisporium** sp. (1) | | | | |
| **Oedocephalum albidum** Saccardo (1) | | | | |
| QM *92a* | C+ W+ | W. L. White | Knapsack | New Guinea |
| **Oedocephalum** sp. | | | | |
| QM *904* | | | Paper | from J. W. Sinden |
| **Oidium** sp. (3) | | | | |
| QM *696* (CZ *60*) | C− W− | | Leaf | Canal Zone |
| **Oospora lactis** (Fresenius) Saccardo (3) | | | | |
| QM *787* (JQMD *1242*) | C+ W− | W. L. White | Tarpaulin | New Guinea |
| **Oospora** sp. (3) | | | | |
| **Oothecium** sp. (1) | | | | |
| **Paecilomyces aureo-cinnamomeum** (Biourge) Thom (1) | | | | |
| QM *536* (Pan *B-C37A*) | C− W− | K. B. Raper | Air | Canal Zone |
| **Paecilomyces varioti** Bainier (52) | | | | |
| QM *10a* | C− W− | W. L. White | Canvas | New Guinea |
| QM *47d* | C− W− | " | Wax paper | India |
| QM *72e* | C− W− | | Leather scabbard | New Guinea |
| QM *108e* | C− W− | | Shoe | Florida USA |
| **Paecilomyces** sp. (5) | | | | |
| QM *286* | C− W− | W. L. White | Ink | Costa Rica |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Papularia arundinis** (Corda) Fresenius (2) | | | | |
| QM *788* (Fla *F-43*) | C+ W+ | D. H. Linder | Suspenders | Florida USA |
| QM *789* (Fla *F-182*) | C+ W+ | “ | Socks | Florida USA |
| **Papulospora** sp. (5) | | | | |
| QM *790* (JQMD *385*) | C+ W+ | G. W. Martin | Soil | Indiana USA |
| QM *791* (Fla *C-32*) | C+ W+ | | Sewing string | Florida USA |
| **Pazschkella** sp. (1) | | | | |
| QM *697* (Pan *52B6BII*) | C+ W+ | D. H. Linder | Textile | Canal Zone |
| **Pellicularia** sp. (2) | | | | |
| QM *792* (JQMD *1022*) | C+ W+ | G. W. Martin | Tent rope | Guadalcanal |
| QM *793* (JQMD *1032*) | C+ W+ | L. G. Isfort | Mattress cover | Guadalcanal |
| **Peltaster** sp.? (1) | | | | |
| QM *617* (Pan *B-766A*) | C+ W− | D. H. Linder | Textile sample | Canal Zone |
| **Penicillium africanum** Doebelt (1) | | | | |
| **Penicillium atramentosum** Thom (1) | | | | |
| **Penicillium avellaneum** Thom & Turesson (1) | | | | |
| **Penicillium baiiolum** Biourge (5) | | | | |
| **Penicillium biforme** Thom (3) | | | | |
| **Penicillium biourgeianum** Zaleski (4) | | | | |
| **Penicillium brevi-compactum** Dierckx (11) | | | | |
| **Penicillium brevi-compactum** series (6) | | | | |
| **Penicillium carmino-violaceum** Dierckx (3) | | | | |
| **Penicillium charlesii** Smith (1) | | | | |
| **Penicillium charmesinum** Biourge (10) | | | | |
| **Penicillium chrysogenum** Thom (25) | | | | |
| **Penicillium chrysogenum** series (10) | | | | |
| **Penicillium cinerascens** Biourge (9) | | | | |
| **Penicillium citreo-viride** Biourge (21) | | | | |
| **Penicillium citrinum** Thom (17) | | | | |
| **Penicillium citrinum** series (280) | | | | |
| **Penicillium commune** Thom (2) | | | | |
| **Penicillium corylophilum** Dierckx (9) | | | | |
| **Penicillium cyaneum** (Bainier & Sartory) Biourge (10) | | | | |
| **Penicillium decumbens** Thom (4) | | | | |
| **Penicillium dierckxii** Biourge (1) | | | | |
| **Penicillium digitatum** Saccardo (1) | | | | |
| **Penicillium expansum** Link (2) | | | | |
| **Penicillium fellutanum** Biourge (10) | | | | |
| **Penicillium flavi-dorsum** Biourge (9) | | | | |
| **Penicillium fluitans** Tiegs (2) | | | | |
| **Penicillium frequentans** series (15) | | | | |
| **Penicillium funiculosum** series (53) | | | | |
| **Penicillium fusco-glaucum** Biourge (2) | | | | |
| **Penicillium griseo-brunneum** Dierckx (1) | | | | |
| **Penicillium gladioli** Machacek (1) | | | | |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Penicillium hagemi** Zaleski (1) | | | | |
| **Penicillium herquei** Bainier & Sartory (4) | | | | |
| **Penicillium implicatum** Biourge var. **aureo-marginatum** Thom (5) | | | | |
| **Penicillium implicatum** series (10) | | | | |
| **Penicillium intricatum** series (1) | | | | |
| **Penicillium italicum** Wehmer (1) | | | | |
| **Penicillium islandicum** Sopp (1) | | | | |
| **Penicillium janczewskii** Zaleski (2) | | | | |
| **Penicillium janthinellum** Biourge (5) | | | | |
| **Penicillium javanicum** van Beyma (1) | | | | |
| **Penicillium jenseni** Zaleski (1) | | | | |
| **Penicillium lilacinum** Thom (15) | | | | |
| **Penicillium luteum** Zukal (6) | | | | |
| **Penicillium luteum** series (84) | | | | |
| **Penicillium majusculum** Westling (1) | | | | |
| **Penicillium melinii?** Thom (1) | | | | |
| **Penicillium multicolor** Grigorieva-Manoilova & Poradielova (5) | | | | |
| **Penicillium musae** Weidmann (1) | | | | |
| **Penicillium namyslowskii** Zaleski (1) | | | | |
| **Penicillium nigricans-janczewskii** (1) | | | | |
| **Penicillium niklewskii** Zaleski (1) | | | | |
| **Penicillium notatum** Westling (1) | | | | |
| **Penicillium oxalicum** Currie & Thom (2) | | | | |
| **Penicillium paczoskii** Zaleski (3) | | | | |
| **Penicillium siemaszki** Zaleski (1) | | | | |
| **Penicillium simplicissimum** (Oudemans) Thom (20) | | | | |
| **Penicillium soppi** Zaleski (1) | | | | |
| **Penicillium spinulosum** Thom (3) | | | | |
| **Penicillium spinulosum** series (1) | | | | |
| **Penicillium steckii** Zaleski (5) | | | | |
| **Penicillium suavolens** Biourge (3) | | | | |
| **Penicillium sulfureum** Sopp (8) | | | | |
| **Penicillium swiecickii** Zaleski (1) | | | | |
| **Penicillium tardum** Thom (8) | | | | |
| **Penicillium tardum** series (9) | | | | |
| **Penicillium umbonatum** Sopp (2) | | | | |
| **Penicillium varians** Munk-Wehmer (1) | | | | |
| **Penicillium vermiculatum** Dangeard (1) | | | | |
| **Penicillium versicolor** Wehmer (1) | | | | |
| **Penicillium vinaceum** Gilman & Abbott (1) | | | | |
| **Penicillium virido-albus** Sopp (1) | | | | |
| **Penicillium palitans** Westling (2) | | | | |
| **Penicillium paxilli** Bainier (6) | | | | |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Penicillium phaeo-janthinellum** Biourge (2) | | | | |
| **Penicillium pinophilum** Hedgecock (1) | | | | |
| **Penicillium piscarium** Westling (1) | | | | |
| **Penicillium puberulum** Bainier (1) | | | | |
| **Penicillium purpurogenum** Stoll (9) | | | | |
| **Penicillium purpurogenum** series (9) | | | | |
| **Penicillium raciborskii** Zaleski (1) | | | | |
| **Penicillium restrictum** Gilman & Abbott (1) | | | | |
| **Penicillium roqueforti** Thom (3) | | | | |
| **Penicillium roseo-cinnabarinum** Biourge (1) | | | | |
| **Penicillium roseo-purpureum** Dierckx (7) | | | | |
| **Penicillium rugulosum** Thom (7) | | | | |
| **Penicillium sanguifluus** series (1) | | | | |
| **Penicillium sanguineum** Sopp (3) | | | | |
| **Penicillium sartoryi** Thom (2) | | | | |
| **Penicillium waksmani** Zaleski (5) | | | | |
| **Penicillium westlingi** Zaleski (43) | | | | |
| **Penicillium wortmanni** Klocker (6) | | | | |
| **Penicillium** sp. (194) | | | | |
| **Periconia circinata** (Mangin) Saccardo (0) | | | | |
| QM *352* | C+ W+ | from R. W. Leukel | Roots of dwarf milo | Maryland USA |
| **Periconia pycnospora** Fresenius (1) | | | | |
| QM *794* (JQMD *1137*) | C+ W+ | J. H. Miller | Tent | New Guinea |
| **Periconia** sp. (1) | | | | |
| **Pestalotia adusta** group (1) | | | | |
| QM *558* (Pan *B-205A*) | C+ W− | D. H. Linder | Canvas | Canal Zone |
| **Pestalotia bicolor** Ellis & Everhart (1) | | | | |
| QM *664* (Pan *B-11c*) | C+ W+ | D. H. Linder | Decayed leaf | Canal Zone |
| **Pestalotia copernica** (21) | | | | |
| **Pestalotia dichaeta** Spegazzini (15) | | | | |
| QM *698* (Fla *F-176*) | C+ W+ | D. H. Linder | Bath towel | Florida USA |
| **Pestalotia palmarum** Cooke (1) | | | | |
| **Pestalotia royenae** Guba (2) | | | | |
| QM *531* (Pan *H5F1A*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Pestalotia virgatula** Klebahn (46) | | | | |
| QM *478* (Pan *57B5D*) | C+ W− | D. H. Linder | Textile sample | Canal Zone |
| QM *479* (Pan *57B5BII*) | C+ W+ | " | Textile sample | Canal Zone |
| **Pestalotia** sp. (123) | | | | |
| QM *2d* | C+ W− | W. L. White | Cotton duck | Bougainville |
| QM *119b* | C+ W− | " | Canvas | Canal Zone |
| QM *121L* | C+ W− | " | Canvas | Canal Zone |
| QM *795* (JQMD *654*) | C+ W− | G. W. Martin | Tent | New Guinea |
| QM *796* (Fla *C-72*) | C+ W+ | D. H. Linder | Cotton cord | Florida USA |
| **Phialophora compactum** (0) | | | | |
| QM *260* (NIH *8605*) | C− W− | | Human skin | Puerto Rico |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Phialophora fastigiata** (Lagerberg & Melin) Conant (0) | | | | |
| QM *265* (NIH *8705*) | C+ W− | E. Melin | Wood pulp | Sweden |
| **Phialophora jeanselmei** (Langeron) Emmons (0) | | | | |
| QM *270* (NIH *8724*) | C− W− | | Hand | New York USA |
| **Phialophora lagerbergii** (Melin & Nannfeldt) Conant (0) | | | | |
| QM *267* (NIH *8707*) | C− W− | E. Melin | Wood pulp | Sweden |
| **Phialophora lingnicola** (Nannfeldt) Goidanich (30) | | | | |
| **Phialophora melinii** (Nannfeldt apud Melin & Nannfeldt) Conant (0) | | | | |
| QM *266* (NIH *8706*) | C+ W+ | E. Melin | Wood pulp | Sweden |
| **Phialophora obscura** (Nannfeldt apud Melin & Nannfeldt) Conant (0) | | | | |
| QM *268* (NIH *8708*) | C+ W− | E. Melin | Wood pulp | Sweden |
| **Phialophora pedrosoi** (0) | | | | |
| QM *259* (NIH *8603*) . . | C− W− | | Human skin | Puerto Rico |
| QM *261* (NIH *8610*) | C− W− | | Human skin | Georgia USA |
| QM *262* (NIH *8615*) | C− W− | | Human skin | Louisiana USA |
| **Phialophora richardsiae** (Nannfeldt apud Melin & Nannfeldt) Conant (0) | | | | |
| QM *263* (NIH *8703*) | C+ W− | E. Melin | Wood pulp | Sweden |
| **Phialophora verrucosa** Medlar (0) | | | | |
| QM *264* (NIH *8704*) | C− W− | | Wood pulp | Sweden |
| QM *269* (NIH *8723*) | C− W− | | Human Skin | Missouri USA |
| **Phialophora** sp. (1) | | | | |
| QM *645* (JQMD *289*) | C+ W+ | | Tent | New Guinea |
| **Phoma pigmentivora** Massee (0) | | | | |
| QM *502* | C+ W+ | | from R. K. S. Wood | England |
| **Phoma terrestris** Hansen ? (13) | | | | |
| QM *106d* | C+ W+ | | Canvas legging | New Guinea |
| QM *120k* | C+ W+ | | Tarpaulin | Canal Zone |
| QM *797* (Fla *D-92*) | C+ W+ | | Cot fabric | Florida USA |
| **Phoma** sp. (36) | | | | |
| QM *13e* | C+ W+ | W. L. White | Canvas | New Hebrides |
| QM *798* (JQMD *655*) | W+ | G. W. Martin | Tent | New Guinea |
| QM *799* (Fla *B-30*) | C+ W+ | D. H. Linder | Cloth | Florida USA |
| Phomaceae (4) | | | | |
| QM *831* (Reuszer *234*) | C+ W+ | Reese & Downing | Cotton duck | Canal Zone |
| QM *832* (Reuszer *156*) | C+ W+ | " | Cotton duck | Canal Zone |
| QM *857* (Reuszer *281*) | C+ W+ | " | Cotton duck | Canal Zone |
| QM *896* (Romano *3*) | C+ W+ | " | Cotton duck | Florida USA |
| **Phomopsis** sp. (6) | | | | |
| QM *699* (Pan *VC2A5B*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| Phycomycete (3) | | | | |
| **Piedraia hortai** (Brumpt) Fonseca & Leao (0) | | | | |
| **Placosphaeria** sp. (3) | | | | |
| QM *700* (Pan *B-238F*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Platygloea** sp. (1) | | | | |
| QM *800* (JQMD 1223) | C− W− | G. W. Martin | Tent | New Guinea |
| **Pleurophoma** sp. (4) | | | | |
| QM *701* (Pan *5A7B*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Pleurophomella** sp. (1) | | | | |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Polyporus sulfureus** (Bulliard) Fries (0) | | | | |
| QM *509* (Fergus *24681-S*) | | | | |
| **Pseudocoprinus** sp. (5) | | | | |
| QM *801* (JQMD *1060*) | C+ W+ | L. G. Isfort | Tent | New Guinea |
| QM *897* (JQMD *1143*) | C+ W+ | J. V. Harvey | Tent | New Guinea |
| **Pullularia pullulans** (deBary) Berkhout (140) | | | | |
| QM *72c* | C− W+ | W. L. White | Leather scabbard | New Guinea |
| QM *122b* | C− W− | " | Cotton duck | Canal Zone |
| QM *279c* | C− W− | " | Painted wood | Costa Rica |
| QM *338* (Reese *110*) | C− W− | " | Rutin | New Jersey USA |
| QM *802* (JQMD *364*) | C− W− | G. W. Martin | Belt | New Guinea |
| QM *803* (Fla *B-37*) | C− W− | W. L. White | Cloth | Florida USA |
| **Pycnis** sp. (3) | | | | |
| QM *618* (Pan *B-209X*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Pycnodothis** sp. (1) | | | | |
| QM *702* (Pan *52A6CII*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Pycnosporium** sp. (3) | | | | |
| QM *703* (Pan *B-222D*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Pyrenochaeta** sp. (9) | | | | |
| QM *29b* | C+ W+ | W. L. White | Tarpaulin | Hawaii |
| QM *804* (JQMD *831*) | C+ W+ | G. W. Martin | Tent | New Guinea |
| QM *805* (JQMD *1146*) | | L. G. Isfort | Tent | New Guinea |
| QM *830* (Reuszer *200*) | C+ W+ | Reese & Downing | Cotton duck | Canal Zone |
| **Rhinotrichum** sp. (2) | | | | |
| QM *806* (JQMD *395*) | C+ W+ | G. W. Martin | Blanket | New Guinea |
| QM *807* (JQMD *1208*) | C+ W+ | L. G. Isfort | Head band | New Guinea |
| **Rhizopus arrhizus** Fischer (17) | | | | |
| QM *46c* | C− W+ | V. M. Cutter | Tent rope | India |
| QM *187a* | C− W+ | " | Rice | Utah USA |
| QM *808* (JQMD *538*) | C− W+ | | Shoe | New Guinea |
| QM *809* (JQMD *932*) | C− W+ | V. M. Cutter | Tent rope | Guadalcanal |
| QM *839* (JQMD *208*) | C− W+ | " | Tarpaulin | New Guinea |
| QM *500* (42 Chem. *8*) | C− W− | " | Jungle hammock | New Guinea |
| **Rhizopus nigricans** Ehrenberg (10) | | | | |
| QM *387* (AMP *32*) | C− W+ | D. H. Linder | Wireless set | New Guinea |
| QM *810* (Fla *C-30*) | C− W+ | " | Sewing string | Florida USA |
| QM *860* (Fla *C-15*) | C− W+ | " | Shower curtain | Florida USA |
| **Rhizopus oryzae** Went & Geerlings (4) | | | | |
| QM *811* (JQMD *464*) | C− W+ | V. M. Cutter | Sock | New Guinea |
| **Rhizopus** sp. (2) | | | | |
| QM *231* | C− W− | W. L. White | Wool | Penna. USA |
| **Rhodoseptoria** sp. ? (1) | | | | |
| QM *704* (Pan *B-216A*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Robillarda** sp. ? (1) | | | | |
| QM *576* (Pan *B-206A*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Schizophyllum** sp. (1) | | | | |
| QM *812* (JQMD *1181*) | C− W+ | J. V. Harvey | Tent | New Guinea |
| **Sclerotinia fructicola** (Winter) Rehm (0) | | | | |
| QM *282* (Vrg. *38*) | C− W− | | Sweet cherry | New York USA |
| **Sclerotinia sclerotiorum** (Libert) Massee (0) | | | | |
| QM *505* | C− W− | | from Dr. Shade | |
| **Sclerotium** sp. (3) | | | | |
| QM *93a* | C+ W+ | | Tarpaulin | New Guinea |
| QM *103e* | C+ W+ | | Canvas tent | New Guinea |
| **Scopulariopsis brevicaulis** (Saccardo) Bainier (17) | | | | |
| QM *609* (Pan *BC-3*) | C+ W+ | K. B. Raper | Binocular reticule | Canal Zone |
| QM *813* (Fla *C-28*) | C+ W+ | D. H. Linder | Sewing string | Florida USA |
| QM *814* (Fla *C-35*) | C+ W+ | K. B. Raper | Sewing string | Florida USA |
| QM *815* (Fla *F-90*) | C+ W+ | “ | Cigarette | Florida USA |
| **Scopulariopsis repens** Bainier (3) | | | | |
| QM *399* (AMP *69*) | C+ W+ | D. H. Linder | Canvas | Australia |
| **Sepedonium** sp. (4) | | | | |
| QM *816* (JQMD *645*) | C− W+ | G. W. Martin | Case liner | Georgia USA |
| QM *817* (JQMD *908*) | C+ W− | L. G. Isfort | Tent | New Guinea |
| **Septocylindrium** sp. (1) | | | | |
| QM *667* (Pan *B-654A*) | C− W− | D. H. Linder | Textile sample | Canal Zone |
| **Septomyxa affinis** (Sherbakoff) Wollenweber (2) | | | | |
| QM *40b* | C+ W+ | C. D. Sherbakoff | Canvas tent | India |
| **Septonema** sp. (1) | | | | |
| QM *818* (Fla *F-41*) | C+ W+ | D. H. Linder | Suspenders | Florida USA |
| **Septoria** sp. (2) | | | | |
| QM *705* (Pan *52B41*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Sordaria fimicola** (Rabenhorst) Cesati & deNotaris (1) | | | | |
| QM *707* (Pan *4CA10A*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Sordaria humana** (Fuckel) Winter (4) | | | | |
| QM *819* (JQMD *144*) | C+ W+ | J. H. Miller | Textile sample | Columbia |
| QM *820* (JQMD *1185*) | C+ W+ | J. V. Harvey | Tent | New Guinea |
| **Sordaria macrospora** Auerswald (1) | | | | |
| QM *821* (JQMD *1127*) | W+ | J. H. Miller | Tent | New Guinea |
| **Spegazzinia tessarthra** (Berkeley & Curtis) Saccardo (7) | | | | |
| QM *371e* | C+ W+ | W. L. White | Cardboard | Florida USA |
| QM *373c* | C+ W+ | “ | Cardboard | Florida USA |
| QM *840* (JQMD *657*) | C+ W+ | “ | Tent | New Guinea |
| QM *841* (JQMD *935*) | C+ W+ | “ | Tent | New Guinea |
| Sphaeropsidales (non-sporulating) (38) | | | | |
| **Sphaeropsis** sp. (3) | | | | |
| QM *46h* | C− W− | W. L. White | Tent rope | India |
| QM *47a* | C− W− | “ | Wax paper | India |
| QM *104g* | C− W− | | Rubber boot | New Guinea |
| **Spicaria** sp. (3) | | | | |
| QM *822* (JQMD *511*) | C− W− | G. W. Martin | Shoe | New Guinea |
| QM *823* (JQMD *957*) | C− W− | “ | Shoe leather | Guadalcanal |
| QM *824* (JQMD *1036*) | C− W− | L. G. Isfort | Canvas cover | Guadalcanal |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Sporochisma** sp. ? (2) | | | | |
| QM *708* (Fla *E-97*) | C+ W− | D. H. Linder | Food cans | Florida USA |
| **Sporocybe** sp. ? (1) | | | | |
| **Sporotrichum pruinosum** Gilman & Abbott (7) | | | | |
| QM *168* (*UP-215*) | C+ W− | W. L. White | Photogr. film | |
| QM *244* | C+ W− | “ | Burlap | Penna. USA |
| QM *303* | C+ W− | “ | Burlap | Penna. USA |
| QM *591* (JQMD *490*) | C+ W− | “ | Raincoat | New Guinea |
| QM *593* (JQMD *545*) | C+ W− | “ | Shoe | New Guinea |
| QM *825* (JQMD *432*) | C+ W− | “ | Blanket | New Guinea |
| QM *826* (JQMD *1214*) | C+ W− | “ | Hand band | New Guinea |
| **Sporotrichum schenckii** Hektoen & Perkins (0) | | | | |
| QM *257* (NIH *7109*) | C− W− | | Human leg | Guatemala |
| QM *258* (NIH *7021*) | C− W− | | Human arm | S. Africa |
| **Sporotrichum** sp. (30) | | | | |
| QM *89a* | C+ W− | | Canvas legging | New Guinea |
| **Stachybotrys atra** Corda (20) | | | | |
| QM *94d* | C+ W+ | W. L. White | Trousers | New Guinea |
| QM *102a* | C+ W+ | “ | Leather band | New Guinea |
| QM *134b* | C+ W+ | “ | Haversack | New Georgia |
| QM *341* (F. Meehan *637*) | C+ W+ | Meehan, conf. White | Pepper seed | Iowa USA |
| QM *395* (AMP *65*) | C+ W+ | | Haversack | New Guinea |
| QM *827* (Fla *B-10*) | C+ W+ | W. L. White | Tent | Florida USA |
| **Stachybotrys** sp. (7) | | | | |
| QM *369a* | C+ W+ | | Cardboard | New Guinea |
| QM *371b* | C+ W+ | | Cardboard | Florida USA |
| QM *900* (Fla *C-10*) | C+ W+ | | Shower curtain | Florida USA |
| **Stemphylium botryosum** Wallroth (0) | | | | |
| QM *544* (Schneidau *6770*) | C+ W+ | | Air contaminant | Louisiana USA |
| **Stemphylium consortiale** (v. Thümen) Groves & Skolko (5) | | | | |
| QM *41b* | C− W+ | W. L. White | Tent rope | India |
| QM *147c* | C+ W+ | J. W. Groves | Tent | New Georgia |
| **Stemphylium sarcinaeforme** (Cavara) Wiltshire (0) | | | | |
| QM *283* | C+ W− | | Red clover | New York USA |
| **Stemphylium** sp. (10) | | | | |
| QM *78b* | C+ W+ | | Canvas tent | New Guinea |
| QM *367a* | C+ W+ | White & Downing | Cardboard | Florida USA |
| **Stereum** sp. ? (1) | | | | |
| **Stilbum** sp. (1) | | | | |
| QM *833* (JQMD *1085*) | C+ W+ | L. G. Isfort | Wool | Indiana USA |
| **Stysanus** sp. (1) | | | | |
| QM *834* (JQMD *187*) | C+ W+ | | Soil | Indiana USA |
| QM *905* | C+ W+ | | Paper | From J. W. Sinden |
| **Syncephalastrum elegans** Marchal (3) | | | | |
| QM *709* (Fla *G-13*) | C− W− | D. H. Linder | Suspenders | Florida USA |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Syncephalastrum nigricans** Vuillemin (3) | | | | |
| QM *835* (Fla *F-92*) | C− W− | D. H. Linder | Matches | Florida USA |
| **Syncephalastrum racemosum** (Cohn) Schroeter (18) | | | | |
| QM *57a* | C− W− | V. M. Cutter | Leatherette | New Guinea |
| QM *82b* | C− W− | " | Haversack | New Guinea |
| QM *836* (Fla *B-23*) | C− W− | D. H. Linder | Canteen cover | Florida USA |
| **Syncephalastrum** sp. (12) | | | | |
| QM *837* (JQMD *349*) | C− W− | | Belt | New Guinea |
| **Syncephalis** sp. (1) | | | | |
| QM *838* (JQMD *933*) | C− W+ | V. M. Cutter | Tarpaulin | New Guinea |
| **Synsporium** sp. (1) | | | | |
| **Thamnidium elegans** Link (0) | | | | |
| QM *545* (Schneidau *8140*; ATCC *8997*) | C− W− | | | |
| **Thamnidium piriforme** (Bainier) Migula (0) | | | | |
| QM *546* (Schneidau *8148*; ATCC *8992*) | C− W− | | | |
| **Thielavia sepedonium** Emmons (10) | | | | |
| QM *46a* | C+ W+ | C. W. Emmons | Tent | India |
| QM *47g* | C+ W+ | " | Wax paper | India |
| QM *842* (JQMD *963*) | C+ W+ | | Tent | New Guinea |
| **Thielavia terricola** (Gilman & Abbott) Emmons (6) | | | | |
| QM *214* (Emmons *5100*; ATCC *1722*) | C+ W+ | | Soil | Iowa USA |
| QM *843* (JQMD *1170*) | C+ W+ | C. W. Emmons | Tent | New Guinea |
| **Thielaviopsis basicola** (Berkeley & Broome) Ferraris (0) | | | | |
| QM *547* (Schneidau *8500*; ATCC *9853*) | C− W− | | | New Zealand |
| **Tilachlidium** sp. (1) | | | | |
| QM *619* (Pan *B-218EIII*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Tolypomyria prasina** Preuss (1) | | | | |
| **Torula** sp. (6) | | | | |
| QM *216* (BOL *D-45*) | C− W− | | Jute canvas | India |
| QM *217* (BOL *D-150*) | W+ | | Webbing tape | |
| **Torulina** sp. (46) | | | | |
| QM *710* (Fla *D-51*) | C+ W+ | D. H. Linder | Cot straps | Florida USA |
| **Traversoa** sp. (1) | | | | |
| **Treleasiella** sp. (1) | | | | |
| QM *711* (Pan *B-816AII*) | C+ W+ | D. H. Linder | Textile sample | Canal Zone |
| **Trichoderma viride** Harz (363) | | | | |
| QM *6a* | C+ W+ | W. L. White | Shelter half | Bougainville |
| QM *18a* | C+ W+ | " | Tentage | New Hebrides |
| QM *33a* | C+ W+ | " | Pistol belt | New Guinea |
| QM *46d* | C+ W+ | " | Tent rope | India |
| QM *63d* | W+ | " | Cotton rope | New Guinea |
| QM *844* (Fla *C-55*) | C+ | D. H. Linder | Socks | Florida USA |
| **Trichoderma viride** Harz var. **Koningii** Oudemans (10) | | | | |
| **Trichoderma** sp. (32) | | | | |
| QM *219* (BOL *D-166*) | C+ W+ | | Parachute | |

FUNGI (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| **Trichophyton mentagrophytes** (Robin) Blanchard (0) | | | | |
| QM *248* (NIH *640*) | C− W+ | | Human foot | Georgia USA |
| QM *252* (NIH *666*) | C− W+ | | Dog | Kansas USA |
| **Trichophyton rubrum** (Castellani) Sabouraud (0) | | | | |
| **Trichophyton sulfureum** Sabouraud (0) | | | | |
| QM *249* (NIH *651*) | C− W+ | | Human scalp | Mexico |
| **Trichophyton tonsurans** Malmsten (0) | | | | |
| QM *251* (NIH *662*) | C− W+ | C. W. Emmons | Human scalp | Guatemala |
| **Trichosporium** sp. (3) | | | | |
| QM *846* (JQMD *836*) | W+ | L. G. Isfort | Tent | New Guinea |
| QM *847* (JQMD *1023*) | C+ W+ | " | Tent rope | Guadalcanal |
| **Trichothecium roseum** Link (3) | | | | |
| QM *102e* | C− W+ | | Leather liner | New Guinea |
| **Tritirachium dependens** Limber (1) | | | | |
| QM *4g-2* | C− W− | W. L. White | Leather shoes | Bougainville |
| **Tritirachium roseum** van Beyma (4) | | | | |
| QM *164* | C− W− | | Veg. ivory button | Tropics |
| QM *285a* | C− W− | W. L. White | Kapok pad | Penna. USA |
| QM *494* | C− W− | Reese & Downing | Cotton & nylon | Ohio USA |
| **Tritirachium** sp. (5) | | | | |
| **Tryblidopycnis** sp. (1) | | | | |
| **Tubercularia** sp. (5) | | | | |
| QM *848* (JQMD *198*) | C+ W− | G. W. Martin | Tent | New Guinea |
| **Vermicularia** section (2) | | | | |
| QM *712* (Pan *B-607D*) | C+ W+ | D. H. Linder | Canvas | Canal Zone |
| **Verticicladium** sp. (2) | | | | |
| **Verticillium dahliae** Klebahn (0) | | | | |
| **Verticillium malthousei** Ware (0) | | | | |
| QM *515* | C− W+ | E. T. Reese | Mushroom | Penna. USA |
| **Verticillium niveostratosum** Lindau (1) | | | | |
| **Verticillium** sp. (26) | | | | |
| QM *849* (JQMD *310*) | C− W− | | Belt | New Guinea |
| QM *851* (Fla *B-59*) | C+ W+ | W. C. Snyder | Tent | Florida USA |
| QM *852* (Fla *C-7*) | C+ W+ | " | Web belt | Florida USA |
| **Volutella** sp. (1) | | | | |
| **Wardomyces anomala** Brooks & Hansford (0) | | | | |
| QM *903* (Illman-*V-135*) | C− W− | | | |
| **Xenosporium** sp. (2) | | | | |
| **Zygodesmus** sp. (3) | | | | |
| QM *853* (JQMD *865*) | C+ W+ | | Tent | New Guinea |
| QM *854* (JQMD *1114*) | C+ W+ | | Tent | New Guinea |
| QM *855* (JQMD) *1174*) | C+ W+ | | Tent | New Guinea |
| **Zygorrhynchus moelleri** Vuillemin (1) | | | | |
| QM *856* (Fla *A-29*) | C− W− | | Soil sample | Florida USA |
| Mycelia sterila (523) | | | | |
| Undetermined (163) | | | | |

## BACTERIA, ACTINOMYCETES AND YEASTS

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| *Acetobacter suboxydans* Kluyver and deLeeuw. (0) | | | | |
| QM *B1473* Army Medical School *621* | | | | |
| *Actinomyces albus* Krainsky (0) | | | | |
| QM *B1478* Bur. Nutr. & Home Ec., *502* | W+ | S. Waksman | | |
| *Actinomycete*, unidentified (53) | | | | |
| QM *B76* | C– | H. W. Reuszer | Dyed duck | Canal Zone |
| QM *B157* | C+ | " | Dyed duck | Canal Zone |
| QM *B642* | C– | " | Blanket | New Guinea |
| QM *B668* | C– | " | Raincoat | New Guinea |
| QM *B681* | C– | " | Socks | New Guinea |
| QM *B814* | C+ | E. T. Reese | Tarpaulin | New Guinea |
| QM *B937* | C– | H. W. Reuszer | Haversack | New Guinea |
| QM *B957* | C– | " | Cotton rope | New Guinea |
| QM *B1058* | C– | " | Shoe | New Guinea |
| QM *B1086* | C+ | " | Shoe | New Guinea |
| QM *B1359* | C+ | " | Cot, canvas | Florida USA |
| QM *B1477* | W+ | H. S. Levinson | Wool, buried | Penna. USA |
| QM *B1479* | | M. H. Downing | Wool, buried | Penna. USA |
| *Aerobacillus* (*schuylkilliensis*) Eisenberg (0) | | | | |
| QM *B1461* J. T. Baker Chemical Co. *B-20* | | G. M. Eisenberg | | |
| *Aerobacter aerogenes* (Kruse) Beijerinck (0) | | | | |
| QM *B1463* (NRRL *B562*) | | | | |
| *Alcaligenes bookeri* (Ford) Bergey et al (0) | | | | |
| QM *B1484* ATCC *9128* | W– | | | |
| *Alcaligenes faecalis* Castellani and Chalmers (0) | | | | |
| QM *B1483* ATCC *8749* | W– | | | |
| *Bacillus alvei* Cheshire and Cheyne (3) | | | | |
| QM *B1006* | C– | N. R. Smith | Trousers | New Guinea |
| QM *B1087* | | " | Tent flap | New Guinea |
| QM *B1105* | C– | " | Shoe | New Guinea |
| *Bacillus amylolyticus* Kellerman and McBeth (0) | | | | |
| QM *B529* N. R. Smith *120* | C– | | | |
| *Bacillus brevis* (Flügge) Migula emend. Ford (13) | | | | |
| QM *B470* | W+ | N. R. Smith | Treated canvas | Canal Zone |
| QM *B842* | C– W– | " | Tentage | New Guinea |
| QM *B1080* | C– | " | Shoe | New Guinea |
| QM *B1334* | | " | Elastic covering | Florida USA |
| *Bacillus cereus* Frankland and Frankland (112) | | | | |
| QM *B28* | W– | N. R. Smith | Tent | Canal Zone |
| QM *B42A* | W+ | " | Canvas | Canal Zone |
| QM *B387* | W+ | " | Decayed wood | Canal Zone |
| QM *B476* | C– W+ | " | Tent | Canal Zone |
| QM *B826* | C– W+ | " | Shoe | India |
| QM *B927* | W– | " | Shoe | New Guinea |
| QM *B1079* | | " | Shoe | New Guinea |
| QM *B1286* | | " | Socks | Florida USA |

BACTERIA, ACTINOMYCETES AND YEASTS (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| *Bacillus cereus* var. *mycoides* Flügge (57) | | | | |
| QM *B479* | W+ | N. R. Smith | Soil | Colombia |
| QM *B610* | C− W− | " | Tarpaulin | New Guinea |
| QM *B743* | C− W+ | " | Tent | New Hebrides |
| QM *B825* | C− W− | " | Shoe | India |
| QM *B898* | C− W+ | " | Scabbard | New Guinea |
| QM *B964* | W+ | " | Knapsack | New Guinea |
| QM *B1081* | | N. R. Smith | Shoe | New Guinea |
| QM *B1405* | | " | | Canal Zone |
| *Bacillus circulans* Jordan, emend. Ford (11) | | | | |
| QM *B353* | C− | N. R. Smith | Canvas | Canal Zone |
| QM *B629* | C− | " | Belt | New Guinea |
| QM *B857* | C− W+ | " | Kit, Canvas | New Guinea |
| QM *B1292* | | " | Socks | Florida USA |
| QM *B1335* | | " | Elastic cover | Florida USA |
| QM *B1376* | | " | Cotton bag | Florida USA |
| QM *B1470* VD Research Laboratory *M-14* | | C. McLeod | Produces antibiotic | |
| *Bacillus firmus* Werner (13) | | | | |
| QM *B172* | C− W− | N. R. Smith | Canvas | Canal Zone |
| QM *B647* | C− | " | Trousers | New Guinea |
| QM *B666* | W+ | " | Raincoat | New Guinea |
| QM *B719* | C− | " | Shoe | Guadalcanal |
| QM *B824* | W− | " | Rope | India |
| QM *B1124* | | " | Tarpaulin | New Guinea |
| *Bacillus firmus-circulans intermediates* (5) | | | | |
| QM *B787* | W− | N. R. Smith | Tentage | Hawaii |
| QM *B988* | C− W− | " | Tentage | New Guinea |
| *Bacillus megatherium deBary* (188) | | | | |
| QM *B603* | W− | N. R. Smith | Tent | New Guinea |
| QM *B705* | W+ | " | Tent | New Guinea |
| QM *B773* | W+ | " | Rope | Russell Is. |
| QM *B793* | W+ | " | Canvas bag | New Guinea |
| QM *B844* | C− W+ | " | Leather | New Guinea |
| QM *B975* | W− | " | Trousers | New Guinea |
| QM *B980* | W+ | " | Helmet liner | New Guinea |
| QM *B1193* | | " | Rope | Florida USA |
| QM *B1227* | | " | Precoated can | Florida USA |
| QM *B1276* | | " | Shelter half | Florida USA |
| *Bacillus polymyxa* (Prazmowski) Migula (4) | | | | |
| QM *B768* | C− | N. R. Smith | Tarpaulin | New Hebrides |
| QM *B995* | C− | " | Rubber boot | New Guinea |
| QM *B1100* | C− | " | Khaki shirt | New Guinea |
| *Bacillus pumilus* Gottheil (66) | | | | |
| QM *B21* | W− | N. R. Smith | Tentage | Canal Zone |
| QM *B170* | W+ | " | Canvas | Canal Zone |
| QM *B746* | W+ | " | Tent | New Hebrides |
| QM *B803* | W+ | " | Pistol belt | New Guinea |
| QM *B846* | W+ | " | Leather | New Guinea |
| QM *B910* | W+ | " | Cover, cellulose | New Guinea |

BACTERIA, ACTINOMYCETES AND YEASTS (*continued*)

| *Organism* | *Activity* | | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|---|
| QM *B1309* | | | " | Canvas bag | Florida USA |
| QM *B1383* | | | " | Cotton socks | Florida USA |
| *Bacillus sphaericus* Neide (7) | | | | | |
| QM *B41* | | | N. R. Smith | Canvas | Canal Zone |
| QM *B891* | C– | W– | " | Shoe | New Guinea |
| QM *B1118* | C– | | " | Tarpaulin | New Guinea |
| QM *B1152* | C– | | " | Suspender straps | New Guinea |
| *Bacillus sphaericus* var. *fusiformis* Gottheil (17) | | | | | |
| QM *B784* | C– | W– | N. R. Smith | Shoe | Hawaii |
| QM *B811* | | W– | " | Legging | New Guinea |
| QM *B873* | | W– | " | Web strap | New Guinea |
| QM *B896* | | | " | Glove, canvas | New Guinea |
| QM *B1082* | | | " | Shoe | New Guinea |
| *Bacillus subtilis* Cohn, emend. Prazmowski (55) | | | | | |
| QM *B639* | | W+ | N. R. Smith | Socks | New Guinea |
| QM *B655* | | W– | " | Socks | New Guinea |
| QM *B742* | C– | W+ | " | Canvas roll | New Guinea |
| QM *B778* | | W+ | " | Grey netting | Russell Is. |
| QM *B835* | | W+ | " | Tent lines | Hawaii |
| QM *B845* | C– | W– | " | Leather | New Guinea |
| QM *B922* | | W+ | N. R. Smith | Tent | New Guinea |
| QM *B942* | C– | W+ | " | Shoe | New Guinea |
| QM *B952* | | W+ | " | Tentage | New Guinea |
| QM *B1228* | | | " | Precoated can | Florida USA |
| QM *B1230* | | | " | Lacquered can | Florida USA |
| *Bacteria* unidentified (435; for the most part gram-negative to gram-variable rods) | | | | | |
| QM *B54* | C+ | | | Tentage | Canal Zone |
| QM *B123* | C+ | | | Cotton duck | Canal Zone |
| QM *B142* | C+ | | | Cotton duck | Canal Zone |
| QM *B230* | C+ | | | Cotton duck | Canal Zone |
| QM *B240* | | | | Cotton duck | Canal Zone |
| QM *B275* | C+ | | | Cotton duck | Canal Zone |
| QM *B283* | C+ | | | Cotton duck | Canal Zone |
| QM *B318* | C+ | | | Cotton duck | Canal Zone |
| QM *B319* | C+ | | | Cotton duck | Canal Zone |
| QM *B1469* | | | | Liquefies cellosize (Hydroxyethyl cellulose) | Penna. USA |
| QM *B1471* | | | | Rhotex-QS L-200 (Rohm & Haas) | Penna. USA |
| *Cellulomonas biazotea* (Kellerman) Bergey et al. (0) | | | | | |
| QM *B525* N. R. Smith *127* C+ | | | | | |
| *Cellulomonas cellasea* (Kellerman and McBeth) Bergey et al. (0) | | | | | |
| QM *B526* N. R. Smith *124* | | | | | |
| *Cellulomonas fimi* McBeth and Scales (0) | | | | | |
| QM *B527* N. R. Smith *133* C+ | | | | | |
| *Cellulomonas flavigena* (Kellerman and McBeth) Bergey et al. (0) | | | | | |
| QM *B528* N. R. Smith *134* C+ | | | | | |
| *Cellvibrio fulvus* Stapp and Bortels (2) | | | | | |
| QM *B18* | C+ | | W. C. Haynes | Soil | Canal Zone |
| QM *B102* | C+ | | " | Cotton duck | Canal Zone |

BACTERIA, ACTINOMYCETES AND YEASTS (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| *Cellvibrio vulgaris* Stapp and Bortels (11) | | | | |
| QM *B1* | C+ | W. C. Haynes | Duck, in soil | Canal Zone |
| QM *B2* | C+ | " | Duck, in soil | Canal Zone |
| QM *B4* | C+ | " | Duck, in soil | Canal Zone |
| QM *B6* | C+ | " | Muslin | Canal Zone |
| QM *B8* | C+ | " | Soil | Canal Zone |
| QM *B9* | C+ | " | Soil | Canal Zone |
| QM *B12* | C+ | " | Soil | Canal Zone |
| *Cellvibrio* sp. (3) | | | | |
| QM *B89* | | H. W. Reuszer | Tarpaulin | Canal Zone |
| QM *B93* | | " | Tarpaulin | Canal Zone |
| *Corynebacterium* sp. (12) | | | | |
| QM *B487* | C+ | H. W. Reuszer | Sling, rifle | New Guinea |
| QM *B493* | C+ | " | Tentage | New Hebrides |
| QM *B503* | C+ | " | Leggings | New Guinea |
| QM *B509* | C+ | " | Haversack | New Guinea |
| QM *B514* | C+ | " | Tent | New Guinea |
| QM *B521* | | " | Tent rope | New Guinea |
| *Escherichia coli* (Migula) Castellani and Chalmers (0) | | | | |
| QM *B1457* | | | Strain for reduction of dihydroascorbic acid. | |
| QM *B1465* J. T. Baker *B-44*(ATCC *9673*) | | | | |
| *Lactobacillus arabinosus* Fred, Peterson and Anderson (0) | | | | |
| QM *B1475* Army Medical School *31-0-1* | | | | |
| *Lactobacillus casei* (Orla-Jensen) Holland (0) | | | | |
| QM *B1474* Army Medical School *31-E-1* | | | | |
| *Lactobacillus fermenti* Beijerinck (0) | | | | |
| QM *B1476* Army Medical School *31-1L-1* | | | | |
| *Micrococcus pyogenes* var. *aureus* (Rosenbach) Zopf (0) | | | | |
| QM *B1458* | | G. F. Reddish | FDA strain for phenol coefficient test. | Penna. USA |
| *Micrococcus* sp. (23) | | | | |
| QM *B30* | | | Tentage | Canal Zone |
| QM *B296* | C− | | Cotton duck | Canal Zone |
| QM *B398* | C− | | Lens | Canal Zone |
| QM *B454* | | | Cotton duck | Canal Zone |
| QM *B821* | C− | | Tenting | India |
| *Proteus vulgaris* Hauser (0) | | | | |
| QM *B1464* J. T. Baker *B-31* (ATCC *7246*) W− | | | | |
| *Pseudomonas aeruginosa* (Schroeter) Migula (0) | | | | |
| QM *B1468* | W− | H. S. Levinson | Contaminant on agar plate. | |
| QM *B1485* | | P. Kopper | Creatinine decomposer; no pyocyanin produced. | |
| *Pseudomonas elongata* Humm (0) | | | | |
| QM *B1472* | | H. Humm | Agar liquefier. Marine source | |
| *Pseudomonas* sp. (1) | | | | |
| QM *B1482* | W+ | H. S. Levinson | Wool | Penna. USA |

BACTERIA, ACTINOMYCETES AND YEASTS (*continued*)

| *Organism* | *Activity* | *Identified By* | *Substrate* | *Locality* |
|---|---|---|---|---|
| *Rhodotorula bronchialis* (Ciferri and Redaelli) Lodder (0) | | | | |
| QM *B1480* | | T. Sproston | Air contaminant | Vermont USA |
| *Saccharomyces lactis* (0) | | | | |
| QM *B1450* | | | Bakers' yeast | Bavaria |
| QM *B1452* | | | Bakers' yeast | Bavaria |
| QM *B1454* | | | Bakers' yeast | Bavaria |
| *Salmonella paratyphi* (Kayser) Castellani and Chalmers (0) | | | | |
| QM *B1459* (ATCC *9150*) | | P. C. Norman | Carrier strain | Illinois USA |
| *Salmonella typhosa* (Zopf) White (0) | | | | |
| QM *B1460* | | | FDA strain for phenol coefficient test. | Penna. USA |
| *Serratia marcescens* Bizio (0) | | | | |
| QM *B1455* | | | From M. Landy, Wyeth Drug Co. | Phila. USA |
| QM *B1466* (ATCC 990) | | | | |
| *Sporocytophaga myxococcoides* (Krzemieniewska) Stanier (23) | | | | |
| QM *B482* USDA, Gray's strain | C+ | | | |
| QM *B490* | C+ | | Trousers | New Guinea |
| QM *B492* | | H. W. Reuszer | Shoe | New Guinea |
| QM *B497* | C+ | " | Tenting | Italy |
| QM *B506* | C+ | " | Canteen cover | New Guinea |
| QM *B511* | | " | Trousers | New Guinea |
| QM *B517* | C+ | " | Suspender straps | New Guinea |
| *Sporobolomyces salmonicolor* (0) | | | | |
| QM *B1488* ATCC *623* | | | | |
| *Streptococcus lactis* (Lister) Löhnis (0) | | | | |
| QM *B1467* J. T. Baker *B-78* (NRRL *B446*) | | | | |
| *Torula sphaerica* (0) | | | | |
| QM *B1489* ATCC *2504* | | | | |
| *Torula utilis* (0) | | | | |
| QM *B1487* ATCC *8206* | | | | |
| *Trichosporon asteroides* (0) | | | | |
| QM *B1486* ATCC *4155* | | | | |

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# CLASSIFICATION OF YEASTS FROM THE FERMENTATION OF COMMERCIALLY BRINED CUCUMBERS [1,2]

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During the fermentation of cucumbers in salt brines, a part of the microbiological activity is due to yeasts. Their portion of the fermentation proper is considered gaseous in nature and covers a wide range with respect to brine concentration, the maximum salt tolerance observed under commercial conditions being upwards of 20 to 22 percent by weight. Since a vigorous gaseous fermentation by yeasts in cucumber brines is associated with the production of "bloaters" or hollow cucumber stock, their behavior is of economic importance to the industry. Previous work on the subject has dealt chiefly with population studies. Specifically, these reports have been concerned with the influence of brine concentration (Etchells, 1941; Etchells and Jones, 1943); the addition of organic acids (Jones, *et al*, 1940); the addition of sugar (Veldhuis, *et al*, 1941); and more recently in connection with the amount of fermentation gas evolved and its composition (Etchells, Fabian, and Jones, 1945).

While the above work established that yeasts were associated with cucumber fermentations under conditions typical of the industry, it gave no information as to the species that might be growing in the brines. The present investigation was undertaken with a two-fold purpose; (1) to obtain more specific information on the principal types of yeasts occurring during the gaseous fermentation of salt-stock cucumbers, and (2) to determine whether a definite sequence of yeast types occurred during the period of general yeast activity. Basic information of this nature is of prime importance since only through such studies can suitable brining procedures or control measures be properly developed, with the ultimate objective of placing the cucumber pickling industry in the group of controlled fermentation industries.

Studies of the chiefly oxidative *surface* yeasts, associated with luxuriant scum formation, constitute the bulk of the information known concerning the yeast types present in connection with brined, salted, and pickled vegetables. The latter types are commonly present on the surface of brines exposed to air but sheltered from direct sunlight. At the outset in the present work a clear-cut distinction should be made between the film-forming yeasts and the fermentative *subsurface* yeasts in commercial cucumber brines which are responsible for the gaseous fermentation.

[1] Agricultural Chemical Research Division Contribution No. 236.

[2] This study was carried out under a cooperative project with the Department of Horticulture of the North Carolina Agricultural Experiment Station.

It has been pointed out (Etchells and Jones, 1946; Etchells, Jones, and Lewis, 1947) that conditions permitting active growth of film-yeasts, such as afforded by open containers sheltered from direct sunlight, are not generally favorable for obtaining the best information as to the predominating subsurface yeast flora contributing to the gaseous fermentation. In the present study, 40 of the 42 commercial fermentations in large vats were under outside conditions. Hence, growth of surface scum was controlled by direct sunlight. In the case of the two sheltered vats, film-yeasts were present on the brines but the regular sampling technique (from approximately 6 feet beneath the brine surface) reduced contamination of the subsurface brine samples with film-yeasts to the point where it was no problem. Thus, species of *Debaryomyces*, *Pichia* and *Mycoderma* such as found by Mrak and Bonar (1939) from surface films of various brined foods would not ordinarily be expected in any numbers. This point is substantiated in the data to follow.

## INTRODUCTORY STUDIES

During the 1946 brining season a beginning was made on the yeast classification work with 218 isolates which were obtained from 22 unsheltered fermenting vats, the latter being divided equally between two commercial plants (A and B) located in eastern North Carolina. The brining treatments were similar in that the initial concentration employed by both plants to cover the green cucumbers was designed to equalize at about 10 percent. They differed chiefly in the rate of increase of brine strength; plant A increased the brine strength to 15 percent in about 6 weeks, whereas plant B took about one-half that time to reach the same strength. At both plants, the fermentations selected were about 18 to 21 days old and all showed active gas evolution. These vats were sampled only three to four times each during the period from the middle of July until the first week of September. It was intended that this introductory study should give information on how many generic groups might be involved and the possible influence of the two brining treatments on these groups.

It developed that the 218 isolates could be divided into 213 that were asporogenous and 5 that were sporogenous. The asporogenous group was divided into 138 isolates which had small to tiny cells, fermented 3 sugars (glucose, sucrose, and raffinose ⅓), and were strongly nitrate positive; and 75 isolates that were round to oval, fermented both lactose and maltose, and were moderately to weakly nitrate positive. The first group was classified as *Torulopsis* and predominated during the first part of the fermentation; the second group was classified as *Brettanomyces*, and predominated during the latter part. Further, the two groups had one characteristic in common; both were short-lived on slant cultures of ordinary dextrose agar. This fact nearly resulted in loss of the collection of these yeasts. It was first discovered in connection with the tiny-celled type, and a large proportion of the isolates obtained from the brine samples taken during July and

August were dead by the latter part of September. The 75 lactose and maltose fermenters were then inspected and found to be in a very poor state of viability. These were finally revived by adding lactose broth directly to the slant culture. Thereafter, they were kept in 4 percent lactose broth at room temperature with excellent results for periods up to 9 months.

In October 1946, an effort was made to re-isolate the tiny-type *Torulopsis* from the original brine samples of the 22 vats taken during the two samplings of July and August and which had been refrigerated (3–4°C.). This was only partially successful. A possible explanation for this appeared to lie in the fact that 74 of the 75 *Torulopsis* isolates obtained came from the 11 fermentations followed at plant B, where the brines, as compared to those from plant A, had very little acidity. The rapid increase in brine salinity employed at plant B afforded very little opportunity for a fermentation by the lactic acid bacteria. This would indicate that the tiny-cell type *Torulopsis* was sensitive to the brine acid of the plant A samples during storage in the refrigerator.

It was indicated that the sporogenous isolates, classified as *Hansenula* and *Torulaspora*, were obtained less frequently since only 3 cultures of the former genus and 2 of the latter were found.

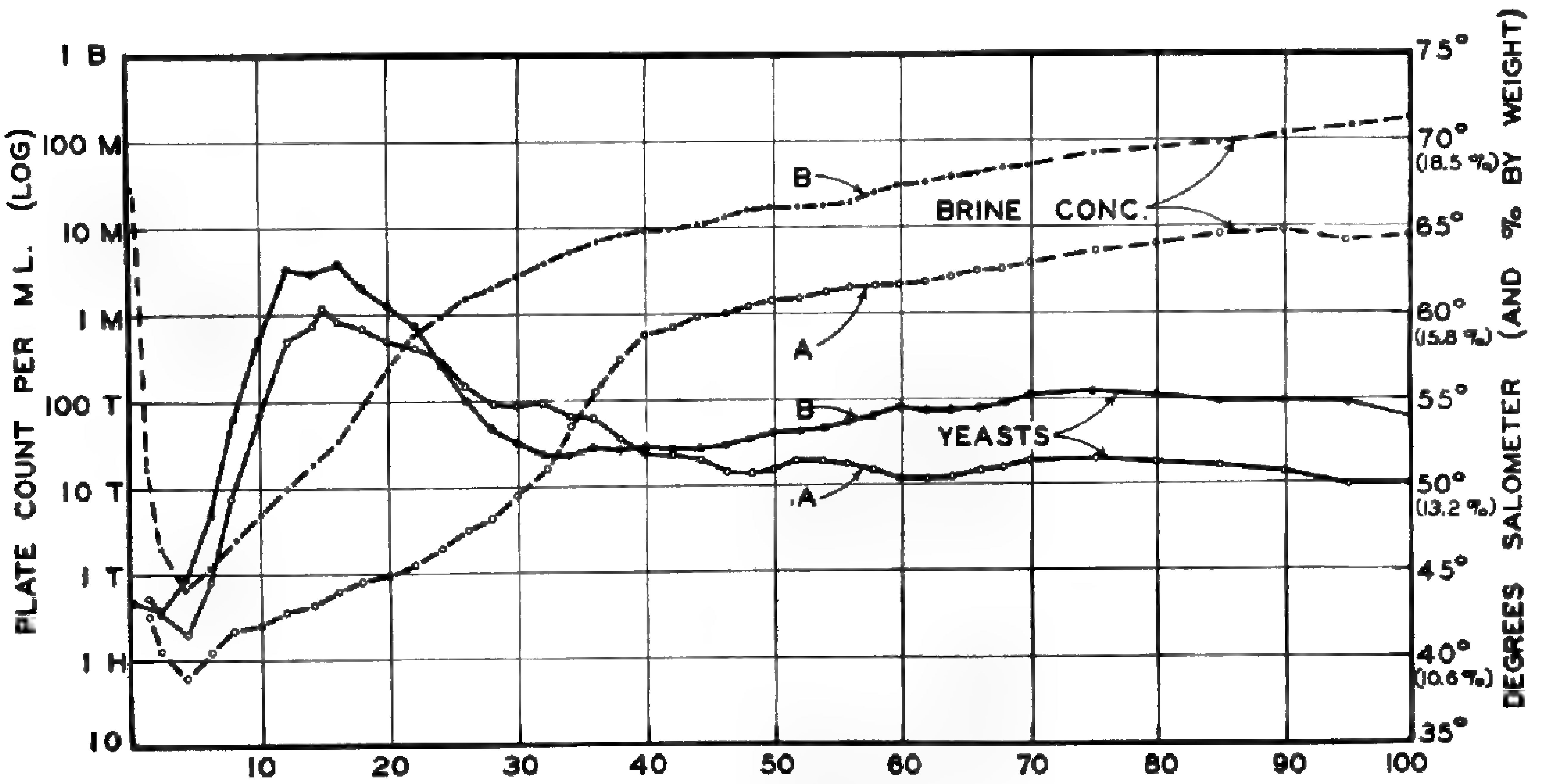

**Figure 1.** Yeast populations and the increase of brine concentration at two commercial plants (A and B).

## EXPERIMENTAL

With the above points in mind, the work for the 1947 season was continued at the two plants mentioned in the 1946 study and included 10 fermentations at each plant. Sampling started shortly after the vats were filled and brined and continued at frequent intervals for approximately 100 days. Individual vats were chosen at random and represented different periods of the season during which cucumbers were being brined. Fermentations occurred for the most part over a period from July until mid-October with brine temperatures within the range of 25 to 27°C., except for the period from mid-September to mid-October when they were 20 to 25°. Eighteen vats were located outside and were unsheltered; two at plant B were sheltered. The brine temperature of the latter two vats averaged about 3° lower than those that were outside. The rate of increase in brine strength employed by each plant, and the resulting yeast populations ob-

TABLE 1. ORIGIN OF 1226 YEAST ISOLATES FROM 20 FERMENTATIONS AT 2 COMMERCIAL PLANTS (1947 SEASON)

| PLANT A | | | | | |
|---|---|---|---|---|---|
| Vat Number (and Date Filled) | Vat Capacity (and cucumber size) [1] | | Number of Isolates Obtained Using Glucose Agar | | Fermentation Period Covered by Isolations |
| | | | Without Salt | With Salt | |
| | *bu.* | (*no.*) | | | *days* |
| F–161<br>(7–3) | 415 | (3's) | 40 | 27 | 11th to 104th; (16,14) [2] |
| F–163<br>(7–3) | 425 | (3's) | 37 | 26 | 7th to 76th; (15,15) |
| F–164<br>(7–3) | 450 | (3's) | 45 | 30 | 7th to 104th; (17,16) |
| F–167<br>(7–3) | 725 | (3's) | 40 | 31 | 7th to 104th; (15,15) |
| F–221<br>(7–6) | 475 | (3's) | 35 | 28 | 8th to 101st; (15,14) |
| F–236<br>(7–6) | 495 | (3's) | 39 | 28 | 8th to 101st; (16,15) |
| F–287<br>(7–13) | 580 | (2's) | 25 | 22 | 1st to 94th; (14,12) |
| F–288<br>(7–13) | 320 | (3's) | 22 | 20 | 1st to 94th; (12,10) |
| F–291<br>(7–20) | 600 | (2's,1's) | 37 | 21 | 1st to 87th; (12,11) |
| F–10 [3]<br>(7–20) | 390 | (1's) | 21 | 15 | 8th to 59th; (9,8) |
| Sub-total | | | 341 | 248 | |
| Total | | | 589 | | |

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[1] Plant A: No. 1's, small cucumbers up to 1″ in dia.; No. 2's, medium, up to 1½″ dia.; No. 3's large, above 1½″ dia.

Plant B: FR refers to field run cucumbers, ungraded as to size.

Plant A used the National variety; plant B, the Earliest of All.

[2] Figures in parentheses in column represent the number of brine platings on glucose agar without salt and with salt, respectively, from which isolations were made.

[3] Vat emptied by plant before observations were completed.

[4] Vats sheltered from weather; all others in the open.

PLANT B

| Vat Number (and Date Filled) | Vat Capacity (and cucumber size) [1] | | Number of Isolates Obtained Using Glucose Agar | | Fermentation Period Covered by Isolations |
|---|---|---|---|---|---|
| | | | Without Salt | With Salt | |
| | *bu.* | (*no.*) | | | *days* |
| 21–20<br>(7–2) | 650 | (FR) | 41 | 32 | 8th to 105th; (15,15) [2] |
| 21–21<br>(7–3) | 650 | (FR) | 36 | 25 | 11th to 104th; (15,14) |
| 22–21<br>(7–3) | 610 | (FR) | 41 | 24 | 11th to 104th; (15,12) |
| 1–7 [3]<br>(7–3) | 625 | (FR) | 40 | 30 | 4th to 76th; (15,14) |
| 23–3<br>(7–5) | 850 | (FR) | 35 | 28 | 2nd to 102nd; (15,14) |
| 23–4<br>(7–5) | 775 | (FR) | 42 | 26 | 2nd to 102nd; (16,13) |
| 14–10 [4]<br>(7–9) | 750 | (FR) | 42 | 23 | 5th to 98th; (16,12) |
| 15–10 [4]<br>(7–9) | 1000 | (FR) | 31 | 26 | 8th to 98th; (13,13) |
| B1–1<br>(7–19) | 620 | (FR) | 42 | 20 | 9th to 88th; (12,10) |
| B2–13<br>(7–19) | 500 | (FR) | 31 | 22 | 9th to 88th; (12,11) |
| Sub-total | | | 381 | 256 | |
| Total | | | 637 | | |

tained, are shown in figure 1. The curves represent mean values for 10 fermentations at each plant.

The brine samples were collected, plated, and counted according to methods previously described by Etchells (1941) and later revised by Etchells and Jones (1946). Two collections of isolates (1,226 in all) were obtained; one from acidified dextrose agar, the other from the same medium containing 8 percent salt by weight. The purpose of the salted medium was to determine whether any types were present that required salt in relatively high concentrations for growth. None, however, was found and the plate counts for the fermentations were essentially the same on either medium. At each plating interval the plates from the high dilutions were set aside for picking representative colonies.

The details concerning the origin of the isolates obtained during the 1947 season are shown in table 1. Of the total number of isolates picked, approximately 48 percent came from the fermentations at plant A, and 52 percent from plant B. In both cases there were fewer isolates picked from salt agar, since it had originally been intended only to supplement those from the unsalted media as a check against missing any of the halophilic types mentioned. In all but two cases the cultures isolated covered the fermentation period adequately from the standpoint of yeast activity. The exceptions were vat F–10 at plant A, and vat 1–7 at plant B; both were emptied before the last sample could be obtained.

The methods employed and classification systems used were essentially those outlined in the monographs by the Dutch workers, Stelling-Dekker (1931), Lodder (1934), Diddens and Lodder (1942), and Custers (1940). The work of Bedford (1942) was used for the genus *Hansenula*. Also, the excellent review by Henrici (1941) was most helpful, as was the generous assistance of Dr. L. J. Wickerham of the Northern Regional Research Laboratory, U. S. Department of Agriculture.

Certain modifications and additions were made in connection with the taxonomic tests of the Dutch workers. The basal broth for sugar fermentations consisted of peptone 0.5 percent, yeast extract 0.25 percent, and 3 to 4 percent solutions of the test sugars in 15 x 150 mm.-tubes containing 10 x 45 mm.-inserts. In order to determine the status of the raffinose fermentation (⅓ or complete fermentation), both raffinose and melibiose (in 4 percent solutions) were used. Here, owing to cost of these compounds, small 8 x 75 mm.-tubes were used either with a petroleum jelly seal or one of heavy mineral oil. The latter seal was preferred for the slow fermentation characteristic of some of the yeasts encountered. The basal medium used for sugars was also employed for determinations on the utilization of ethyl alcohol (3%). Inoculated and uninoculated basal medium controls were run in all cases.

For the nitrate test, the synthetic medium of Stelling-Dekker was used, but in liquid form fortified with an addition of 0.1 percent of yeast extract, which was necessary as a supplementary source of growth accessory substance for one yeast group (*Torulopsis*). Wickerham (1946) has shown that certain species of yeasts previously recorded as negative for utilization of ammonium sulfate, urea, and asparagine were found to be positive when required amounts of pure vitamins were added. In the present work the test for nitrate reduction was not by growth differential but by the common test for nitrites used by bacteriologists (S. A. B. Manual, 1937). In our opinion, the test as we use it is more satisfactory than the growth test on slants particularly for species where slant growth is ordinarily scant and for those which require a supplementary source of vitamins. The chemical test is not infallible, however, and the precautions outlined in the Manual should be followed, particularly in case of negative results. The test, according to Wickerham (1947), should be repeated at about 2-day intervals of growth to establish maximum nitrite accumulation and to avoid false negatives. The use of both slant and broth cultures for testing has proved very helpful in our hands when nitrate reduction is weak, or nitrite accumulation is of small magnitude.

For the sporulation tests a vegetable juice medium prepared from a commercially canned product was used.[3] This medium was essentially the same as that originally described by Wickerham, Flickinger, and Burton (1946). We prepare the medium as follows: Equal parts of juice and water are adjusted to pH 6.0 by addition of 10 percent sodium hydroxide. Then, 2 percent agar and 0.4 percent calcium sulfate are added, the mixture is heated to dissolve the agar, tubed, and sterilized at 15 lbs. pressure for 15 minutes. The final pH is usually about 5.8. The medium has a tendency to foam and wet the plugs, but this can be corrected for the most part by placing the racks of tubed media in a boiling water bath for 10 minutes and then autoclaving carefully. The principal difference in the two media is the higher pH (6.8) preferred by Wickerham *et al.* and the addition of a yeast cake. Also, they prefer the use of fresh slants not over 8 hours old.

Early in the present study a test was made using the modified vegetable juice medium and seven other sporulating media, i.e., potato plugs, potato agar, dilute carrot juice agar (McKelvey, 1926), carrot plugs, Gorodkowa's agar, dilute cucumber juice agar, and gypsum slants (Lindegren, 1945). Two *Torulaspora* isloates and 4 *Hansenula* isolates from brines, together with 3 known species of *Saccharomyces* and 2 of *Hansenula*, were tested on each medium. The media were observed at intervals for a period of several weeks. Considering all genera as a group, the vegetable juice medium was considered superior for indicating spore formation; Gorodkowa's was next best. Carrot agar was the best individual medium for the *Hansenula*, but very poor to negative sporulation for these yeasts was obtained on the 2 potato media. However, the potato media proved superior for the *Torulaspora* isolates. The results for the known species were essentially the same in that the vegetable juice was the best single medium. One strain of *S. ellipsoideus* gave poor results on all media used. As a result of this and subsequent tests with known species from the Northern Regional Research Laboratory (Peoria), the vegetable juice agar was adopted as a screening medium for dividing all the brine isolates into sporogenous and asporogenous types. Representatives of the latter types were thoroughly tested, however, on several other media before recording negative results.

The test for mycelium production was made using point inoculations on poured plates of cornmeal agar to which centered cover glasses were applied (Wickerham and Rettger, 1939). The potato medium of Lodder was also tried but the above procedure gave better results. Modifications of Custers' "standard test" were used in detecting acid production in aerobic culture. Several concentrations of suspended chalk in slants and poured plates of both regular glucose agar and a synthetic agar with glucose were tried. The regular glucose agar (used in this and other tests where mentioned) consisted of the following ingredients; Glucose, 2 to 5 percent; yeast extract, 0.25 percent; $K_2H\ PO_4$, 0.1 percent; salt, 0.5 percent; peptone, 0.5

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[3] Manufactured by Campbell Soup Co. under the name "V-8." It is probable that other products of essentially the same composition would prove satisfactory.

TABLE 2. SUMMARIZED MORPHOLOGICAL, CULTURAL, AND BIOCHEMICAL CHARACTERISTICS OF 1424 YEAST ISOLATES FROM 42 COMMERCIAL CUCUMBER FERMENTATIONS.

| Generic group, species allocation, number of isolates.[1] | Vegetative Cells | Glucose Agar Growth | Glucose Broth Growth |
|---|---|---|---|
| I. *Torulopsis* Berlese<br>A. *T. caroliniana* sp. nov.<br>717 isolates<br>49.6% | From veg. juice agar and glucose agar, cells small to tiny, av. 1.5–2 × 3–4μ. Short-oval to egg-shaped and in clusters; some elongated. | White, moist, glistening; secondary colonies along streak. Scant amount of growth. Cells short-lived; death in approx. 3–6 wks. on slants or in broth. | No ring;<br>no film;<br>broth clears rapidly. |
| B. *T. holmii* (Jörgensen) Lodder<br>4 isolates<br>0.3% | Cells predominately short-oval, 3–4 × 4–5.5μ. | Light buff, glistening, practically smooth. | No ring;<br>no film. |
| II. *Brettanomyces* Kuff. et van Laer<br>A. *B. versatilis* sp. nov.<br>561 isolates<br>38.8% | From broth 3–4 × 4–5μ, round to oval, some elongated. On agar slants, generally the same size. Characteristic cell colonies in broth. Ogive cells in old cultures. | Young growth white, glistening, smooth; old cultures develop light pink to lavender color from center. Cells short-lived in slant cultures. Abundant growth. | Ring;<br>no film. |
| B. *B. sphaericus* sp. nov.<br>27 isolates<br>1.9% | Cells predominately round, but also may be slight oval; 3–5μ dia., some slightly larger; clusters of many cells. Ogive cells in old cultures. | White, smooth, glistening, abundant growth. | Ring;<br>no film. |
| III. *Saccharomyces* (Meyen) Reess<br>Subgenus *Zygosaccharomyces* Barker<br>A. *Z.* sp<br>50 isolates<br>3.5% | From broth, cells generally large, mostly oval and in cell colonies. Av. 4–5 × 4.5–7μ; some larger; elongated chains of cells on old media. | White to light cream; dull; irregular; surface gently folded; moderate to abundant growth. | Ring;<br>no film. |
| B. *Z.* sp.<br>9 isolates[5]<br>0.6% | | | |
| IV. *Hansenula* Sydow<br>*H. subpelliculosa* Bedford<br>49 isolates<br>3.4% | Cells large, round, oval, sausage-shape, irregular; 6 × 8μ, some elongated. Clusters of several cells. | White, smooth, moist, glistening, abundant growth; discolors with age. | Ring;<br>very slight film. |
| V. *Torulaspora* Lindner<br>*T. rosei* Guillermond<br>6 isolates<br>0.4% | Cells predominately round to slight oval, 3–6μ dia., mostly 4.5μ. Clusters of three to four cells. | White, smooth, glistening, abundant growth. Some strains with granular surface. | Ring;<br>no film. |
| VI. *Kloeckera* Janke<br>*K. magna* (De 'Rossi) Janke<br>1 isolate<br>0.1% | Young cells, oval or apiculate, 3–6 × 5–12μ singly or pairs. | Grey, thin, moist, glistening, smooth; transparent wavey edges. | No ring;<br>no film. |

| Growth in Ethyl Alcohol | Nitrate Assimilation | Action on Sugars |  | Ascospore Production | Outstanding Characteristics |
|---|---|---|---|---|---|
|  |  | Fermented | Not Fermented |  |  |
| Absent | Strongly positive | Glucose (2)[2]<br>Sucrose (3)<br>Raffinose (2) | Maltose<br>Galactose A[3]<br>Lactose<br>Melibiose | Not found on 8 sporulation media observed over period of several months. | Small cell size; short-lived nature; strong nitrate test; rapid fermentation; scant amount of growth; characteristic colony formation. |
| Moderate | Negative | Glucose (2)<br>Sucrose (2)<br>Galactose (2)<br>Raffinose (2) | Maltose<br>Lactose<br>Melibiose | Not found on sporulation media observed over period of several months. | Rapid fermentation of glucose, sucrose, galactose, and raffinose (1/3); short, oval cells. |
| Good growth with ring; no film. | Positive | Glucose (4)<br>Sucrose (6)<br>Maltose (5)<br>Galactose (8)<br>Lactose (8)<br>Raffinose (12)<br>Melibiose (12) |  | Not found on 8 sporulation media observed over period of several months. | Fermentation of maltose, lactose, and melibiose; usually a slow, prolonged fermentation behavior; death of cells in aerobic culture due to acid production; high salt tolerance. |
| Moderate growth with ring; no film. | Positive (latent) | Glucose (7)<br>Maltose (12) | Sucrose A<br>Galactose A<br>Lactose<br>Raffinose<br>Melibiose | Not found on sporulation media observed over period of several months. | Predominately round cells; slow, prolonged fermentation of glucose and maltose; vigorous assimilation of galactose; high salt tolerance; death of cells in aerobic culture. |
| Moderate growth with ring after one month. | Negative | Glucose (3) | Sucrose[4] A<br>Maltose[5]<br>Galactose A<br>Lactose<br>Raffinose A<br>Melibiose | Positive; isogamic or heterogamic conjugation; 1–3 spores per ascus. Av. spore 3 × 4.5μ; round to oval. | Limited fermentation power; variable action on sucrose in low concentrations; typical sporulation; high salt tolerance. |
| Moderate growth with ring; no film. | Positive | Glucose (3)<br>Sucrose (3)<br>Raffinose (7) | Maltose[6] A<br>Galactose A<br>Lactose<br>Melibiose | Positive; usually hat-shaped spores, 1–4 per ascus; spores mostly 2 × 3μ; occasionally round spores, 3μ dia. | Lack of significant film formation; vigorous galactose assimilation; variable action on maltose; typical sporulation. |
| Moderate growth with very slight ring; no film. | Negative | Glucose (1.5)<br>Sucrose (1.5)<br>Raffinose (1.5) | Maltose<br>Galactose<br>Lactose<br>Melibiose | Positive; conjugation tubes formed prior to spore formation, but no conjugation. Spores smooth, round, 1–4 per ascus, 3–4μ dia. | Formation of long conjugation tubes and absence of distinct evidence of conjugation; 1–4 characteristic spores, with oil drop. |
| Negative | Negative | Glucose | Sucrose<br>Maltose<br>Galactose<br>Lactose<br>Raffinose<br>Melibiose | Not found on several sporulation media. | Apiculate cells and very strong acid production, exceeding the *Brettanomyces*. |

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[1] Percentages shown on basis of total isolations made (1444); 20 isolates (1.4%) remain not fully classified but include 3 isolates of *Candida*, 4 of *Endomycopsis*, and 1 atypical *Torula spora*. Also, totals include 218 cultures from 1946 season in the following groups: IA, 138; IIA, 75; IV, 3; V, 2.

[2] Numbers in parentheses refer to approximate age in days for maximum gas in insert.

[3] Assimilation of compound.

[4] Action on sucrose variable ranging from none to a latent fermentation.

[5] Nine of 59 isolates ferment maltose strongly in 3 days and apparently belong to a different species.

[6] Action on maltose variable, ranging from no fermentation to a latent, weak fermentation.

percent; and agar, 1.5 percent. The synthetic medium was the same as that used by Stelling-Dekker except it contained 0.01 percent yeast extract.

The most clear-cut results were obtained with poured plates of chalk glucose agar receiving a 2 mm. spot inoculation of the test yeast. At least two levels of chalk suspension, i.e., about 0.5 and 0.8 percent, were found to be helpful in determining the degree of acid production indicated by the cleared zone around the yeast growth. In preparation, the finely ground chalk should be kept in suspension and the plates poured just short of the agar solidification point.

## RESULTS

The characteristics of the genera found during the 2-year study are shown in table 2. Column 1 of this table gives summarized data on the predominance of individual species.

### *Predominating Genera*

The predominant genera found fall into the following groups: (1) genus *Torulopsis*; (2) genus *Brettanomyces*; (3) genus *Saccharomyces*, subgenus *Zygosaccharomyces*; (4) genus *Hansenula*; (5) genus *Torulaspora*; (6) genus *Kloeckera*; plus an initial group, genera *Rhodotorula* and *Debaryomyces*, and an unclassified group of 20 isolates.

Group I, Genus *Torulopsis*: Of the 721 cultures isolated in this group, four were identical to *T. holmii* (Jörgensen) Lodder and require no further discussion. The remaining isolates were a homogenous group having small to tiny cells, which ferment glucose, sucrose, and raffinose (⅓) rapidly, are short-lived, strongly nitrate positive, and apparently sensitive to the acid they produce. On chalk-containing media definite acid production is observed. They are rather tolerant of solutions of high osmotic pressure as indicated by rapid growth and gas production in broth containing 40 and 60 percent by weight of sucrose. In laboratory tests their tolerance to salt is $> 15$ but $< 20$ percent by weight. Their tolerance in cucumber brines is probably slightly above 15 percent.

These yeasts have certain characteristics in common with the three species isolated by Kroemer and Krumbholz (1931) and described in detail by Krumbholz (1931) as the "small-celled osmophilic *Saccharomyces*" which were identified as *S. stellatus*, *S. bacillaris*, and *S. granulatus*. Later, Lodder (1934) reclassified the first two as *Torulopsis stellata* and *T. bacillaris*, but did not mention the status of *S. granulatus*. We have been unable to locate a culture of this species either in this country or abroad.[4] Krumbholz describes *S. granulatus* as very small and short-lived; but it cannot be definitely identified with our group of isolates since he did not report on response to the nitrate test; nor did he find growth in raffinose, although dextrose and sucrose were fermented. Both *T. stellata* and *T.*

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[4] Later, in June 1948 Miss N. J. W. van Rij of the CBS advised us that they had requested this yeast from Krumbholz shortly after his paper was published but the culture had died.

*bacillaris* ferment the same sugars as our isolates but are nitrate negative as recorded by Lodder (and confirmed by us in repeated tests) and would be eliminated on this count alone.

Although it appears that a definite relationship exists between the two small-celled osmophilic species of Kroemer and Krumbholz and the small-celled brine isolates, the relationship is not sufficient to prohibit species separation. Hence, we propose to place our isolates as *Torulopsis caroliniana* sp. nov.[5]

Group II, Genus *Brettanomyces*: The isolates placed in this genus consisted of 561 that fermented all seven test sugars (including lactose and maltose) and 27 that fermented only two, glucose and maltose. This second group are nearly spherical in shape (with a tendency for ogive shape in old cultures) and the fermentation of the two sugars is very slow. Also, they are inclined to be short-lived on slant cultures and death is presumably due to acid production as indicated by clearing of chalk agar. The nitrate test, however, is generally weak and latent, appearing after about 10 days on slant cultures. This point, plus the absence of any pseudomycelium, may appear to raise a question as to the allocation of this group to the *Brettanomyces*; but neither of these characteristics is considered critical by Custers (1940) in his thorough study of the genus. The fact also that they were obtained during the latter stage of fermentation (from six vats at plant B only, 1947) when the other *Brettanomyces* species was present, is an additional strong point in favor of their inclusion in this genus. They will be therefore considered as such for the present under the proposed name of *Brettanomyces sphaericus* sp. nov.

The group of 561 cultures that fermented all seven sugars was similar to *B. claussenii* Custers; differing in that they fermented raffinose and melibiose (equivalent to complete raffinose). They differed also, in that the cells were round to oval as compared to the more elongated cells of

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[5] Since completion of the present investigation, a culture labelled *Torulopsis lactis-condensi* (Hammer) was received from the "Centraalbureau." It was isolated by Hammer in 1919, from gassy sweetened condensed milk. Our study of this yeast showed, in part, that it was inclined to be small-celled, and fermented glucose, sucrose, and raffinose rapidly (1 to 2 days). Furthermore, it reduced nitrate very strongly. The fermentation of raffinose was somewhat surprising in view of the negative test reported by Olson and Hammer (1935) in a redescription of the original characteristics (Hammer, 1919) for *Torula lactis-condensi.* The nitrate reduction test had not been used in either study. Thus a close relationship undoubtedly exists between this yeast and our *Torulopsis caroliniana* sp. nov. However, the cells of *T. lactis-condensi* are distinctly larger than those of our isolates and have a somewhat different shape and internal appearance. Furthermore, *T. lactis-condensi* resembles *T. caroliniana* only to a limited degree in respect to being short-lived on both liquid and solid media (including chalk agar); nor is *T. lactis-condensi* critical in this property with respect to usual cultivation methods. These differences seem sufficient to separate the two yeasts, and this would be in keeping with accepted yeast classification methods in practice today (Stelling-Dekker, Lodder, Diddens and Lodder, Custers). Possibly further study of other isolates of *T. lactis-condensi* from condensed milk (other than the CBS culture) would indicate the exact extent of the similarity between the two yeasts. However, additional strains do not appear to be available here or abroad (Wickerham, 1948).

*B. claussenii.* The *Brettanomyces* from brine origin were extremely salt-tolerant, as might be expected from their appearance in the fermentation at a time of high brine strength. In laboratory tests they grew on solid media containing 24 percent salt by weight. Fermentation in a 60 percent sucrose solution was also better than in a 40 percent solution, although there was much more cell growth in the latter. Tests on cornmeal agar did not reveal the presence of pseudomycelium for the isolates tested, and essentially the same results were obtained when *B. claussenii* (NRRL 1414) was used. The pseudomycelium for *B. claussenii* in the illustration by Custers shows it to be extremely poorly developed. Yet the brine isolates showed even less. Strong acid production by the *Brettanomyces* on slant cultures is given considerable taxonomic weight by Custers. This characteristic was thoroughly studied on glucose media with different concentrations of chalk suspended in the agar. All the yeast genera found in brines as well as the four known species of *Brettanomyces* were tested for acid production. In brief, it was observed that the known *Brettanomyces* (*B. bruxellensis, B. lambicus, B. anomalus,* and *B. claussenii*) species as reported by Custers are very strong acid producers; however, this characteristic is not restricted to them alone. The lone *Kloeckera* species from brine was more active. Also, other genera from brines (*Torulopsis* and *Hansenula*) were good chalk-clearers at the 0.5 to 0.8 percent suspension level. The *Brettanomyces* isolates from brine likewise produced acid as indicated by the zone of chalk cleared, but were not equal to the four known species.

To our knowledge this is the first time that yeasts of the genus *Brettanomyces* have been obtained and described from sources other than European breweries. In his thorough study of the genus *Brettanomyces,* Custers found that all but one of the 17 strains collected were of brewery origin. The exception was an isolate obtained from fermenting grape must, reidentified by him as *B. bruxellensis.* There was no indication that the genus had been isolated outside of Europe. There is the possible exception of a single isolate from 31° Balling sirup reported by Bedford (1942) as *B. bruxellensis.* Bedford did not describe the isolate which was incidental to a thorough study of the *Hansenula* genus, and attached no significance to its occurrence. A study of his thesis (Bedford, 1941) shows several characteristics that make his placing of the isolate as *B. bruxellensis* questionable. Since Bedford's culture was presumably no longer living (Mrak, 1948) no comparison could be made with our CBS culture of *B. bruxellensis.*[6]

The fermentation reactions and different morphology of the *Brettanomyces* isolates from high-salt brines during the latter portion of the fermentation is considered sufficient basis for species separation from *B.*

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[6] Later, however, we were informed by Wickerham (1948), who was one of the reviewers of this paper, that Bedford's isolate was in his collection. He stated that it does not belong in *Brettanomyces,* but is a species closely related to *Torulopsis utilis.* We are inclined to accept Wickerham's classification of Bedford's isolate as being correct.

*claussenii*. The name *Brettanomyces versatilis* sp. nov. is suggested. Two *Brettanomyces* isolates, Y-207 and Y-232, were found during the 1946 study that were characterized by growth but no fermentation of sucrose in low concentrations; however, both raffinose and melibiose (complete raffinose) were fermented and in other respects they were similar to the main group. For the present they are considered as variations of *B. versatilis* sp. nov.

Group III, Genus *Saccharomyces*, subgenus *Zygosaccharomyces*: The 59 isolates in this genus were divided into two groups; A, 50 that fermented glucose, but gave a variable action on sucrose; and B, 9 that fermented glucose, sucrose, and maltose. Growth in sucrose media prior to making the test did not appear to influence the results for the Group A isolates; nor did the use of 10 percent sucrose solution instead of the 4 percent solution regularly used. Whereas the 10 and 20 percent solutions of sucrose gave good growth but no gas, the 40 and 60 percent solutions were fermented. This indicated an osmophilic relationship for the action on sucrose. Growth in salt media was within the range of 20 to 24 percent by weight. Group B yeasts were not tested for salt tolerance on laboratory media, but their growth in the fermenting brines at about 18 percent is ample proof of their ability to withstand high osmotic pressures. The *Zygosaccharomyces* are well known for their tolerance toward solutions of high osmotic pressure, particularly those containing sugar, such as honey, maple syrup, and concentrated grape musts. This subject has been adequately reviewed by Henrici (1941). Their tolerance to high salt brines, however, does not appear to be so well established. (Cf. Addendum.)

In an attempt to place the yeasts of Group A as to species, a compilation of the detailed characteristics of some 25 known species was prepared. About one-half of these fell into the "weakly fermentative" class. Species separation appeared to be based on such minor differences that it appeared that continued attempts would further complicate an already confused picture. For this reason, our *Zygosaccharomyces* will be listed merely as species A and B until a satisfactory taxonomic examination of the described species is made by workers in this field. The new culture list by the "Centraalbureau" (CBS, 1947) names 50 species, 8 of which have synonyms; undoubtedly there are more than this conservative number.

Group IV, Genus *Hansenula*: The 49 isolates placed in this genus were characterized by the fermentation of glucose, sucrose, and raffinose (⅓); a variable maltose fermentation; a vigorous galactose utilization; and either extremely thin film production or no film at all. These characteristics (supplemented with the rest shown in table 2) are similar, but not identical, to the species *H. subpelliculosa* Bedford. The variable fermentation of maltose is not entirely consistent; but out of 11 cultures studied by Bedford, one did not ferment this sugar. In a test of an additional 136 cultures by us obtained from refrigerated brine samples (which are not included in our present total of *Hansenula* isolates), 58 fermented maltose in varied degrees while 78 did not. As to utilization of galactose, Bedford had 6 out of 11 cultures that gave a negative test in a synthetic medium. We are inclined to believe that the fermentation of maltose could well be considered a weak characteristic for the species, providing a sufficient number of cultures are studied. It is obvious that galactose utilization is variable for Bedford's isolates; hence, we believe that for the present no sound basis exists for separating our isolates from the species *Hansenula subpelliculosa* Bedford. For this reason, the 49 isolates listed in table 2 and the 136 obtained from refrigerated brine samples are placed in that species. Representative isolates fermented 60 percent sucrose, and on laboratory media tolerated between 20 and 24 percent salt by weight. When compared to the pseudomycelium produced by *H. anomala*, that produced by the brine *Hansenula* appeared insignificant.

Group V, Genus *Torulaspora*: The 6 cultures of this genus were considered identical with *T. rosei* Guillermond. Four characteristic spores per ascus were frequently found on vegetable juice agar although this important characteristic is not mentioned for the species by Stelling-Dekker. Any redescription of this yeast should include this observation on sporulation. A single culture of *T. rosei* was isolated from grapes by Mrak and McClung (1940), but otherwise it appears not to have been found in this country. The salt tolerance for the brine isolates was between 15 and 20 percent. Rapid growth and fermentation of 40 and 60 percent sugar solutions was obtained.

Group VI, Genus *Kloeckera*: A single culture similar to *Kloeckera magna* (De 'Rossi) Janke was obtained. As previously mentioned, this yeast produced more acid in aerobic culture, using a chalk agar, than any of the four known species of *Brettanomyces*. This was found to be true at different levels of chalk suspension (approx. 0.5, 0.8, and 1.6 percent). Mrak *et al.* (1942) demonstrated that an isolate of *Kloeckera africana* (and one of *Hansenula anomala* var. *sphaerica*) clarified slants of Custers' chalk media more readily than did species of other genera (*Pichia*, *Hanseniaspora*, *Candida*, *Torulopsis*) isolated from figs.

Initial Group, Genera *Rhodotorula* and *Debaryomyces*: Earlier work (Etchells, 1941; and Etchells and Jones, 1943) has shown that the beginning of active yeast development in cucumber brines of about 10 percent strength starts in about 1 week. It was also shown that the initial yeast populations present at the time the vats are filled and covered with brine drop to extremely low numbers during the first few days prior to active development. In the present study, it had been planned to investigate the initial flora at the time the vats were filled and brined. This would be termed the "initial" plating at "0" days. This portion of the study was not fully realized for two reasons; (1) such vats were not always available at both plants, and (2), more important, there was a high incidence of molds in most of the initial brines sampled, making the plates useless for picking colonies, although after the first few days the molds are no longer found. Of the 7 vats that were sampled initially, only 3 had plates (salt agar only) that were at all suitable for picking. Twelve isolates were picked. Of the 9 placed generically, 4 were classified as *Rhodotorula* and 5 as *Debaryomyces*. Representatives of these genera were not obtained again throughout the study of the 20 fermentations. (The above yeasts have not been included in the total number of isolates since they represent initial values for only 3 of the 20 vats studied and were obtained from only one plating medium.)

Unclassified Group: Twenty isolates were obtained which have not yet been fully classified. Although they have been studied rather thoroughly, some do not fit into known species descriptions, for one reason or another. Some segregation of the group, however, can be made. Seven of the isolates are film yeasts, four of which were taken from the heavy surface film of the two sheltered vats followed at plant B and properly should be excluded from this study. All of the film yeasts produced well developed pseudomycelium and four appear to have a mixture of both true and pseudomycelium. The latter 4 have been classified as *Endomycopsis*. The remaining three film yeasts, which came from 1- to 2-day-old samples, appear to fall in the genus *Candida*. The finding of four isolates classified as *Endomycopsis* is significant because heretofore yeasts of this genus have not been associated with surface films present on brined material (Mrak and Bonar; Henrici).

### *Distribution of Isolates According to Source*

For this discussion, cultures from both media used for isolations will be grouped together since no outstanding floral differences arose through the use of the glucose agar with salt. The summarized results (table 3) show that two yeasts, *T. caroliniana* sp. nov. and *B. versatilis* sp. nov., were consistently found in all 20 fermentations and represented the bulk (88 percent) of all cultures identified. It appears that the individual brining treatment may have exerted an influence on the frequency with which certain of the minor species were obtained. For example, all of the isolates of *Torulopsis holmii, Torulaspora rosei,* 45 of the 46 *Hansenula subpelliculosa* cultures, and 50 of the 59 *Zygosaccharomyces* isolates came from plant A. Also, none of the 27 cultures of the new species, *B. sphaericus* was obtained at plant A. As mentioned before, generally this plant employed a much slower rate of increase in brine strength (from 10 to 16 percent) than plant B, and considerably lower total yeast populations were obtained (Cf. figure 1). In connection with the 45 isolates of *H. subpelliculosa* obtained at plant A, 28, or 62 percent, came from one fermentation (vat 167). This was the only case of what amounted to an active fermentation by this yeast. The 50 *Zygosaccharomyces* (species A) cultures came from 8 fermentations at plant A, whereas the 9 cultures of species B all came from one fermentation (sheltered vat 15–10) at plant B.

TABLE 3. DISTRIBUTION OF BRINE YEASTS ACCORDING TO SOURCE OF ISOLATION (1947 SEASON).

| *Vat No.* | I *Torulopsis* | | | | II *Brettanomyces* | | | | III *Zygosaccharomyces* | | | | IV *Hansenula* | | V *Torulaspora* | | Unclassified | | Total Isolations per Vat | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *T. caroliniana* | | *T. holmii* | | *B. versatilis* | | *B. sphaericus* | | *Z.* sp. A | | *Z.* sp. B | | *H. subpelliculosa* | | *T. rosei* | | | | | |
| Plant A | GA[1] | GS[2] | GA | GS | GA | GS | GA | GS | GA | GS | GA | GS | GA | GS | GA | GS | GA | GS | GA | GS |
| F–161 | 18 | 12 | 0 | 0 | 15 | 13 | 0 | 0 | 3 | 1 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 40 | 27 |
| F–163 | 19 | 13 | 1 | 1 | 10 | 9 | 0 | 0 | 4 | 1 | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 0 | 37 | 26 |
| F–164 | 20 | 14 | 1 | 0 | 14 | 12 | 0 | 0 | 8 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 45 | 30 |
| F–167 | 12 | 9 | 0 | 0 | 11 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 11 | 0 | 0 | 0 | 0 | 40 | 31 |
| F–221 | 18 | 16 | 0 | 0 | 9 | 12 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 35 | 28 |
| F–236 | 17 | 11 | 1 | 0 | 13 | 14 | 0 | 0 | 6 | 2 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 39 | 28 |
| F–287 | 7 | 9 | 0 | 0 | 12 | 9 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 25[3] | 22 |
| F–288 | 9 | 10 | 0 | 0 | 12 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 22 | 20 |
| F–291 | 22 | 8 | 0 | 0 | 7 | 9 | 0 | 0 | 8 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 21 |
| F–10 | 6 | 5 | 0 | 0 | 13 | 10 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 21 | 15 |
| Sub-total | 148 | 107 | 3 | 1 | 116 | 109 | 0 | 0 | 37 | 13 | 0 | 0 | 28 | 17 | 3 | 1 | 5 | 0 | 341 | 248 |
| Plant total | 255(43.3%) | | 4(0.7%) | | 225(38.2%) | | 0 | | 50(8.6%) | | 0 | | 45(7.7%) | | 4(0.7%) | | 5(0.8%) | | 589 | |

| Plant B | GA | GS | GA | GS | GA | GS | GA | GS | GA | GS | GA | GS | GA | GS | GA | GS | GA | GS | GA | GS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21–20 | 23 | 11 | 0 | 0 | 18 | 19 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 41 | 32 |
| 21–21 | 20 | 13 | 0 | 0 | 15 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 36 | 25 |
| 22–21 | 22 | 10 | 0 | 0 | 19 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41 | 24 |
| 1–7 | 17 | 14 | 0 | 0 | 23 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 30 |
| 23–3 | 18 | 11 | 0 | 0 | 14 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 35 | 28 |
| 23–4 | 25 | 13 | 0 | 0 | 17 | 11 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 42 | 26 |
| 14–10[4] | 27 | 13 | 0 | 0 | 7 | 4 | 5 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 42 | 23 |
| 15–10[4] | 21 | 11 | 0 | 0 | 2 | 2 | 1 | 7 | 0 | 0 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 4 | 31 | 26 |
| B1–1 | 24 | 9 | 0 | 0 | 16 | 9 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 42 | 20 |
| B2–13 | 14 | 8 | 0 | 0 | 15 | 11 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 31 | 22 |
| Sub-total | 211 | 113 | 0 | 0 | 146 | 115 | 6 | 21 | 0 | 0 | 7 | 2 | 1 | 0 | 0 | 0 | 10 | 5 | 381 | 256 |
| Plant total | 324(50.9%) | | 0 | | 261(41.0%) | | 27(4.2%) | | 0 | | 9(1.4%) | | 1(0.2%) | | 0 | | 15(2.3%) | | 637 | |
| GRAND TOTAL | | | | | | | | | | | | | | | | | | | | |
| 20 Vats | 579(47.3%) | | 4(0.3%) | | 486(39.7%) | | 27(2.2%) | | 50(4.1%) | | 9(0.7%) | | 46(3.8%) | | 4(0.3%) | | 20(1.6%) | | 1226 | |

[1] Isolates from glucose agar.

[2] Isolates from glucose agar with salt.

[3] Total includes 1 *Kloeckera magna* obtained at the first sampling, 24 hrs. after filling and brining.

[4] Sheltered vats; all others in open.

*Predominance of Individual Species*

The results for the 2-year study with respect to the individual number of isolates assigned to individual species, and their percentage of the total isolations made (column 1 of table 2), are given for the six generic groups

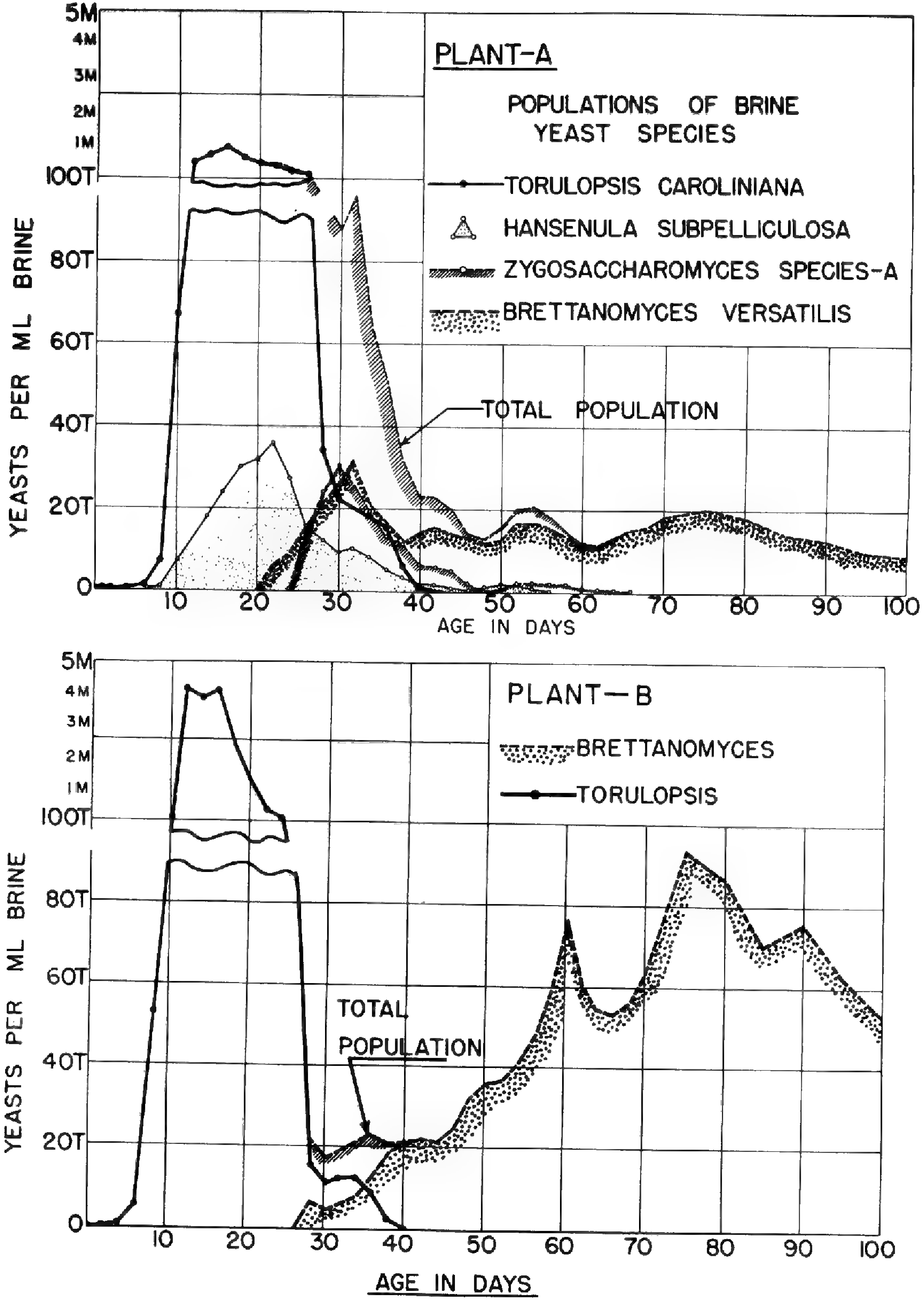

**Figure 2.** Yeast populations at two commercial plants according to sequence of species. Upper part, plant A; lower part, plant B.

encountered, in the decreasing order of frequency with which they were found.

The *Torulopsis* and *Brettanomyces* genera represented 1,309 cultures out of 1,444, slightly over 90 percent of all yeasts isolated, were obviously by far the types most frequently obtained. The remaining four genera (*Hansenula, Zygosaccharomyces, Torulaspora,* and *Kloeckera*), constituted but 115 cultures, about 8 percent of the total isolates. A breakdown of the two principal genera found shows that two individual species within *Torulopsis* and *Brettanomyces*, i.e., the tiny-celled yeast *T. caroliniana* sp. nov. and the fermentative yeast *B. versatillis* sp. nov., predominated, accounting for 1,278 cultures, 88.4 percent of the total cultures. The former species represented almost 50 percent of all cultures, and the latter nearly 40 percent.

Before it can be stated whether a definite sequence of species existed during the general fermentation, a few remarks concerning their respective periods of activity are needed. At both plants the tiny-celled yeast, *T. caroliniana* sp. nov., after starting growth within about 7 days, represented the bulk of the total populations, until about the 30th day, when their numbers declined. At plant B, these yeasts reached much higher numbers than at plant A. Between the 25th to 40th day, the fermentative yeast, *B. versatilis* sp. nov., appeared and thereafter was consistently found throughout the remainder of the 100-day period of observation. In the case of plant B this yeast appeared later but reached definitely higher numbers (five-to ten-fold) than for plant A. The less frequently obtained species from plant A were found as follows: The cultures of *Torulopsis holmii* and of *Torulaspora rosei* appeared at the end of the fermentation by *Torulopsis caroliniana.* The *Zygosaccharomyces* (Type A) appeared between the 32d to the 55th day. The *Hansenula subpelliculosa* cultures generally were found near the end of the *T. caroliniana* fermentation; in the case of vat 167 they were consistently found between the 18th and 49th days. The less frequently obtained yeasts at plant B were the Type B *Zygosaccharomyces* found between the 43rd to 70th day (in one vat only); and the poorly fermentative *Brettanomyces* species found between the 23rd to 70th day.

A general picture as to yeast sequence in the fermentations at plants A and B, based on the glucose agar isolates from the 1947 season, is shown in figure 2. In the preparation of these diagrams, only data for four principal yeasts that showed definite individual population trends were used. Data for the two sheltered vats from plant B (vats 14–10 and 15–10) are omitted because the brine strengths in these two cases, after reaching 15 percent, were not increased as were the 8 outside vats.

### *Description of New Species*

**Torulopsis caroliniana** sp. nov.

Cellulae parvae vel perpusillae, breve ovales vel ovoideae, plerumque aggregatae, in agaro glucoso in 24–48 horis 1.5–2 x 3–4 $\mu$; in mediis liquidis multo saccharosis leniter majores; fermentationem glucosii, sucrosii, raffinosii (⅓) in diebus 2–3 inducens, jure glucoso cito claro, annulo et pellicula absentibus; fermentatio maltosii, galactosii, lactosii, et melibiosii non visa, set assimilatio galactosii producta; auctus in alcoholi ethylico carens; reductio valida nitrati ad nitritum in diebus 3–4; pseudomycelium non visum in agaro solanaceo nec maltoso in 3 hebdomadibus; in jure solanaceo solo coloniae cellularum elongatarum praesentes; ascosporae non visae in mediis 8 sporulantibus menses plures observatis; cellulae caducae (3–6 hebdomades) in mediis vulgaribus; productio definita acidi in mediis cretaceis; culturae in mediis glucosis albae, madidae, coruscae, auctu moderato; colonia gigantea in agaro glucoso parva, circa 1 cm mense una, typice margine lobato et annulis concentricis praedita, centro in aetate ferruginosa; fermentationem rapidam solutionum 40–60% saccharium inducens; toleratio salis $> 15$ sed $< 20\%$ in culturis, in fermentationibus salsimentorum naturalibus supra 15%.

In fermentationibus salsimentorum cucumeris (10–15% salis) in diebus 7–30.

Cells, small to tiny, short-oval to egg-shaped, usually in clusters. On glucose agar slants and broth at 24 to 48 hours, cells average 1.5–2 x 3–4 $\mu$; cells slightly larger in liquid media with higher sugar concentrations. Rapid fermentation of glucose, sucrose, raffinose (⅓) within 2 to 3 days. Glucose broth clears rapidly; no ring, no film. No fermentation observed for maltose, galactose, lactose, and melibiose; but, moderate assimilation of galactose is obtained. No growth in ethyl alcohol. Strong reduction of nitrate ($KNO_3$) to nitrite after 3 to 4 days (chemical test). Pseudomycelium not found on cornmeal or malt extract agar in 3 weeks; none found in potato broth, only cell colonies with more elongated cells. Ascospores not found on 8 sporulating media observed over several months. Cells short-lived on slants of ordinary media (3 to 6 weeks). Definite acid production on chalk containing media. Glucose slant cultures white, moist, glistening with scant to moderate amount of growth. Giant colony on glucose agar small, approximately 1 cm. at 1 month, characteristically lobed edge with concentric rings. Slight rust color starting at the center with age. Rapid fermentation of high sugar solutions (40 and 60 percent by weight). Tolerance to salt is $> 15$ but $< 20$ percent by weight in cultural tests; tolerance in natural brine fermentations slightly above 15 percent. Source: During the active fermentation of cucumber brines (10 to 15 percent salt), starting on about the 7th day, and continuing until about the 30th day.

**Brettanomyces versatilis** sp. nov.

Cellulae plerumque ovales, interdum rotundae; in agaro et jure glucosis in 48–72 horis 3–4 x 4–5 $\mu$; cellulae ogivae in culturis vetustis; fermentationem glucosii, sucrosii, maltosii, galactosii, lactosii, raffinosii et melibiosii inducens; fermentatio mediorum saccharinorum tarda et menses plures protracta; auctus in alcoholi ethylico bonus, annulo praesenti sed pellicula carenti, etiam in jure glucoso; reductio nitrati in nitritum moderata; pseudomycelium non visum in agaro farinae zeae in 3 hebdomadibus nec in jure solanaceo in 2 mensibus; ascosporae non visae in mediis 8 sporulantibus in mensibus pluribus; cellulae in mediis vulgaribus caducis (4–6 hebdomades) cultures circa 9 menses in jure 4% lactoso in temperatura vulgari persistantes; productio valida acidi in medio cretaceo in culturis aerobicis; culturae juveniles in agaro glucoso albae, coruscae, leves, demum in culturis vetustis e centro roseae usque lavendulae; colonia gigantea in agaro glucoso alba, levis, annulis concentricis inconspicuis praedita, demum infra e centro rosea usque lavendula; fermentationem solutionum sucrosium (40–60%) inducens; toleratio salis extrema (20–24%) in fermentationibus artifactis et naturalibus.

In fermentationibus salsimentorum cucumeris in diebus 30 usque 100 longe et tarde continuanti.

Cells predominately oval but some round. On glucose agar slants and broth at 48 to 72 hours, cells average 3–4 x 4–5 μ. Characteristic cell colonies from broth; typical ogive cells in old cultures. Fermentation of glucose, sucrose, maltose, galactose, lactose, raffinose, and melibiose. Characteristic slow, prolonged fermentation of sugar media over a period of months. Good growth in ethyl alcohol; ring but no film. Ring but no film in glucose broth. Moderate reduction of nitrate ($KNO_3$) to nitrite (chemical test). Pseudomycelium not found on cornmeal agar in three weeks, or in potato broth after 2 months. Ascospores not found on 8 sporulating media observed over several months. Cells short-lived on slants of ordinary media (4 to 6 weeks). Cultures can be maintained for approximately 9 months in 4 percent lactose broth at room temperature. Strong acid production on chalk media in aerobic culture. Young, glucose slant cultures white, glistening and smooth. Latent development of a pink to lavender color in old cultures starting from center area. Giant colony on glucose agar dull white, smooth, with slight concentric rings. Latent development from center (bottom) of pink to lavender color. Fermentation of high sucrose solutions (40 and 60 percent by weight). Extremely salt-tolerant in both laboratory tests and natural fermentations (20 to 24 percent by weight). Source: During the latter part of the fermentation of cucumber brines, starting at about 30 days and continuing in a slow, prolonged manner until at least the 100th day.

**Brettanomyces sphaericus** sp. nov.

Cellulae plerumque rotundae, in agaro glucoso in 48–72 horis 3–5 μ in diam., vel interdum paulo majores, in jure aggregatae; cellulae ogivae in culturis vetustis; fermentationem tardam glucosii maltosiique inducens, non sucrosii, galactosii, lactosii, raffinosii nec melibiosii; sucrosium et galactosium utuntur; auctus moderatus in alcoholi ethylico, annulo praesenti sed pellicula carenti, etiam in jure glucoso; reductio nitrati ad nitritum latens; pseudomycelium non visum in agaro farinae zeae in 3 hebdomadibus; ascosporae non visae in mediis variis sporulantibus menses plures observatis; cellulae caducae in mediis vulgaribus; productio acidi moderata in mediis cretaceis in culturis aerobicis; culturae juveniles in medio glucoso albae, leves, coruscae, integrae, auctu abundanti; fermentatio solutionum 40% glucosium auctu flocculento; fermentatio tarda solutionum 60% sucrosium, ad 40% debilis, ad 20, 10 et 5% absens; toleratio salis magna in mediis artifactis et fermentationibus naturalibus 18–20%.

In statibus ultimis fermentationis salsimentorum cucumeris in concentrationibus magnis (15–20%) salis.

Cells predominately round; those from glucose agar slants and broth at 48 to 72 hours, 3–5 μ in diameter; some slightly larger. Clusters of many cells in broth; a tendency for ogive cells in old cultures. Slow fermentation of glucose and maltose. Sucrose, galactose, lactose, raffinose, and melibiose not fermented, but sucrose and galactose utilized. Moderate growth in ethyl alcohol; ring but no film. Ring but no film in glucose broth. Latent reduction of nitrate ($KNO_3$) to nitrite. Pseudomycelium not found in cornmeal agar in three weeks. Ascospores not found on several sporulating media observed over several months. Cells somewhat short-lived on slants of ordinary media. Moderate acid production on chalk media in aerobic culture. Young, glucose slant cultures white, smooth, glistening, entire, with abundant growth. Fermentation of 40 percent glucose solutions with flocculent growth. Slow fermentation of 60 percent sucrose solutions; feeble fermentation of 40 percent; no fermentation at lower concentrations (20, 10, and 5 percent). Very salt-tolerant in artificial media and in natural brine fermentations (18 to 20 percent by weight). Source: During latter part of the fermentation of certain cucumber brines at high salt concentration (15 to 20 percent).

TABLE 4. EXAMINATION OF SALT-STOCK CUCUMBERS FROM SEVEN FERMENTATIONS (PLANT A) FOR BLOATERS OR HOLLOW CUCUMBERS.

| Vat Number (and Date Opened–1948) | Amount of Salt Stock Examined[1] | Bloaters Found | |
|---|---|---|---|
| | *bushels* | *bushels* | *percent* |
| F–161<br>(4–20) | 265 | 144 | 54 |
| F–163<br>(4–24) | 282 | 66 | 23 |
| F–164<br>(4–27) | 274 | 106 | 39 |
| F–167<br>(5–1) | 391 | 176 | 45 |
| F–221<br>(5–28) | 302 | 114 | 38 |
| F–236<br>(5–27) | 305 | 159 | 52 |
| F–288<br>(5–27) | 177 | 81 | 46 |

[1] Vats contained large sized cucumbers (1½ inches in diameter or larger).

### *Bloater Formation During Fermentation*

After the completion of the curing period, the salt-stock from the 10 vats at one of the plants was graded out for percentage of bloaters (hollow cucumbers). This was done according to regular plant procedure. The results for seven vats, those that contained large sized cucumbers (1½ inches in diameter and larger), are shown in table 4. The proportion of bloaters found ranged from 23 to 54 percent of the total amount of stock in individual vats. Bloater formation was attributed to the gaseous yeast fermentation, and *Torulopsis caroliniana* was considered to be the principal species involved. The results on the number of bloaters formed are comparable to those reported by Jones, Etchells, Veerhoff, and Veldhuis (1941) for large sized cucumbers cured in barrels and 85-bushel vats at 10.5 percent brine strength.

Three lots, vats F-287, F-291 and F-10, not shown in table 2, contained small sized stock (less than 1½ inches in diameter). These graded out less than 10 percent bloaters. The relationship of less bloaters being formed during gaseous fermentation when smaller sized cucumbers are brined is the same as that shown earlier by the above authors.

## DISCUSSION

The tiny yeast, *T. caroliniana* sp. nov., and the new *Brettanomyces* species, *B. versatilis,* were in consistently higher numbers in the brines of plant B as compared to plant A. This is attributed to the influence of the more rapid increase in brine strength employed by plant B which markedly reduced the growth of the less salt-tolerant lactic acid bacteria, thereby leaving more fermentable material from the cucumbers for the yeasts. This relationship was readily demonstrated by definitely lower brine acidities for plant B, as compared to plant A, and lower numbers of lactic acid bacteria as demonstrated by microscopic examination and plate counts for these organisms. Previous studies (Jones and Etchells, 1943) have shown that only a very small amount of fermentable sugar remains in the brines by the end of the first 30 days. Hence, the *Brettanomyces* fermentation evidently was supported by another carbon source; probably the ethyl alcohol produced earlier by the *Torulopsis* species, *T. caroliniana,* or the organic acids contributed chiefly by the lactobacilli.

The two species, *T. caroliniana* and *B. versatilis,* dominated the yeast flora at plant B; they were also the types most frequently isolated at plant A. There was evidence, however, of fermentation trends of two additional yeasts, *Hansenula subpelliculosa* and *Zygosaccharomyces* (species A) at the latter plant. Although neither of these yeasts was found in all ten fermentations, they were, however, found with sufficient frequency to indicate at least a minor role in the average fermentation. The well-developed fermentation by *H. subpelliculosa* in vat 167 would be sufficient evidence to warrant inclusion of this yeast in any general consideration of the yeast flora. Since both of these yeasts made their appearance near the end of active development of the tiny-celled *Torulopsis,* it seems plausible that lack of a readily fermentable carbon source was the major factor which limited their continued development. Neither type grows particularly well in ethyl alcohol as compared to the yeast that succeeded them in the brines, namely, *B. versatilis.* The latter species at plant A did not reach populations much above 10,000 to 15,000 per ml. from about the 35th day on, which is further evidence of lack of nutrients in these brines. It is doubtful if the brine acidity had much of an inhibitory influence on the species of *Hansenula, Zygosaccharomyces,* and *Brettanomyces* in plant A brines. Such an effect would have first been noticeable on the *Torulopsis* fermentation, since these yeasts are much more sensitive to the brine acid than the other genera mentioned.

In an investigation of this kind, the principal limiting factor on the extent of species separation is the number of isolates than can be picked and subsequently identified. Even with an unlimited number of isolates from the high dilution plates there is always the question of what minor species might be present at lower population levels. In this connection, it is conceivable that the *Brettanomyces* started growth at about the same time as the tiny-celled *Torulopsis* (about 7 days); but due to lower population levels did not become "predominating" until the tiny yeasts were reduced to a level so that the former group appeared on the plates. The same is probably partly true for the *Hansenula* and *Zygosaccharomyces*. Better separation could no doubt be effected by development of differential media for detection of specific yeast groups, based on their particular biochemical properties.

## SUMMARY

A study of the yeasts predominating during the fermentation of cucumbers under commercial conditions is presented. During the 1946 and 1947 seasons, 1,444 isolates were obtained by frequent sampling of 42 fermenting vats at two commercial pickle plants in eastern North Carolina. During the period of observation, the brine strength of the fermentations was within the range of 10 to 18 percent by weight.

The 1,444 isolates were reduced to the following six genera in the order of frequency of isolation; *Torulopsis* (721); *Brettanomyces* (588); *Zygosaccharomyces* (59); *Hansenula* (49); *Torulaspora* (6); *Kloeckera* (1); plus 20 isolates not fully classified. The first two genera named represented a total of 1,309 cultures or slightly over 90 percent of all yeasts isolated. Furthermore, two new species within these genera, the tiny yeast *Torulopsis caroliniana* sp. nov., and the very fermentative yeast, *Brettanomyces versatilis* sp. nov., predominated, accounting for 1,278, or slightly over 88 percent of the total cultures. The first species dominated the early part of the fermentation and was then followed by the second in a slow fermentation which continued up to the end of the observation period (about 100 days). This was the most clear-cut yeast sequence obtained for all 20 fermentations at both plants. In addition, 4 cultures of *Torulopsis holmii* (Jörgensen) Lodder were found, as well as 27 cultures that have been placed in the *Brettanomyces* genus as *B. sphaericus* sp. nov.

The remaining four genera (*Zygosaccharomyces*, *Hansenula*, *Torulaspora*, and *Kloeckera*) obtained less frequently consisted of 115 cultures, or about 8 percent of the total isolates. These cultures were placed as follows: The 59 *Zygosaccharomyces* (50, type A; 9, type B) were not identified as to species due to the confused state of the genus; the *Hansenula* were considered to be *H. subpelliculosa* Bedford; the *Torulaspora* isolates were identical to *T. rosei* Guillermond; the single isolate of *Kloeckera* was similar to *K. magna* (De 'Rossi) Janke. All the above 115 cultures, with the exception of 9 maltose fermenting *Zygosaccharomyces* cultures and 1

culture of *H. subpelliculosa* were obtained from one plant, as were the 4 cultures of *T. holmii*. This was attributed to the difference in brining treatment.

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## ADDENDUM

The 9 yeast isolates referred to in this report as species B of the genus *Zygosaccharomyces* (Cf. table 2, column 1, Group III, and table 3, column 7) are considered to be the same as *Z. halomembranis* sp. nov. recently obtained from films on commercial cucumber brines. (Cf. Etchells, J. L., & T. A. Bell. 1950. Film yeasts on commercial cucumber brines. Food Tech., 4:77–83.)

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# A REVIEW OF CERAMIUM ALONG THE PACIFIC COAST OF NORTH AMERICA WITH SPECIAL REFERENCE TO ITS MEXICAN REPRESENTATIVES[1]

E. YALE DAWSON

As a result of explorations for marine algae along the Pacific Mexican coast during the last 25 years, the number of species of *Ceramium* recorded in our Pacific North American marine flora has been increased nearly fivefold. Notwithstanding, no key to the species, nor survey of the genus as it is represented in our flora has been prepared, while the task of identifying our plants has become increasingly more difficult and uncertain.

Within the past four years the writer's field work in Mexico has brought to hand some three hundred separate collections of *Ceramium*, study of which has shown that all but two of the known Pacific Coast species occur in Mexico. Several apparently undescribed plants have been detected, and these, together with some troublesome uncertainties among our older species, have called for a practical treatment of the genus at this time. Of each of these new Mexican collections, material kept in liquid preservative has made possible the preparation in a uniform manner of a series of permanent study-slides in which the specimens exhibit minimum distortion.

Dr. George J. Hollenberg of the University of Redlands, Redlands, California, has kindly made available for this study his fine collection of *Ceramium* from southern California. These specimens, particularly his numerous slide preparations, have been most useful in verifying a number of determinations and in indicating northernmost localities in the distribution of many species.

Examples of all of the collections cited, except those of Hollenberg, are on file in the Herbarium of the Allan Hancock Foundation. All collection numbers are the writer's unless otherwise indicated. The dates of the author's collections are as follows: 16–1094, January–February 1946; 1095–1655, April 1946; 1646–1989, May 1946; 2756–3145, October 1946; 3146–3581, November 1946; 3582–3764, December 1946; 3765–3940, January–February 1947; 5143–5312, September 1948; 6462–7278, March 1949.

The drawings were made by the author.

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## A KEY TO THE SPECIES OF CERAMIUM OF THE PACIFIC COAST OF NORTH AMERICA [1]

1\. Thallus completely corticated throughout .................... 2

1\. Thallus with nodal cortication for the most part continuous, but at least in some part with ecorticate internodal spaces, or the cortex thin and loose over internodes .................... 8

1\. Thallus with cortication only at the nodes, or with uninterrupted cortication only in older, lower parts or on reproductive branches .................... 9

  2\. Thallus bearing deciduous or persistent spines on apices or on short, lateral branches .................... 3

  2\. Spines absent .................... 4

3\. With sharp, unicellular spines at apices or terminating short, lateral branchlets .......... **1. Ceramium horridum**

3\. With two or more multicellular spines terminating mature apices of main or lateral branches .......... **7. Ceramium pacificum** (in part)

  4\. Cortical cells, at least for the greater part, in distinct longitudinal rows; apices divergent .......... **2. Ceramium Eatonianum**

  4\. Cortical cells not in distinct, longitudinal rows; apices divergent or forcipate .................... 5

5\. Plants with penetrating, bulb-tipped, pigmented rhizoids .......... **3. Ceramium codicola**

5\. Plants without bulbous rhizoids .................... 6

  6\. Plants creeping, extremely robust, the cortex 200 $\mu$ thick or more .......... **5. Ceramium obesum**

  6\. Plants erect, not particularly robust; cortex much thinner .................... 7

7\. Apices divergent; with many short, proliferous branches, densely congested above .......... **6. Ceramium viscainoense**

7\. Apices more or less incurved; with many proliferous branchlets, but these not congested in upper parts .. **7. Ceramium pacificum** (in part)

  8\. Cortical bands only slightly separated above, covering the expanding internodes below by basipetal growth, but the secondary cortication thin, loose and often incomplete; with many proliferous branchlets .......... **8. Ceramium washingtoniense**

  8\. Nodal cortication discontinuous, particularly so in lower parts, usually continuous above or irregularly discontinuous; usually without conspicuous proliferous branchlets .......... **4. Ceramium sinicola** (in part)

  8A. Cortication continuous above, but not in lower and middle portions .......... **4. Ceramium sinicola** var. **typicum**

  8A. Cortication generally continuous above, but conspicuously interrupted at the dichotomies ...... **4. Ceramium sinicola** var. **interruptum**

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[1] It should be emphasized that identifications according to this key will be most successful when the material being examined is fresh or in liquid-preserved state, since drying distorts the appearance and arrangement of the cortical cells upon which a number of distinctions are based.

8A. Cortication continuous except in extreme basal parts ........................................ 4. **Ceramium sinicola** var. **Johnstonii**

9. Plants bearing conspicuous multicellular spines ........................ 10

9. Plants without conspicuous spines .................................... 11

  10. Spines mainly abaxial, more or less deciduous ........................................ 9. **Ceramium paniculatum**

  10. Spines whorled at the nodes, persistent ........................................ 10. **Ceramium hamatispinum**

11. Cortical band showing conspicuous basipetal and (or) acropetal secondary growth ........................ 12

11. Cortical band without conspicuous basipetal or acropetal secondary growth 13

  12. Tetrasporangia immersed within the cortical band ........................................ 11. **Ceramium Evermannii**

  12. Tetrasporangia projecting from the cortical band ........................................ 12. **Ceramium californicum**

13. Cortical cells arranged in distinct horizontal and vertical rows in lower two thirds of the nodes ...........14. **Ceramium recticorticum**

13. Cortical cells not arranged in vertical rows ............................ 14

  14. Outer cortical cells of nodal band separated into two groups by a horizontal clear space usually at about the lower third of the node; tetrasporangia involucrate ........................ 15

  14. Outer cortical cells of nodal band not clearly divided into two groups; tetrasporangia immersed, involucrate or naked ........................ 17

15. Nodes of most filaments each bearing, at first abaxially, a short, thick, apically rounded, unicellular hair, or these later sometimes whorled ........................................ 13. **Ceramium fimbriatum**

15. Nodes without such a specialized hair ........................ 16

  16. Cells of lower portion of divided cortical band distinctly and persistently horizontally elongated ....15. **Ceramium Masonii**

  16. Cells of lower portion of divided cortical band, except in young stages, angular, small and not distinctly horizontally elongated ........................................ 16. **Ceramium Taylorii**

17. Tetrasporangia immersed in the cortex, not projecting ........................ 18

17. Tetrasporangia projecting, naked ........................ 23

17. Tetrasporangia projecting and involucrate, at least by bracteate filaments (sometimes secondary tetrasporangia obscurely involucrate in *C. personatum*) ........................ 20

  18. With conspicuous opposite branching; procumbent ........................................ 17. **Ceramium procumbens**

  18. Without conspicuous opposite branching; erect or entangled .......... 19

19. Filaments 140–200 μ diam. or more 4. **Ceramium sinicola** (in part)

19. Filaments 80–100 μ diam. .....18. **Ceramium equisetoides**

  20. Filaments less than 50 μ diam. ........................ 21

  20. Filaments 70–200 μ diam. ........................ 22

21. Tetrasporangia solitary at the nodes, the involucres unilateral ........................................ 19. **Ceramium serpens**

21. Tetrasporangia whorled at the nodes, the involucres symmetrical ........................................ 20. **Ceramium Camoui**

22. Cortical band about half as long as broad; tetrasporangia initially secund, mainly abaxial, later whorled, more or less involucrate by bracteate filaments; with descending rhizoidal appendages within some of the axial cells .................... **24. Ceramium personatum**

22. Cortical band about half as long as broad; tetrasporangia initially secund, mainly adaxial, later whorled, slightly involucrate; without appendages within the axial cells ..... **21. Ceramium Gardneri**

22. Cortical band one third to half as long as broad; tetrasporangia secund, abaxial, conspicuously involucrate throughout; without appendages within the axial cells ............ **22. Ceramium mazatlanense**

23. Plants smaller, the lower nodes rarely exceeding 130 $\mu$ in diameter .......... 24

23. Plants larger, the lower nodes 150–450 $\mu$ in diameter (sometimes not over 130 $\mu$ in slender forms of *C. caudatum*) ............................ 26

24. Internodes ordinarily less than 3 times as long as cortical band; adult nodes of more than 2 tiers of cells ............................ 25

24. Internodes, except near tips, 4–10 times as long as cortical band; nodes of only 2 tiers of cells ... **23. Ceramium affine**

24A. Filaments less than 35 $\mu$ diam. .................................................... **23. Ceramium affine** var. **originale**

24A. Filaments more than 40 $\mu$ diam. .................................................... **23. Ceramium affine** var. **peninsularis**

25. Cortical band consisting of larger, rounded, downwardly directed cells in lower part of band, and smaller, angular cells in upper part; lower internodes 1½–2 times as long as broad; distantly branched .................................................... **25. Ceramium avalonae**

25. Cortical bands with irregularly arranged, small, angular cells on the surface throughout; lower internodes less than as long as broad; rather densely branched above .............. **26. Ceramium zacae** (in part)

26. Upper branches reduced in diameter, commonly 100 $\mu$ or less; tetrasporangia appearing large compared to bearing cortical band, ¼ the diameter of the band or larger .................................... 27

26. Upper branches not much reduced in diameter, commonly over 150 $\mu$ (to 300 $\mu$); tetrasporangia mostly appearing small compared to bearing cortical band .................................................. 28

27. Older internodes less than as long as broad .................................................... **26. Ceramium zacae** (in part)

27. Older internodes 1.5–2.5 times as long as broad .................................................... **27. Ceramium caudatum**

28. Apices prominently circinate-forcipate; tetrasporangia mainly projecting from adaxial surface of the node or sometimes scattered around the entire node ................ **28. Ceramium clarionensis**

28. Apices not circinate; tetrasporangia whorled, projecting from upper half, particularly the upper margin, of the cortical band .......................................... **29. Ceramium ornatum**

## SYSTEMATIC LIST

### 1. CERAMIUM HORRIDUM Setchell & Gardner

Setchell & Gardner, 1924, p. 777, pl. 26, figs. 49, 50, pl. 79; Dawson, 1944, p. 318.

Previously well-known in the Gulf of California from Guaymas, Sonora and northward, this distinctive plant has recently been collected in the southern Gulf of California at Isla Carmen (Dawson 6965), in San Lorenzo Channel (Dawson 6926) and at Mangles Anchorage north of Isla Carmen (AHF Sta. 526–36). Its spination makes it one of the most readily recognized of the completely corticated species of our coast.

### 2. **CERAMIUM EATONIANUM** (Farlow) De Toni

De Toni, 1903, p. 1493; Smith, 1944, p. 327, pl. 84, figs. 3–4; Dawson, 1945a, p. 62, 67; 1949a, p. 223; Taylor, 1945, p. 271; Doty, 1947, p. 187. *Centroceras Eatonianum* Farlow, 1875, p. 373. *Ceramium zebrinum* J. Agardh, 1894, p. 37. *Centroceras oregonense* J. Agardh, 1876, p. 107.

Although long well-known in California and in Oregon, this plant has previously been reported in Mexico only from Punta Descanso, Cabo Colnett and Isla Cedros. Recent collections show that it is common along virtually the entire west coast of Baja California. Specimens are now at hand from Punta Baja (Dawson 1142), Miller's Landing (1379), Punta Santa Rosalía (1426, 1513, 2918), Bahía Ositos (1591) and from Bahía Santa María, Isla Magdalena (7267).

### 3. **CERAMIUM CODICOLA** J. Agardh

Plate 1, fig. 6

J. Agardh, 1894, p. 23; Setchell, 1905, p. 60; Smith, 1944, p. 326, pl. 84, fig. 1; Doty 1947, p. 187; Dawson, 1944, p. 318 (in part). *Ceramium codiophila* Setchell & Gardner, 1937, p. 89, pl. 8, figs. 23, 24; Dawson, 1945, p. 25.

Although this species has been known in the California flora for over half a century, it has apparently become increasingly misunderstood as the knowledge of our flora has been extended southward. In 1905, Setchell correctly pointed out one of the major distinguishing features of *Ceramium codicola*: unbranched, chromatophore-containing rhizoids with large, globular ends. Smith, 1944, reiterated this character in describing the plant from Monterey, but it has not heretofore been noticed that the plant distributed in the Phycotheca Boreali-Americana as no. 248 and verified by Kylin, 1941, as identical with the Agardhian type, is not identical with the plant most commonly found epiphytic on *Codium fragile* at La Jolla, and elsewhere in southern California. We have, in fact, two species of *Ceramium* of similar external appearance epiphytic on *Codium*, the one, *C. codicola*, of northern occurrence, north to Alaska, and the other, *C. sinicola*, of southern occurrence south to San José del Cabo and in the Gulf of California (see discussion below). In southern California the ranges of the two species overlap, *C. codicola* being occasional in drift at La Jolla and common on *Codium* in the Channel Islands. *C. sinicola* is common on intertidal *Codium* at La Jolla and may occur on a number of other hosts.

The specimens from Isla Guadalupe, Baja California described by Setchell and Gardner as *Ceramium codiophila* seem clearly to correspond with the original concept of *C. codicola*. Similarly far southern locals for this species are represented by Dawson 2838 from Punta Santa Rosalía, Bahía Viscaino and by Howell 20b, Bahía San Bartolome, Baja California.

### 4. **CERAMIUM SINICOLA** Setchell & Gardner

Plate 1, figs. 4–5

Setchell & Gardner, 1924, p. 773, pl. 25, figs. 40, 41, pl. 75; Dawson, 1944, p. 315; Hollenberg, 1948, p. 158 (in major part). *Ceramium bicorne* Setchell & Gardner, 1924, p. 773, pl. 28, fig. 64, pl. 74. *Ceramium Johnstonii* Setchell & Gardner, 1924, p. 774, pl. 76, 77. *Ceramium interruptum* Setchell & Gardner, 1924, p. 775, pl. 26, fig. 47. *Ceramium codicola* J. Agardh, as interpreted by Dawson, 1944, p. 318 (in part); 1945, p. 67; 1949, p. 26.

Hollenberg's recent report of this species in southern California has called for a review of the species as a whole, and particularly for a clarification of the type locality. The type specimen, found entangled with a *Laurencia* species, was cited by Setchell and Gardner from the Gulf of California following their assumption that "Ensenada Bay" indicated on the original label was in that region. Reëxamination of the original *Laurencia* specimen, Ivan Johnston 67, kindly loaned by the Herbarium of the University of California, shows that it is probably *L. subopposita*, not a species of the Gulf of California, and is associated with another plant unknown there, *Pterosiphonia Baileyi*. A comparison of the date, April 7, 1921, with the general account (Slevin, 1923) of the Expedition of the California Academy of Sciences to the Gulf of California in 1921, reveals that on that date Johnston was aboard the steamer Mazatlán which had departed from Los Angeles, southward bound, on April 5. This would have placed Johnston at Bahía de Todos Santos (often known as Ensenada Bay) Baja California on the date indicated on the label, and explains the identity of the *Laurencia* and *Pterosiphonia* which are not in keeping with the flora of the Gulf. *Ceramium sinicola* becomes, thus, a species positively known from Pacific Baja California by reason of the type. This enables us more readily to accept a wide distribution for this species including southern California, Pacific Baja California and the Gulf of California, an interpretation strongly supported by the large Mexican *Ceramium* collections now at hand.

Although both *Ceramium sinicola* and *C. codicola* occur on *Codium* along southern California and northern Baja California where their ranges overlap, the characters of their rhizoids make them readily distinguishable. The former produces slender, branched, non-bulbous rhizoids (fig. 5) which may be of various lengths and depths of penetration depending upon the texture of the host to which they attach. In *C. codicola*, which seems to occur only on *Codium*, the unbranched rhizoids are pigmented and bulbous at the tips (fig. 6).

One to several multicellular spines commonly occur on mature apices of *C. sinicola* (fig. 4). Such spines appear to be absent in *C. codicola*.

*Ceramium sinicola* is an extremely variable plant, in habitat, size and in cortication, and in some of its varied forms may be confused with other species. It is best identified by means of a series of several specimens, both juvenile and mature, among which the characters particularly of the cortication may be interpreted. In the great majority of cases the uppermost, mature parts of the plants show complete cortication, or cortication only here and there interrupted, most commonly just above the dichotomies. The more slender, basal branches, however, ordinarily show prominent internodal spaces between the truncate cortical bands. In some of the more slender forms, and those growing in less exposed situations, there may be widely discontinuous cortication with internodes in the lowermost, prostrate portions up to 3 times the length of the cortical bands. Depending upon the continuous or discontinuous character of the cortication, three varieties may be recognized (see key): *C. sinicola* var. **typicum** nom. nov., *C. sinicola* var. *Johnstonii* (S. & G.) Dawson, and *C. sinicola* var. *interruptum* (S. & G.) Dawson.

Since *Ceramium sinicola* is already well known as an abundant and widely distributed species epiphytic on various algae throughout the Gulf of California, further collections need not be cited for that area. Its occurrence along the Pacific Coast of California and Baja California may be outlined, however, by the following collections: California — Hollenberg 624.6, Whites Point, San Pedro; Hollenberg 797, 812, Santa Catalina Island; Hollenberg 581.6, 1598, Corona del Mar; Dawson 316, 2084, 5422, La Jolla. Baja California — Dawson 246, Punta Descanso; 1161, Punta Baja; 6707, Isla Magdalena (Pacific side); 6902, Cabeza Ballena; 2953, Miller's Landing.

### 5. **CERAMIUM OBESUM** sp. nov.

Plate 1, figs. 7–9

Thallis prostratis, repentibus, rhizoidum plurium (ubi contactum factum) ope affixis, cylindricis, 90–1100 $\mu$ diametro, totis bene corticatis, ramulis secundariis numerosis spinescentibus donatis; cortice bistratoso ad 300 $\mu$ crasso.

Plants prostrate, creeping, growing over themselves and other small algae and debris, attaching by masses of small rhizoids produced from all contacting surfaces, very coarse, cylindrical, 900–1100 $\mu$ diam., with axes 20–22 mm. long, completely corticated throughout, abruptly reduced at the apex to the short, coarse, strongly forcipate tips; primary branching dichotomous, infrequent; secondary branching irregular, frequent, consisting mostly of very short branchlets with strongly circinately curved tips; cortex very thick, completely covering the axes, consisting of an inner layer of thick-walled rotund cells 25–100 $\mu$ diam. adjoining the central axial cells which are about 400 $\mu$ diam., and an outer layer of densely packed small anticlinally elongated cells 15–25 $\mu$ long by 5–9 $\mu$ wide; reproduction not seen.

Type: Dawson 964, on intertidal rocky shore at Bahía Agua Dulce, Isla Tiburón, Sonora, Mexico. February 21, 1946. HAHF 5279.

This extremely robust species is suggestive in anatomy and gross morphology of *Ceramium crassum* Okam. of Japan, but its prostrate, creeping habit and rhizoidal attachment among mat-forming small algae distinguishes it from that erect, epiphytic species.

### 6. CERAMIUM VISCAINOENSE sp. nov.

Plate 1, figs. 1–3

Thallis 15–25 mm. altis, rosulatis, saxicolis, pro more dichotome ramosis; ramis adultioribus 400–500 μ diametro, nodis constrictis; cortice toto continuo; ramis secundariis proliferis brevibus, multifariis, supra congestis; apicibus divergentibus, acutis; tetrasporangiis immersis.

Thalli 15–25 mm. high, tufted, saxicolous, attached by massed and coalesced short rhizoids which in mature plants form a spongy disc, consisting of several to many dichotomously branched axes arising from the base; older branches 400–500 μ diam., catenately constricted at the nodes, gradually reduced in diameter above and the constrictions less prominent; secondary proliferous branches multifarious, short, increasingly abundant and more congested above; ultimate branches divergent, non-forcipate, acute; cortex continuous throughout, primarily of irregularly disposed small angular cells and a few larger cells at the junction of the rotund axial cells, generally thin or incomplete over the bulging mid-parts of the central axial cells, the longitudinally arranged small, mostly elongated cells of young segments becoming in part increasingly longer or even filamentous as secondary, acropetal and basipetal cortical growth progresses; tetrasporangia 30–35 μ diam., completely immersed in the cortex; cystocarps surrounded by 3–5 involucral branchlets.

TYPE: Dawson 1430, intertidal rocky shore at Punta Santa Rosalía, Baja California, Mexico, April 13, 1946. HAHF 5225.

*Ceramium viscainoense* shows by its microscopic characters a similarity to *C. pacificum*. A comparison of specimens of both species collected at Punta Santa Rosalía on the same day, however, indicates several apparently significant differences. Most conspicuous in *C. viscainoense* are the divergent apices and the dense massing of short, secondary branches in the upper parts of the plant. These short branches are in turn branched, the ultimate segments being spine-like (fig. 2). The prominent constrictions at the nodes and the thin, loose cortications of the internodes (fig. 3) also appear to be characteristic.

### 7. CERAMIUM PACIFICUM (Collins) Kylin

Plate 4, fig. 30

Kylin, 1925, p. 61; 1941, p. 29; Smith, 1944, p. 326, pl. 83, fig. 3; Dawson, 1945a, p. 67; Doty, 1947, p. 187. *Ceramium rubrum* var. *pacificum* Collins, in Phyc. Bor. Amer. no. 893, 1747.

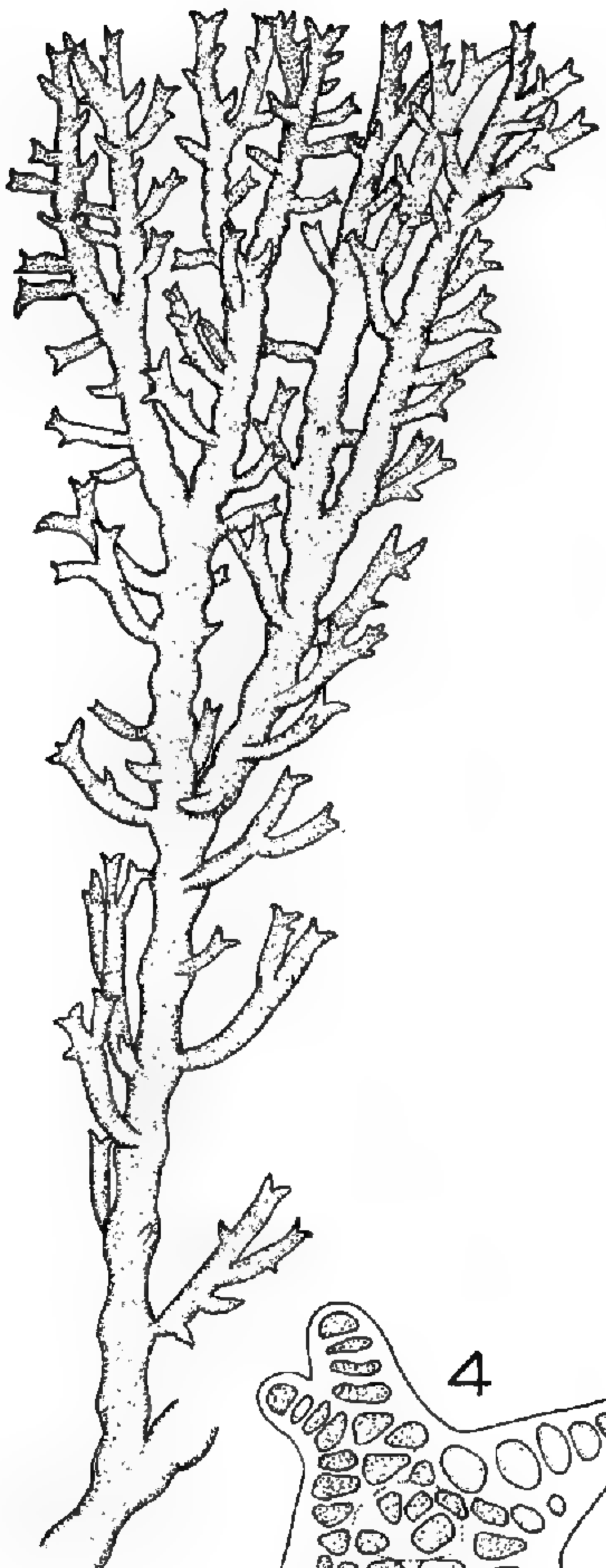
PLATE 1

**Figs. 1–3.** *Ceramium viscainoense.* **1.** Habit of a portion of the type specimen, × 7.5. **2.** Terminal part of a tetrasporangial branch of the same, × 30. **3.** Longitudinal section of an older node, × 80.

**Figs. 4–5.** *Ceramium sinicola.* **4.** Apex of a mature branch to show spine, × 300. **5.** Part of a typical branched rhizoid, × 120.

**Fig. 6.** *Ceramium codicola.* A typical, unbranched, bulb-tipped rhizoid, × 120.

**Figs. 7–9.** *Ceramium obesum.* **7.** Habit of part of the type specimen, × 5. **8.** Outline of a mature apex to show forcipate tips, × 27. **9.** Longitudinal section through a main branch from the type specimen, × 55.



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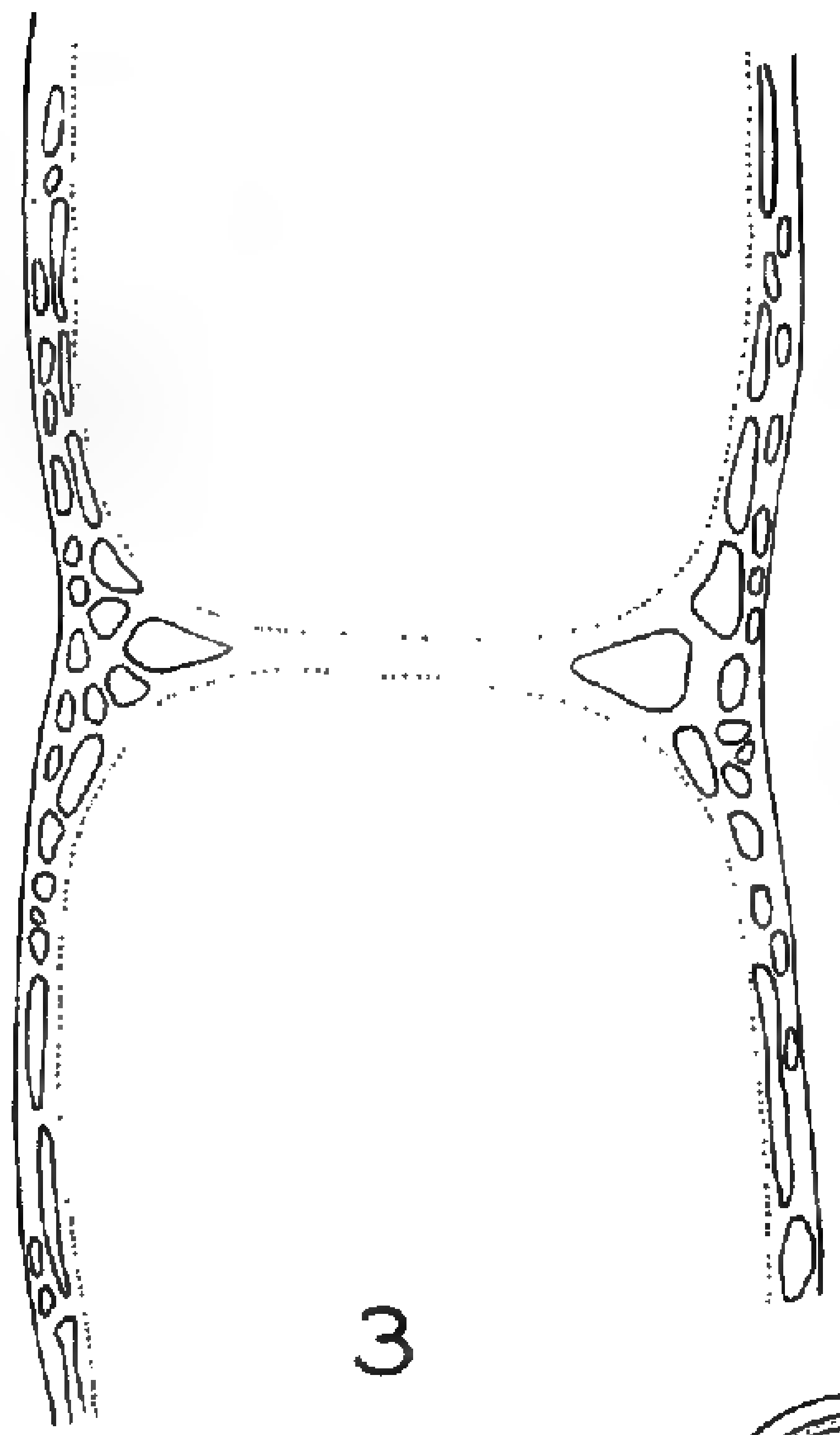

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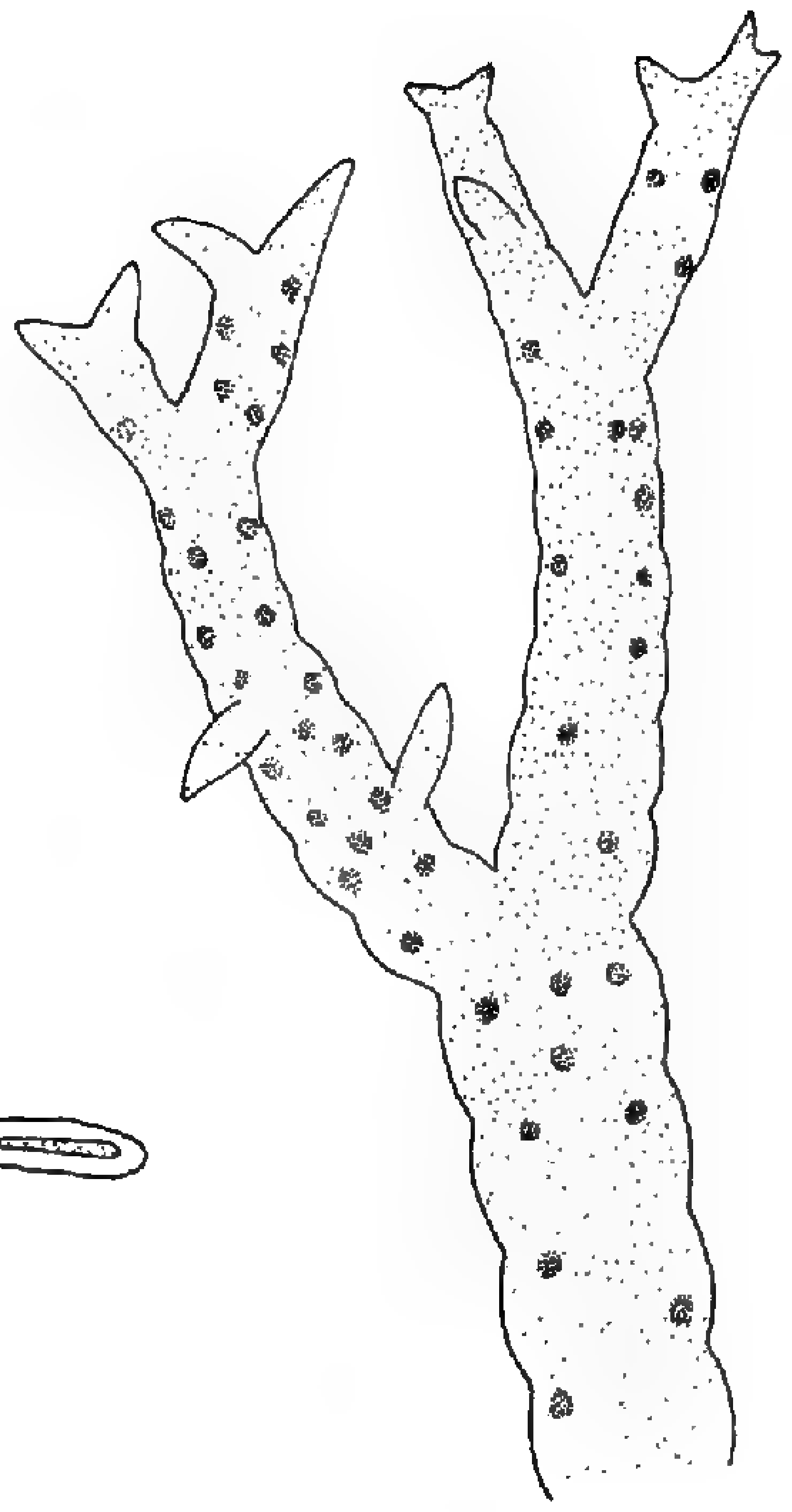

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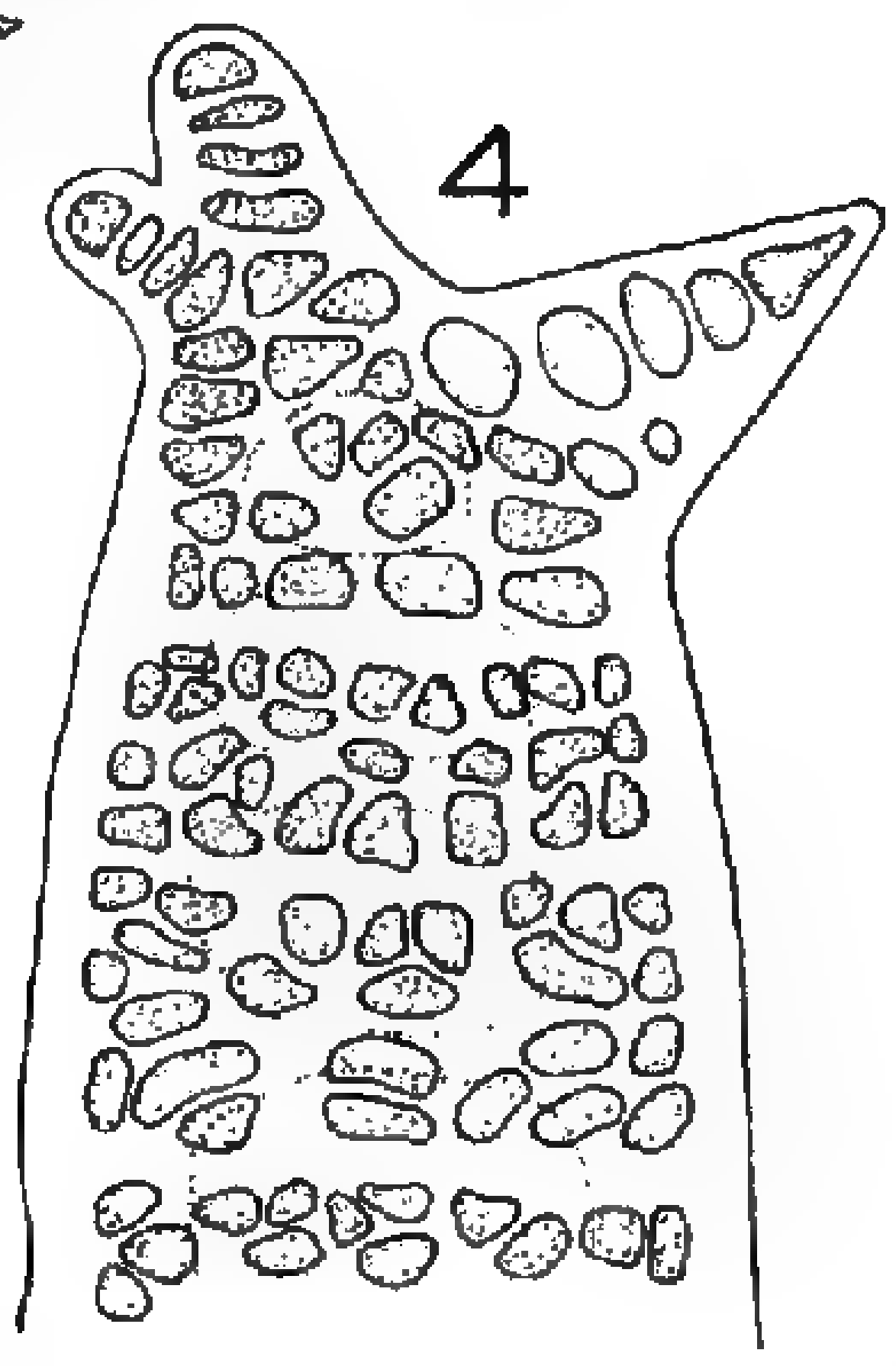

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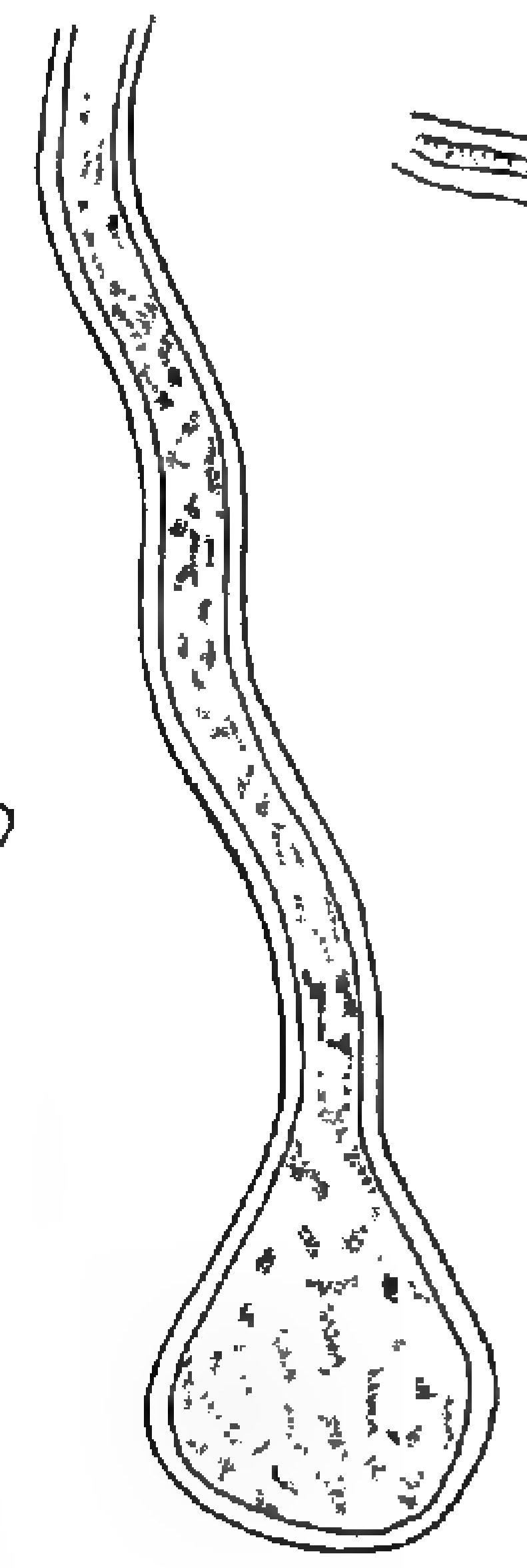

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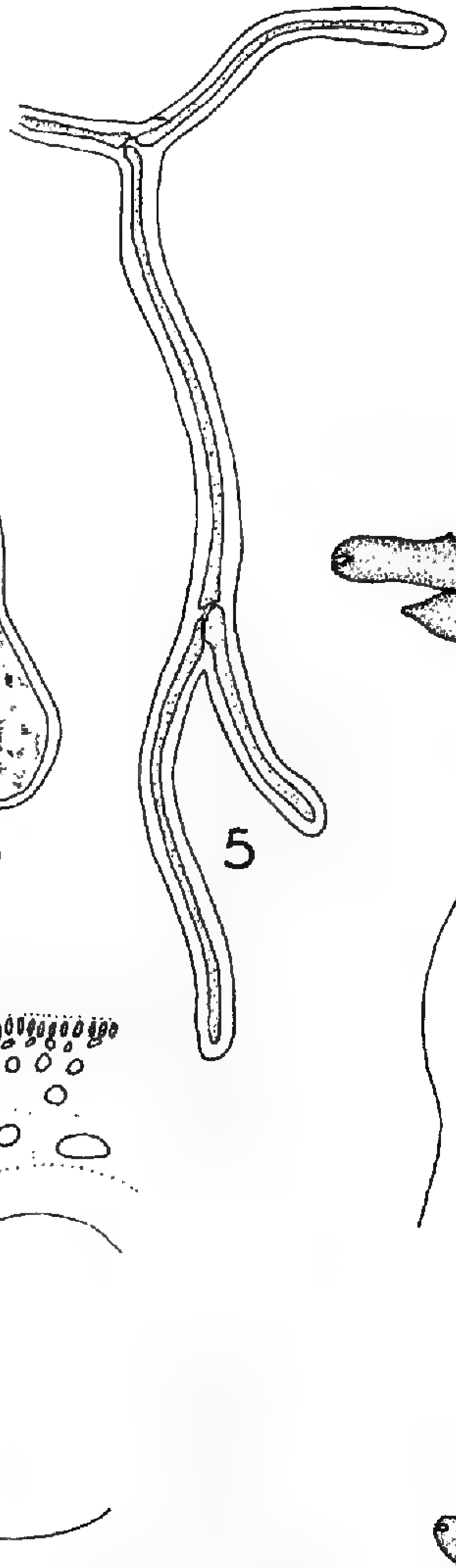

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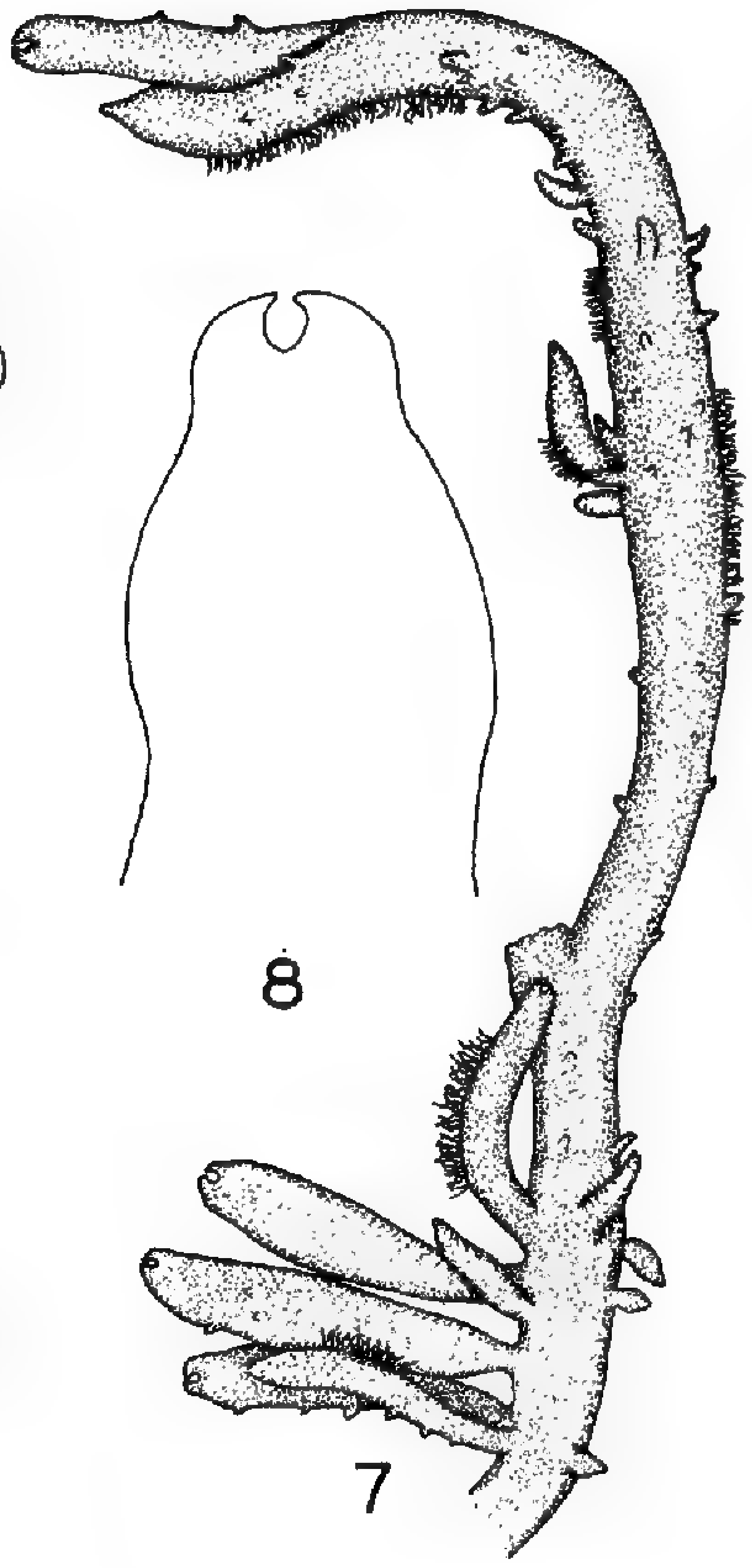

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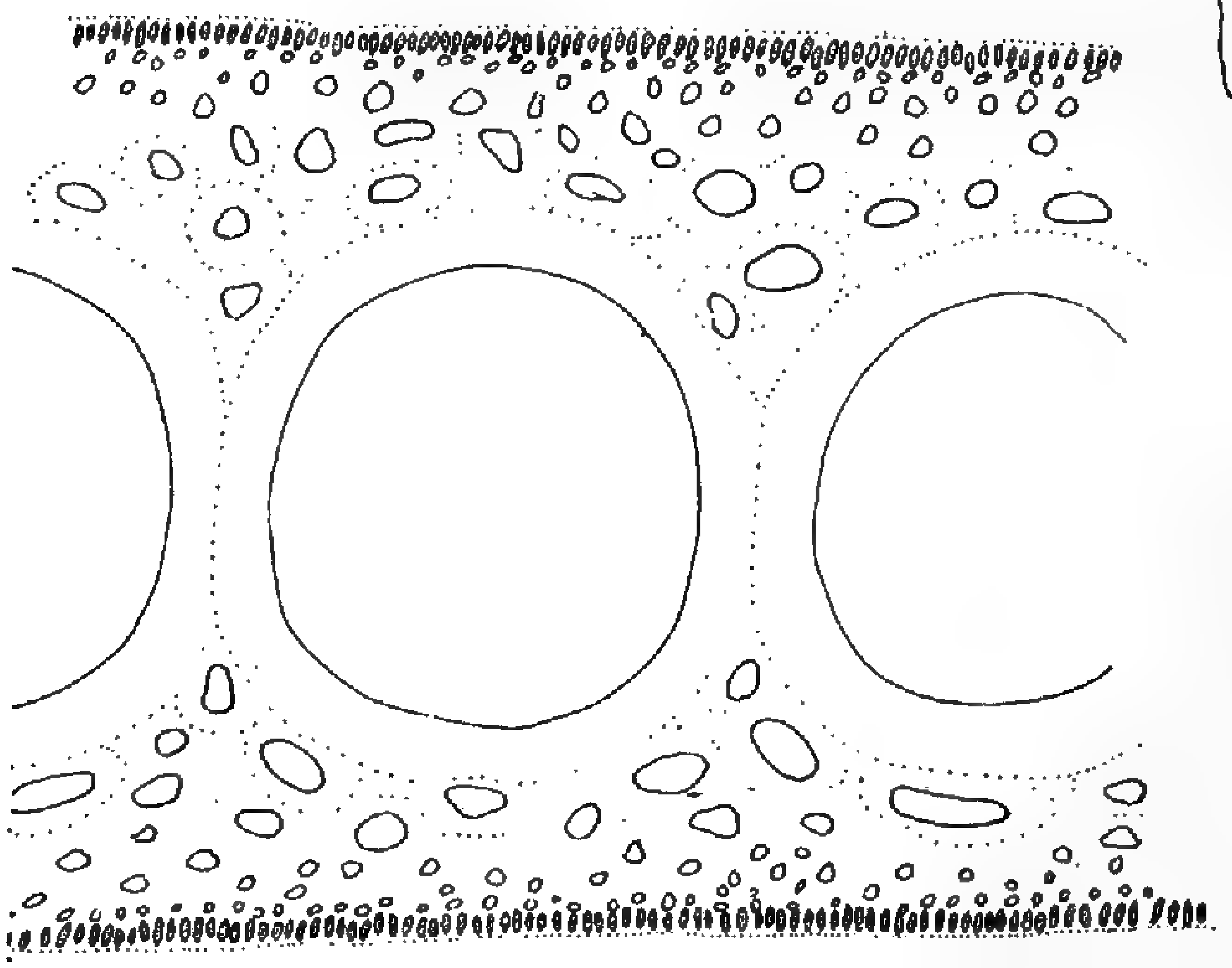

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Widely distributed along the California coast and northward to Vancouver Island, this plant has been reported in Mexico only from extreme northwestern Baja California. Recent collections include several luxuriant examples (Dawson 1509, 1610, 1557) from the area just south of Punta María at the northern edge of Bahía Viscaino.

The specimens of completely corticated *Ceramium* from southern Alaska cited by several authors under *C. rubrum* (see Setchell & Gardner, 1903) have not been reviewed, but they may be expected to represent far northern examples of *C. pacificum*.

### 8. CERAMIUM WASHINGTONIENSE Kylin

Kylin, 1925, p. 62, fig. 41; Doty, 1947, p. 187.

This northern *Ceramium* appears to be the only one of our coast not to be expected to occur in Mexico. Kylin has pointed out several distinctions from its apparent near-relative *C. pacificum*. It is also notable that the continuous cortication above, with only thin separating lines between the nodes, becomes slightly discontinuous below as a result of the elongation of the internodes at a rate slightly greater than that of the growth (mainly basipetal) of the secondary corticating cell rows.

### 9. CERAMIUM PANICULATUM Okamura

Okamura, 1921, p. 114, pl. 179, figs. 8–16; Dawson, 1944, p. 319.

First reported in the eastern Pacific from Guaymas, Sonora, this interesting plant has recently appeared in several other Mexican collections: Dawson 1980, 3522, Guaymas, Sonora, 3237, Punta Palmilla, Baja Calif., 6810, Cabeza Ballena, Baja Calif., and 3637, Mazatlán, Sinaloa. It would seem to be restricted to the more tropical waters of the Pacific Mexican coast. Tetrasporangia found on Dawson 3237 are essentially like those of Japanese specimens.

It should be noted that in some cases, as in the Guaymas collections 3522 and 1980, that the spines on some branches may be only scantily developed, or occasionally not at all.

### 10. CERAMIUM HAMATISPINUM sp. nov.

Plate 3, figs. 20–22.

Thallis in algarum pulvinis intertextis, 90–130 μ diametro, distanter dichotome ramosis, ad nodos tantum corticatis; apicibus circinnatis; nodis verticillo spinarum 5–6 persistentium, crassarum, pro more uncinatarum, multicellularium armatis.

Thalli forming entangled masses amid small, mat-dwelling algae, the filaments 90–130 μ diam., or 50–70 μ diam. in young parts, irregularly and distantly, dichotomously, divergently branched, corticated only at the nodes; apices circinate; nodal cortex 40–60 μ long, of irregularly arranged small, angular cells and producing a whorl of 5–6 usually 3-celled, non-deciduous, stout spines 30–50 μ long with sharp, usually hooked tips, the hook directed basally; internodes elongating early, becoming 100–250 μ long in older filament parts; nodes occasionally with slender, accessory rhizoids; secondary cortical expansion essentially absent; reproduction not seen.

TYPE: Dawson 3706, intertidal, Mira Mar, Nayarit, Mexico, December 20, 1946. HAHF 48800.

This is one of the most distinctive of Pacific *Ceramium* species by manner of the conspicuous whorls of stout, usually hooked spines arising from the middle of each node and persisting throughout the life of the filament.

### 11. CERAMIUM EVERMANNII Setchell & Gardner

Setchell & Gardner, 1930, p. 169, pl. 8, figs. 28–29.

Although some sterile, southern California specimens such as Hollenberg 3343 from Corona del Mar correspond with this species in their vegetative features, *Ceramium Evermannii* remains positively known only from the type locality, Isla Guadalupe, Baja California. The specimens cited under this name by Dawson, 1945, have proved upon reëxamination to be *Ceramium californicum*, since emergent, rather than immersed, tetrasporangia have been detected.

### 12. CERAMIUM CALIFORNICUM J. Agardh

Plate 3, fig. 18.

J. Agardh, 1894, p. 45; Kylin, 1925, p. 61; 1941, p. 29; Collins, Holden & Setchell, in Phyc. Bor. Amer. no. 447. *Ceramium Evermannii* Setchell & Gardner, as interpreted by Dawson, 1945a, p. 62.

This species is amply distinct from our other incompletely corticate species by its tetrasporangial and cortical characters. The cortex is of small, irregularly disposed angular cells external to the larger, submerged nodal cells. The outer cortex grows by both basipetal and acropetal expansion such that in older parts it more or less completely covers the internodes. The projecting tetrasporangia distinguish this plant from the apparently closely related *C. Evermannii.*

Specimens are now at hand from several localities of northwest Mexico: Dawson 5164, 5183, 6494, Cabo Colnett; 1167, 1213, Punta Baja; 1510, Punta Santa Rosalía; 6711, Bahía Magdalena. In the latter specimens the internodes are short above and the cortex in lower parts completely covers the internodes. Most of the specimens examined show a more or less distinct constriction of the cortical band at the nodal junction.

### 13. CERAMIUM FIMBRIATUM Setchell & Gardner

Setchell & Gardner, 1924, p. 777, pl. 26, figs. 43–44; 1937, p. 88, pl. 7, fig. 18; Dawson, 1944, p. 317.

This readily recognized species has heretofore been recorded only from the Gulf of California and from extreme southern Baja California. Recent collections demonstrate its wide occurrence along the Pacific Coast of Mexico: Hollenberg 2571, Punta Banda, Baja Calif., Dec. 1938; Dawson 1407, Punta Santa Rosalía, Baja Calif.; Williams 4/24/46, Scammon Lagoon, Baja Calif.; Dawson 6826, Cabeza Ballena, Baja Calif.; Dawson 3596, Mazatlán, Sinaloa; Dawson 3842a, Acapulco, Guerrero. It is closely related to the group of species including *C. Masonii*, *C. recticorticum* and *C. Taylorii* in which the tetrasporangia are whorled and involucrate, and in which the cortical band is divided at about the lower third into two distinct parts. In *C. fimbriatum* the cells of this lower cortical part are often horizontally elongated somewhat as in *C. Masonii.*

### 14. CERAMIUM RECTICORTICUM sp. nov.

Plate 3, figs. 23–24.

Thallis epiphyticis, e filamentis basalibus ope rhizoidum affixis; partibus erectis ad 3 mm. altis, 50–60 μ diametro, ad nodos tantum corticatis, alternatim ramosis; zonis corticalibus e cellulis rectangularibus factis horizontaliter elongatis, seriebus horizontalibus verticalibus bene formatis, opere ad nodi marginem superum tantum interrupto; tetrasporangiis verticillatis, involucratis.

Thalli epiphytic, 1.5–3 mm. high, often densely tufted, attached to the host by prostrate, basal parts of filaments bearing long rhizoids; branching apparently alternate; filaments 50–60 μ in diam. above, with non-forcipate, slightly incurved apices, corticate only at the nodes; cortical bands about 2/3 as long as broad, slightly tumid, consisting, except at the upper margin, of more or less rectangular cells horizontally elongated and arranged in about four definite horizontal and vertical rows, these regular rows maintained and usually unmodified by growth or enlargement below; internodes scarcely evident in uppermost 500 μ of branch tips, lengthening to 10–30 μ somewhat lower, and then elongating markedly to 300–400 μ in the entangled, basal filaments from which verticils of rhizoids arise at the nodes; tetrasporangia 20–25 μ diam., maturing within 300 μ of apex of terminal branches, borne in whorls of 3–5 (mostly 4) within the cortical band which is modified by their expansion to form an involucre; cystocarps and antheridia unknown.

TYPE: Dawson 1769, on *Coeloseira pacifica*, Bahía Bocochibampo, near Guaymas, Sonora, May 16, 1946. HAHF 48795.

Additional material: Dawson 501, 509, 455a, 1706, 1749, 1772, 3566, epiphytic on various hosts, Bahía Bocochibampo, Sonora; 3667, Mazatlán, Sinaloa.

This species differs from closely related *Ceramium Taylorii* by the strikingly regular arrangement of the cortical cells. At Bahía Bocochibampo,

PLATE 2

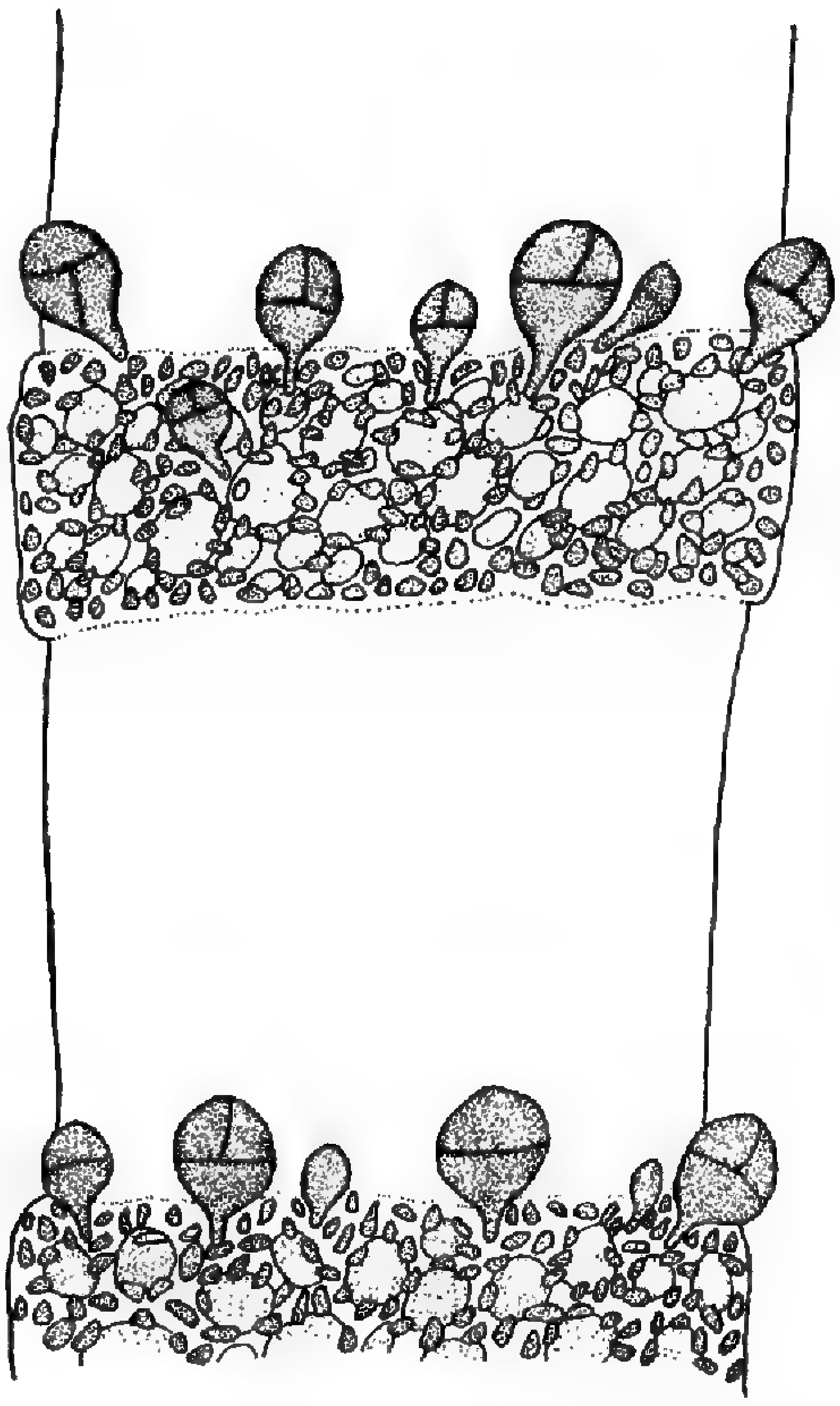
**Fig. 10.** *Ceramium ornatum.* A portion of a tetrasporangial filament from the type collection, × 125.

**Figs. 11–12.** *Ceramium Masonii.* **11.** Portion of the upper part of a plant of Dawson 3417 from La Paz, × 250. **12.** Portion of a filament of Dawson 6770 from Cabeza Ballena, × 250.

**Fig. 13.** *Ceramium Taylorii.* Portion 3 mm. from the tip of a filament of an uncommon form with broader and more medianly situated space between the two parts of the divided outer cortical band (Dawson 3675, Mazatlan) × 250.

**Figs. 14–15.** *Ceramium mazatlanense.* **14.** Upper part of a tetrasporangial plant to show short nodal bands and abaxial tetrasporangia, × 125. **15.** Part of a filament 1.5 mm. from the apex of a mature tetrasporangial plant of the type collection, × 250.

**Figs. 16–17.** *Ceramium affine* var. *peninsularis.* **16.** A sterile part of a filament from the type collection, × 225. **17.** A tetrasporangial node from the type specimen, × 330.



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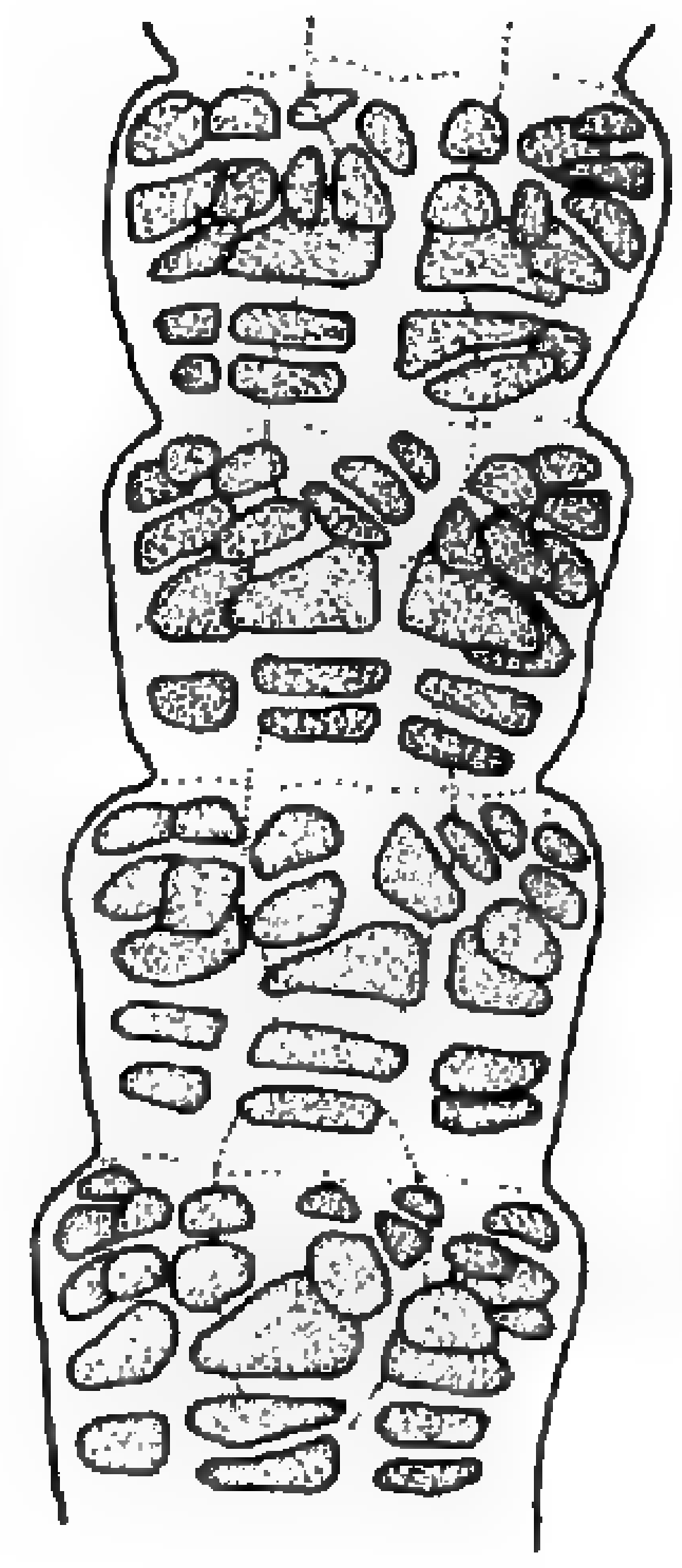

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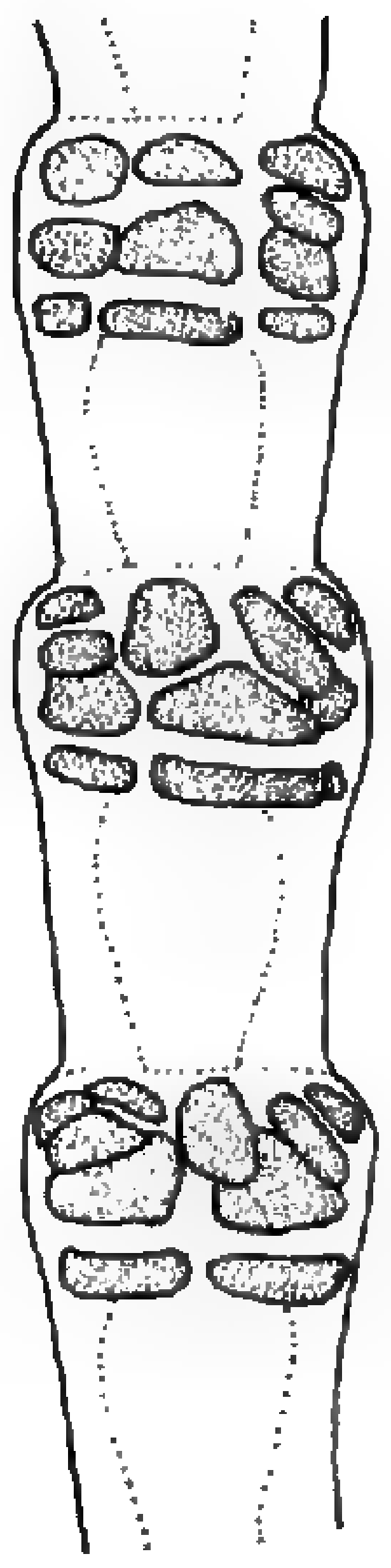

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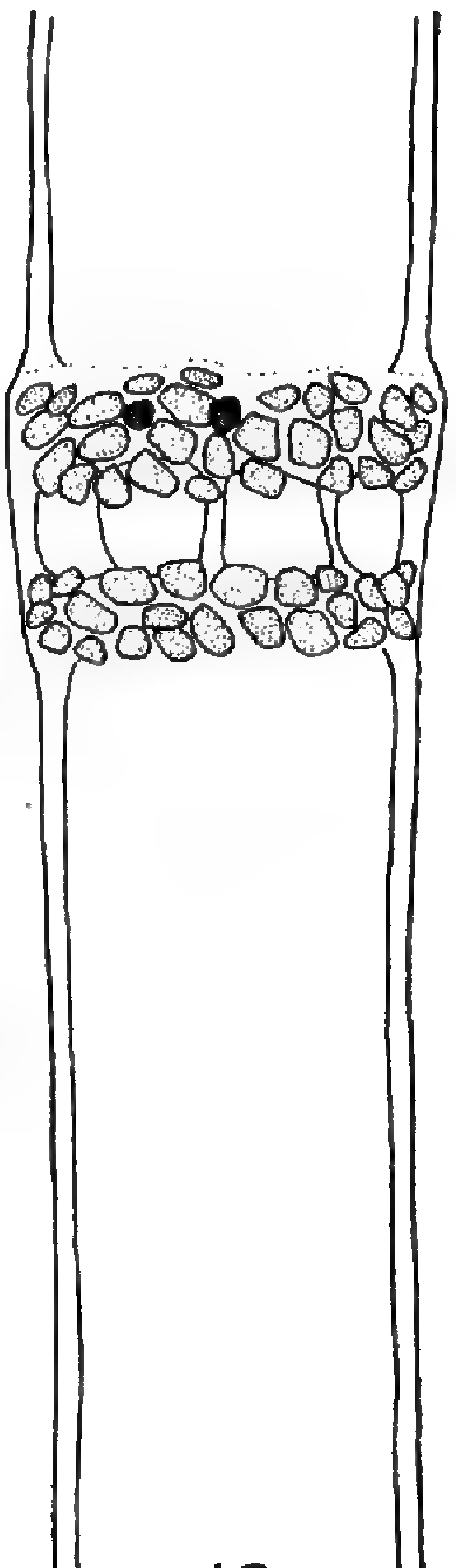

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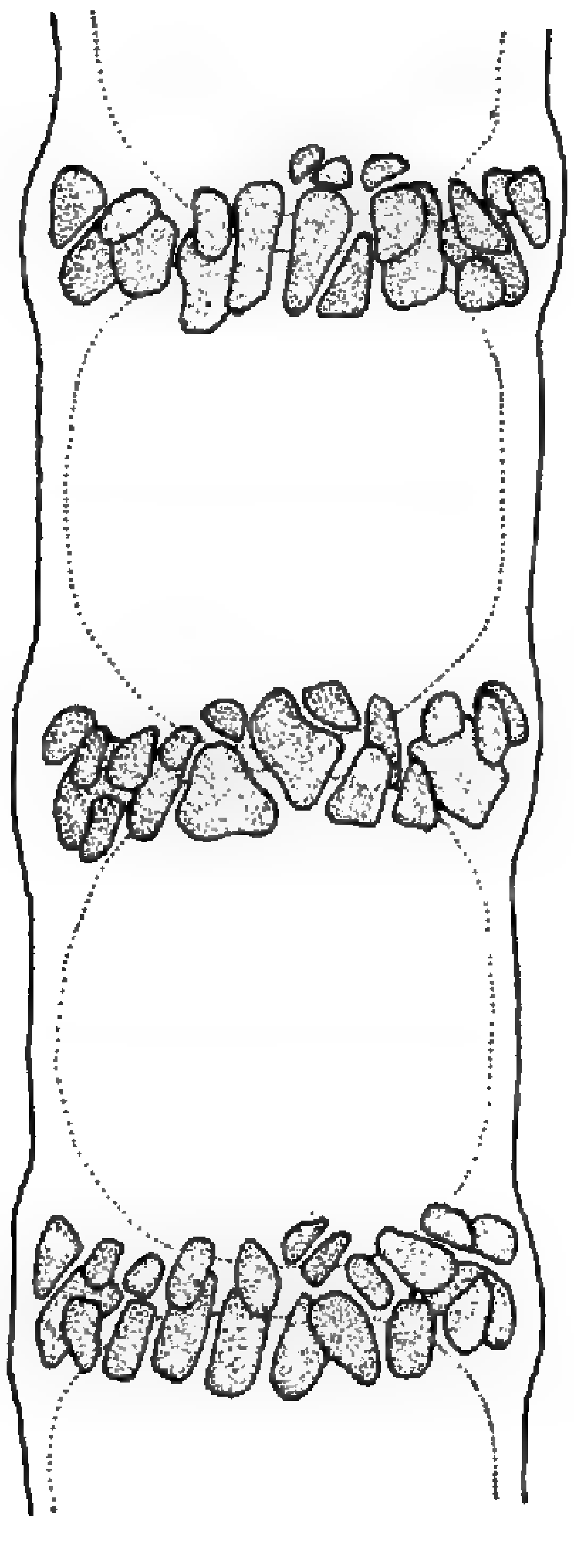

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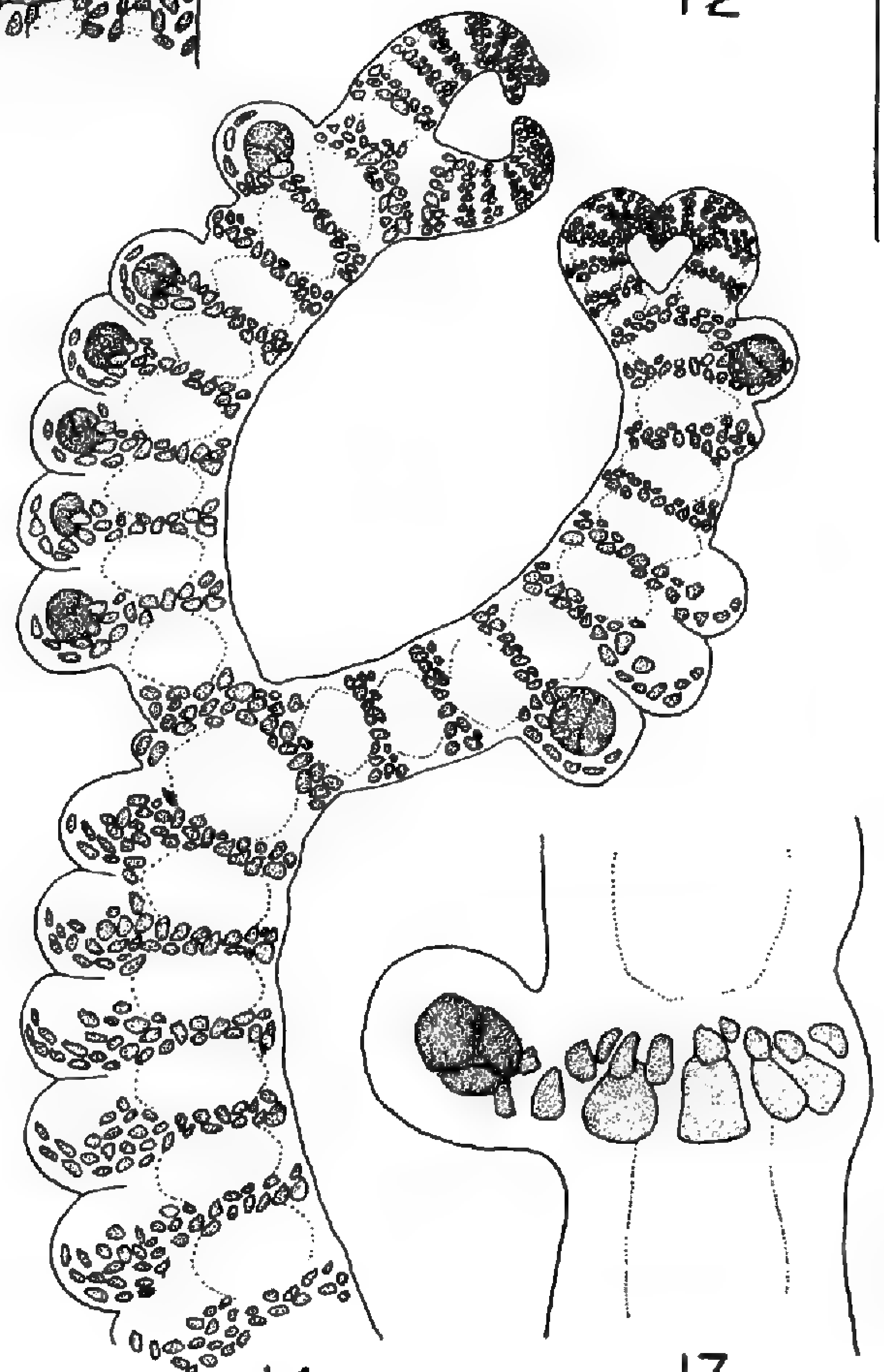

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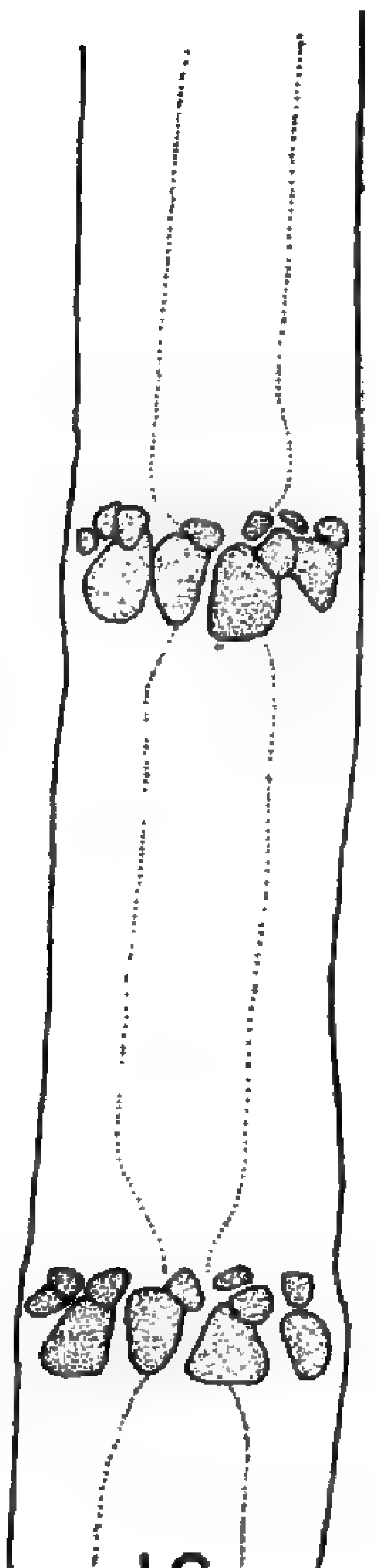

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where both species have been found growing together, they are easily distinguished.

### 15. CERAMIUM MASONII sp. nov.

Plate 2, figs. 11–12

*Ceramium gracillimum* Griffiths & Harvey, as interpreted by Dawson, 1944, p. 319. *Ceramium transversale* Collins & Hervey, as interpreted by Setchell & Gardner, 1930, p. 170, pl. 7, figs. 23, 24; Collins, Holden & Setchell, in Phyc. Bor. Amer. no. 2150.

Thallis epiphyticis ope rhizoidum affixis e filamentis inferis subprostratis vel intertextis orientibus, 4–5 (10) mm. altis, 40–50 μ parte supera diametro, parte infera 60–80 μ diametro tantum, ad nodos corticatis, alternatim ramosis; zonis corticalibus in tertio infero linea perspicua partitis, zonae ipsius tertio infero seriebus 1–2 cellularum elongatarum horizontaliter facto; tetrasporangiis verticillatis, involucratis.

Thalli epiphytic, attached by rhizoids from the nodes of semi-prostrate or entangled lower filaments, to 4–5 (or 10) mm. high, 40–50 μ diam. above, 60–80 μ diam. below, corticated only at the nodes, without secondary cortical expansion; branching apparently alternate; apices non-forcipate, slightly incurved; internodes long below, to 5 times the nodal diameter; cortical bands divided in their lower third by a clear line, consisting in the upper two thirds of larger, angular cells cutting off a few smaller, superficial cells, the lower third of 1–2 tiers of horizontally elongated cells; tetrasporangia whorled, borne within the cortical band which is modified by their growth to form an involucre; antheridia in whorled tufts at the nodes.

TYPE: Dawson 6756, epiphytic on *Galaxaura,* Cabeza Ballena, Baja California, Mexico, March 11, 1949. HAHF 48796.

Additional material: MEXICO — Dawson 6770, Cabeza Ballena; 3442, 3417, Bahía de La Paz; 470, Bahía Bocochibampo, Sonora; 3518, Ensenada de San Francisco, Sonora; 6730, Punta Frailes, Baja Calif.; 6631, Isla Margarita, Baja Calif.; Williams 5/14/46, Isla Cedros, Baja Calif.; Hubbs 46–144, Isla Guadalupe, Baja Calif., Dec. 1946 (identical with the specimens originally collected by Mason on Isla Guadalupe and assigned to *C. transversale* by Setchell & Gardner). CALIFORNIA — Hollenberg 2227, Corona del Mar, Dec. 1937; Phyc. Bor. Amer. 2150, Laguna Beach, Feb. 1913.

Study of the several species of Mexican *Ceramium* in which the cortical band is divided in its lower third has led to a reëxamination of the *Ceramium gracillimum* of Europe and the possibly synonymous *C. transversale* of the western Atlantic and Caribbean in an effort to determine more accurately the relationships of the Pacific Coast plant. At the outset it is assumed that the name *C. byssoideum* Harvey is to be considered synonymous with *C. gracillimum* Griffiths & Harvey in accordance with the studies of Feldmann-Mazoyer (1940). A comparison, then, of the Pacific plants and those of Europe recognized under the latter name has shown some significant differences. Chief among these are a greater regularity of the elongated cells of the lower part of the cortical band in the Pacific plant, the involucrate, whorled, tetrasporangial arrangement, and the absence of the conspicuous gland-cells of *C. gracillimum.* These differences appear to indicate that the Pacific American plants are not conspecific with the European. As for *C. transversale* Collins & Hervey, an examination of some of the type material from Bermuda shows no apparent vegetative difference, though the manner of production of tetrasporangia appears to be unlike that in the Pacific specimens. In *C. transversale* the tetrasporangia are sub-secund and only 1–2 at a node, while in the Pacific plants the tetrasporangia are regularly whorled and in groups of 3 or more.

Inasmuch as there appear to be many uncertainties in an attempt to identify our Pacific Coast specimens either with the European *C. gracillimum* or with the doubtfully distinct western Atlantic *C. transversale*, and in view of the apparent tetrasporangial differences in *C. Masonii*, it has seemed best to consider our Pacific plant as an independent species. The taxonomic history of many other of our plants earlier identified with Atlantic species lends support to this view.

### 16. **CERAMIUM TAYLORII** sp. nov.

Plate 2, fig. 13; Plate 4, figs. 31–33

*Ceramium fastigiatum* Harvey, as interpreted by Taylor, 1945, p. 271 (in part).
*Ceramium gracillimum* Griffiths & Harvey, as interpreted by Hollenberg, 1948, p. 158.

Thallis ope rhizoidum affixis a filamentis basalibus prostratis orientium; partibus erectis 5–16 mm. altis, diametro supra 60–80 μ, subtus ad 180 μ, ad nodos tantum corticatis, alternatim ramosis; zonis corticalibus subtumidis, in tertio infero linea perspicua partitis; zonae ipsius tertio infero in cellulis parvis angularibus partito; tetrasporangiis verticillatis, involucratis.

Thalli epiphytic or saxicolous, arising from prostrate filaments adhering by rhizoids from the ventral nodal surfaces, the erect parts to 5 (or to 16) mm. high, 60–80 μ diam. above, to 180 μ diam. below, apparently alternately branched; tips non-forcipate, divergent or somewhat incurved in youth; cortical bands somewhat tumid, about 2/3 as long as broad, separated by internodal spaces of 40 μ or less above, but sometimes to 150 μ below (or rarely to 700–800 μ in unusual plants of lax habit), divided in the lower third into two parts by a clear line, the cells in the lower third often at first horizontally elongated, but ultimately divided up into small, angular cells, the upper part of the band consisting of several larger, deep-seated cells cutting off smaller cells toward the top and outside of the band; tetrasporangia whorled, 2–6 at a node, about 30 μ diam., borne within the tumid upper 2/3 of the divided cortical band which becomes modified by their expansion to form an involucre; old branches bearing empty involucres appearing catenate; antheridia borne in a more or less continuous superficial layer on terminal branches above the region of internodal elongation, tending to be confined to adaxial surfaces; cystocarps borne terminally, surrounded and completely overarched by 5–6 long, clasping, involucral branches.

TYPE: Dawson 3393, Cabeza Ballena, Baja California, Mexico, November 9, 1946. HAHF 48797.

Additional material: PACIFIC BAJA CALIFORNIA — Dawson 211a, Punta Descanso; 7268, Bahía Santa María, Isla Magdalena; 1644, El Cardón, near Punta María; 1576, 1587, Bahía Los Ositos; 2814, 1425, Punta Santa Rosalía; 6708, Bahía Magdalena. GULF OF CALIFORNIA — 613, 617, 1898, 1962, 1969, 1982, 3520, Ensenada de San Francisco; 759, 786, 724, 744, 800, Isla Patos; 1002, 1018, Isla Partida; 1039, Isla Raza; 7176, Puerto Escondido; 7051, Isla Carmen; 3401, 3368, 3342, 3320, Cabeza Ballena. SINALOA — 3658, 3599, 3675, 3623, 3618, Mazatlán. NAYARIT — 3704, Mira Mar. GUERRERO — 3878, 3899, Acapulco.

Several specimens collected by Hollenberg in southern California, particularly at Laguna Beach, have been seen and verified as this species.

A comparison of Taylor's Mexican specimens with recent collections from Pacific Mexico and with typical *Ceramium fastigiatum* from the Atlantic revealed that two different species are involved. Superficially, in size, habit and in the tumid appearance of the cortical bands, *C. Taylorii* resembles *C. fastigiatum*, but in structure of the cortex they are quite distinct. *C. Taylorii* is particularly easily recognized by the fact that the cortex is divided by a distinct horizontal line, usually in its lower third, into two parts in which cell divisions in each are such as not to obscure or disrupt this line. In *C. fastigiatum* such a division of the cortex does not occur and the cells of the band are irregularly disposed with no special horizontal or vertical arrangement. This division of the cortex is similar to that in *C. Masonii*, but in that plant the cells of the lower part of the cortical band are distinctly horizontally elongated and remain so, while in *C. Taylorii* they become divided up in an angular manner. In *C. Masonii* the number of cell rows in the lower cortical third is usually at first one, later two. In *C. Taylorii* this lower part of the band is broader, usually of two tiers at first, later three or sometimes four. The division into angular cells may sometimes result in horizontally elongated cells, but these are of irregular shape and disposition.

### 17. CERAMIUM PROCUMBENS Setchell & Gardner

Setchell & Gardner, 1924, p. 772, pl. 27, figs. 51–54; Dawson, 1944, p. 318; Hollenberg, 1948, p. 158.

This small, epiphytic plant with extensive prostrate parts and conspicuous opposite branching, first reported in the Gulf of California, has been shown by Hollenberg to be a common epiphyte along southern California. He has also collected it on Santa Catalina Island, California (Hollenberg 759, April 1935). His California specimens have been verified and compared with material from various hosts taken both along Pacific Baja California (Dawson 2763, 2800, Punta Santa Rosalía) and in the Gulf of California (1323, Bahía de Los Angeles, Baja Calif.; 1816, Ensenada de San Francisco, Sonora).

### 18. CERAMIUM EQUISETOIDES Dawson

Dawson, 1944, p. 320, pl. 51, fig. 1. *Ceramium sinicola* var. *interruptum* (Setchell & Gardner) Dawson, as interpreted by Hollenberg, 1948, p. 158 (in minor part).

The type has been reëxamined and compared with several new collections from the Gulf of California. It now appears that this species may be related, because of its immersed tetrasporangia, both to *Ceramium procumbens* and to *C. sinicola,* from which it is distinguished, respectively, by its lack of opposite branches, and by its characteristically elongated internodes and proportionally short cortical bands. In some instances the tetrasporangial branches are 2–3 times forked and occasionally with the swollen fertile parts interrupted just above the dichotomies by 1–2 vegetative segments with ecorticate internodes, somewhat as in *Ceramium sinicola* var. *interruptum.*

Recent collections from five stations between Puerto Libertad, Sonora and La Paz, Baja California confirm the wide range within the Gulf of California. Hollenberg's material from Balboa Harbor, California, including his no. 1082, Oct. 1935, agrees with this species. Its occurrence in the protected harbor appears to be in accord with the ecological requirements of the species as indicated by its habitat in the Gulf of California.

### 19. **CERAMIUM SERPENS** Setchell & Gardner

Setchell & Gardner, 1924, p. 775, pl. 27, fig. 58; Dawson, 1944, p. 318.

This species is similar in size and in the involucrate tetrasporangia to *Ceramium Camoui,* but the tetrasporangia are usually solitary at the nodes rather than in whorls. The involucre, thus, is unilateral. Plants may be much taller than the type, though of the same filament diameter. Dawson 3132 from La Paz, Baja California is topotypic, but is more than 10 mm. high, with elongated internodes below. A collection from Punta Palmilla, Baja California, Dawson 3264, contains specimens identical with the type illustration.

Perhaps related here is a plant from Cabo Pulmo, Baja California, Dawson 3097, epiphytic on *Dictyota crenulata.* It has solitary, emergent, non-involucrate tetrasporangia and heavier cortical bands with more tiers of cells than in *Ceramium affine.*

### 20. **CERAMIUM CAMOUII** Dawson

Dawson, 1944, p. 319, pl. 51, figs. 2–3.

This minute, inconspicuous plant with its highly developed tetrasporangial involucres grows entangled amid other microscopic algae on rock surfaces. Since it seems not to occur in pure stands of its own kind, it is easily overlooked and its presence has been detected thus far only in two of the recent Mexican collections: Dawson 1751, entangled with *Centroceras,* Bahía Bocochibampo, Sonora; 3467, entangled with *Polysiphonia,* La Paz, Baja California. A tetrasporic collection by Hollenberg, 2545, from the bay side of Punta Banda, Baja California, is identical with Dawson 1751 and places this species for the first time in the flora of the outer Pacific Coast. The cortical bands of *C. Camoui* are conspicuously tumid, extremely so when bearing tetrasporangia, and the internodes characteristically long.

### 21. **CERAMIUM GARDNERI** Kylin

Plate 3, fig. 19.

Kylin, 1941, p. 29; Smith, 1944, p. 325, pl. 84, fig. 2. *Ceramium californicum* J. Agardh, as interpreted by Gardner, in Phycotheca Boreali-Americana no. 2248.

Although this species has not been reported in California south of Monterey, two specimens in agreement with cotype material in the Hancock Foundation copy of Phyc. Bor. Amer. are at hand: Cooper 470, Dec. 1946 from Ventura, and Hollenberg 1325, April 1936, from Santa Cruz Island. It has not yet been identified with certainty in the Mexican collections.

*Ceramium Gardneri* is similar to *C. personatum* and may be distinguished by its tetrasporangia which are initially secund and adaxial. In *C. personatum* the tetrasporangia are at first abaxial.

The plants from Puget Sound and Vancouver Island cited by Collins (1913) as *Ceramium tenuissimum* (Phyc. Bor. Amer. 1298) and as *C. strictum*, are apparently related to *C. Gardneri* and are in need of further examination.

### 22. **CERAMIUM MAZATLANENSE** sp. nov.

Plate 2, figs. 14–15.

Thallis epiphyticis, 3–4 mm. altis, ope rhizoidum e filamento prostrato nascentium affixis, 90–110 μ diametro, ad nodos tantum corticatis; zonis corticalibus parvis, 25–30 μ, cellulis angularibus; tetrasporangiis emergentibus, secundis, 1–3 aggregatis in facie abaxiali ramorum, involucratis.

Thalli epiphytic, 3–4 mm. high, attached by rhizoids from the ventral surface of a prostrate, basal part of a filament; erect filaments 90–100 μ diam., rather irregularly dichotomously branched, corticated only at the nodes, without secondary cortical expansion; apices forcipate; cortical band very short, 25–30 μ long, consisting of angular cells 7–25 μ in greatest diameter, the largest below and beneath, bearing numerous fine hairs; internodes elongated below, sometimes to 150 μ; tetrasporangia projecting, secund, borne singly or in groups of 2–3 at the nodes on the abaxial sides

### PLATE 3

**Fig. 18.** *Ceramium californicum.* Part of a filament 1 cm. below the apex, from Dawson 5164, Cabo Colnett, × 100.

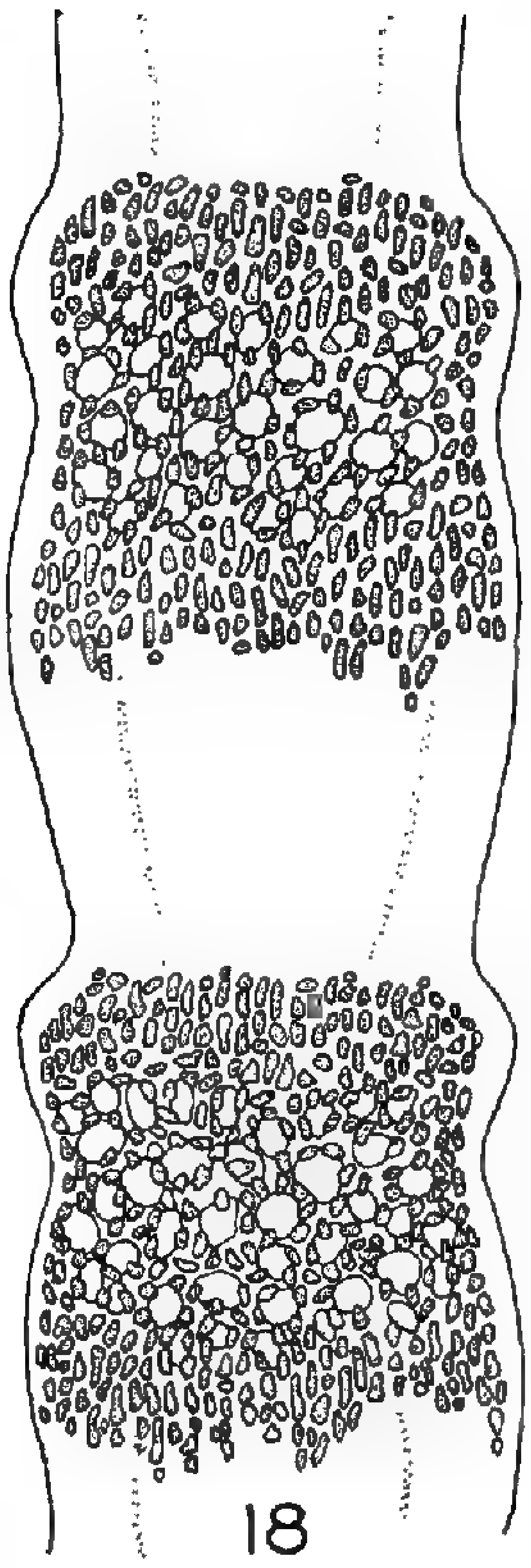
**Fig. 19.** *Ceramium Gardneri.* Part of a filament 1 cm. below the apex, from a cotype specimen in Phyc. Bor. Amer. no. 2248, × 100.

**Figs. 20–22.** *Ceramium hamatispinum.* **20.** Terminal part of a young filament from the type collection to show abundant spines and circinate tips, × 85. **21.** Detail of multicellular, hooked spine, × 550. **22.** Part of an old filament to show persistent, whorled spines, × 100.

**Figs. 23–24.** *Ceramium recticorticum.* **23.** A series of cortical bands from a subterminal portion of the type specimen, × 250. **24.** An older portion of a filament of the type specimen showing persistence of vertical rows of cells, the long internodes and rhizoids, × 250.

**Figs. 25–26.** *Ceramium avalonae.* **25.** A series of nodes near the apex of a topotype specimen, × 225. **26.** An older portion of a filament of the same plant to show lower nodes, × 350.

**Figs. 27–28.** *Ceramium zacae.* **27.** Young nodes of a plant from the type collection, × 225. **28.** Lower nodes of a plant from the type collection, × 350.



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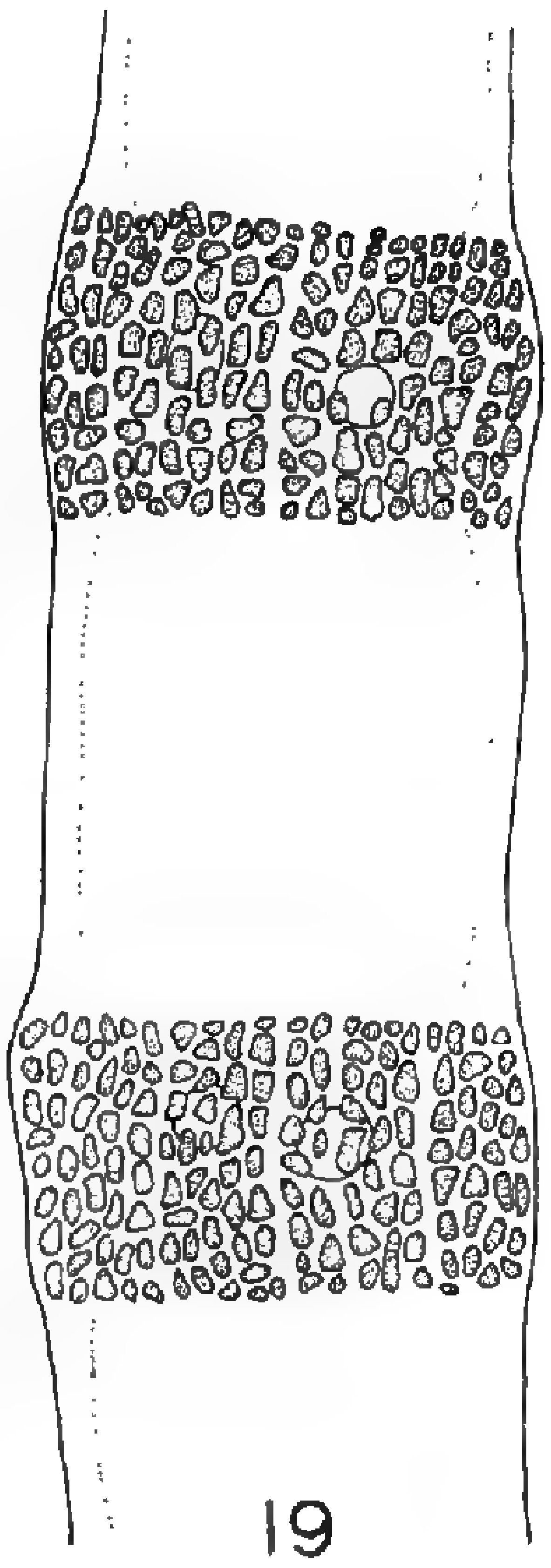

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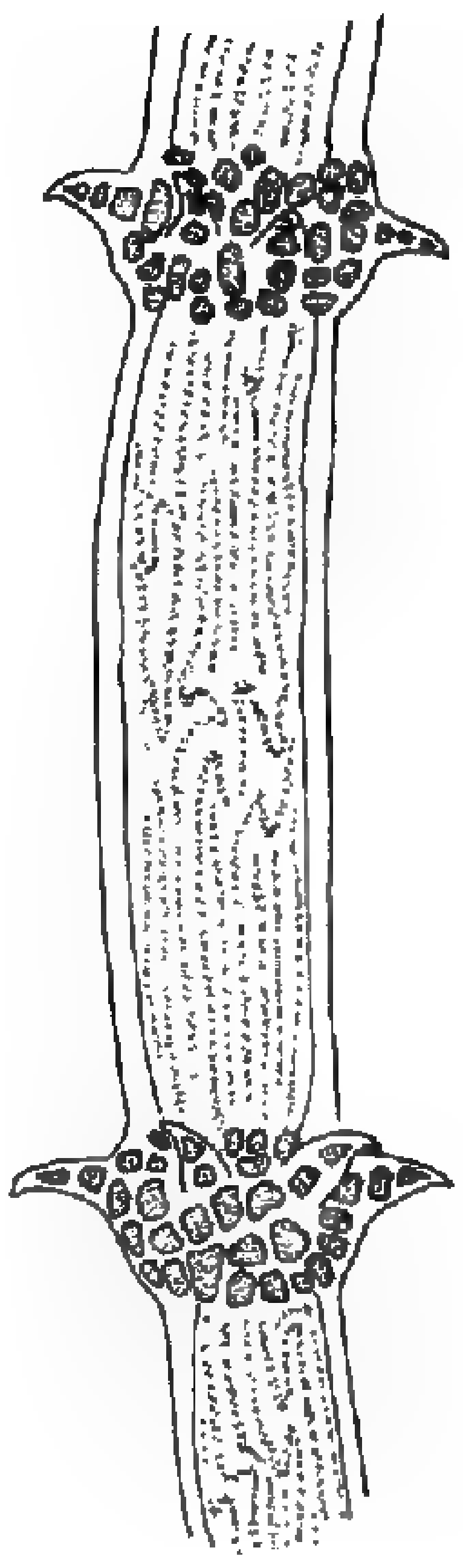

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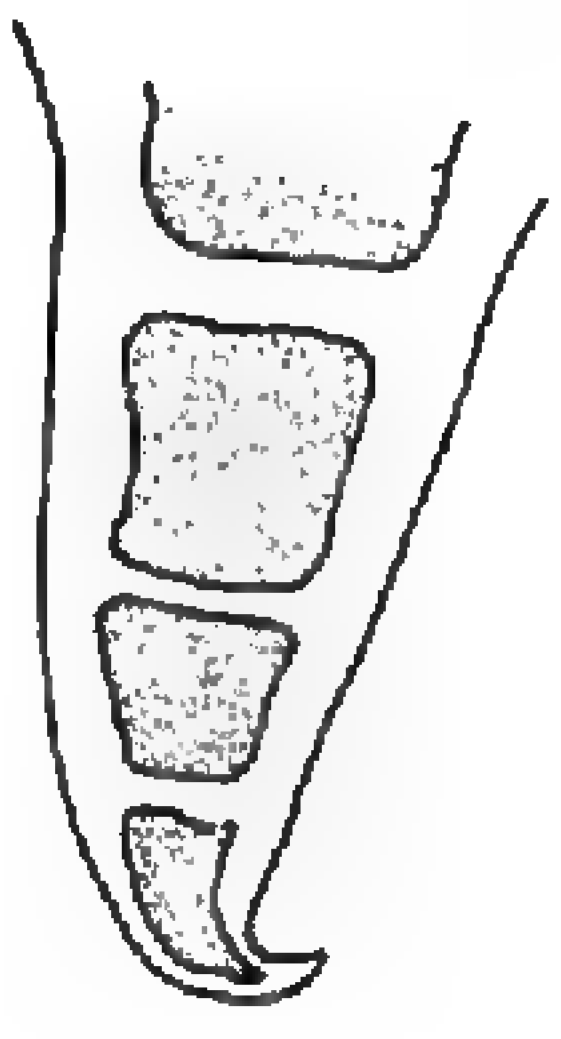

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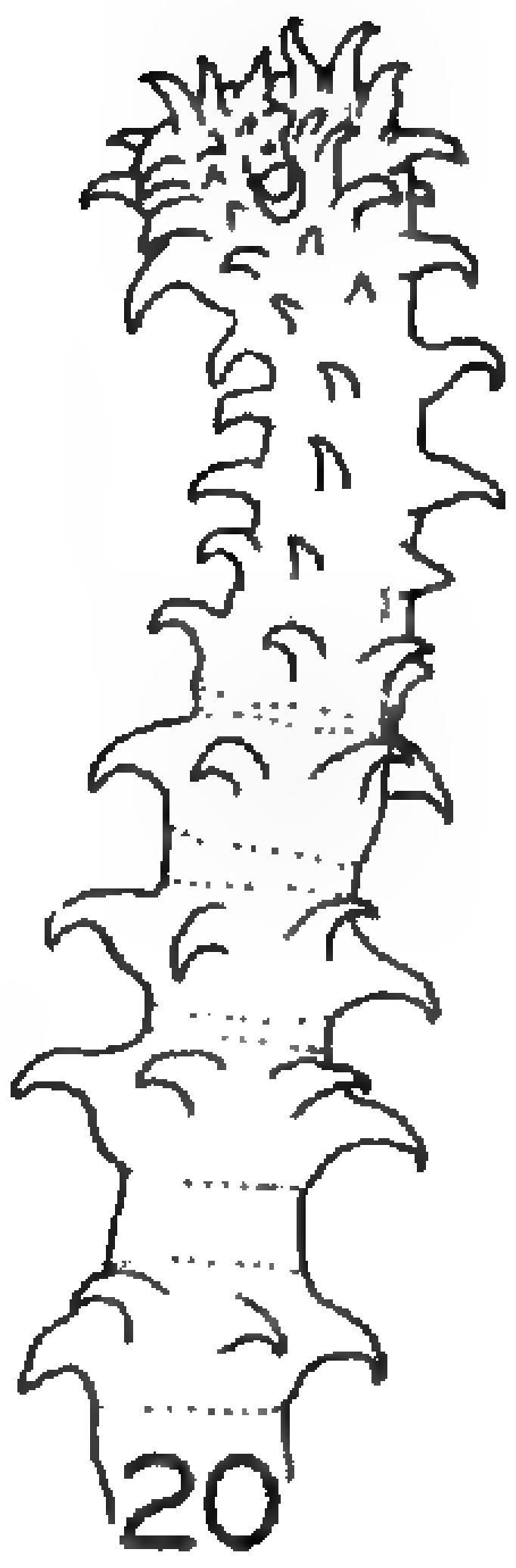

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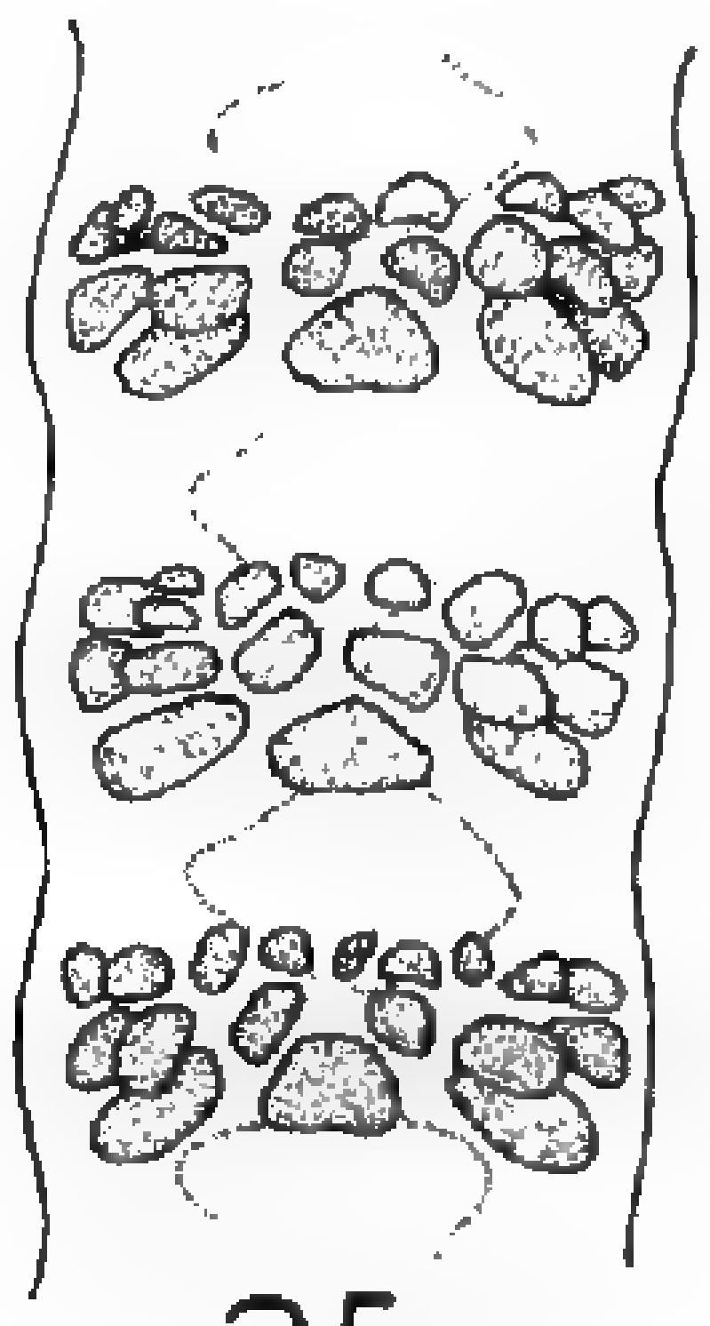

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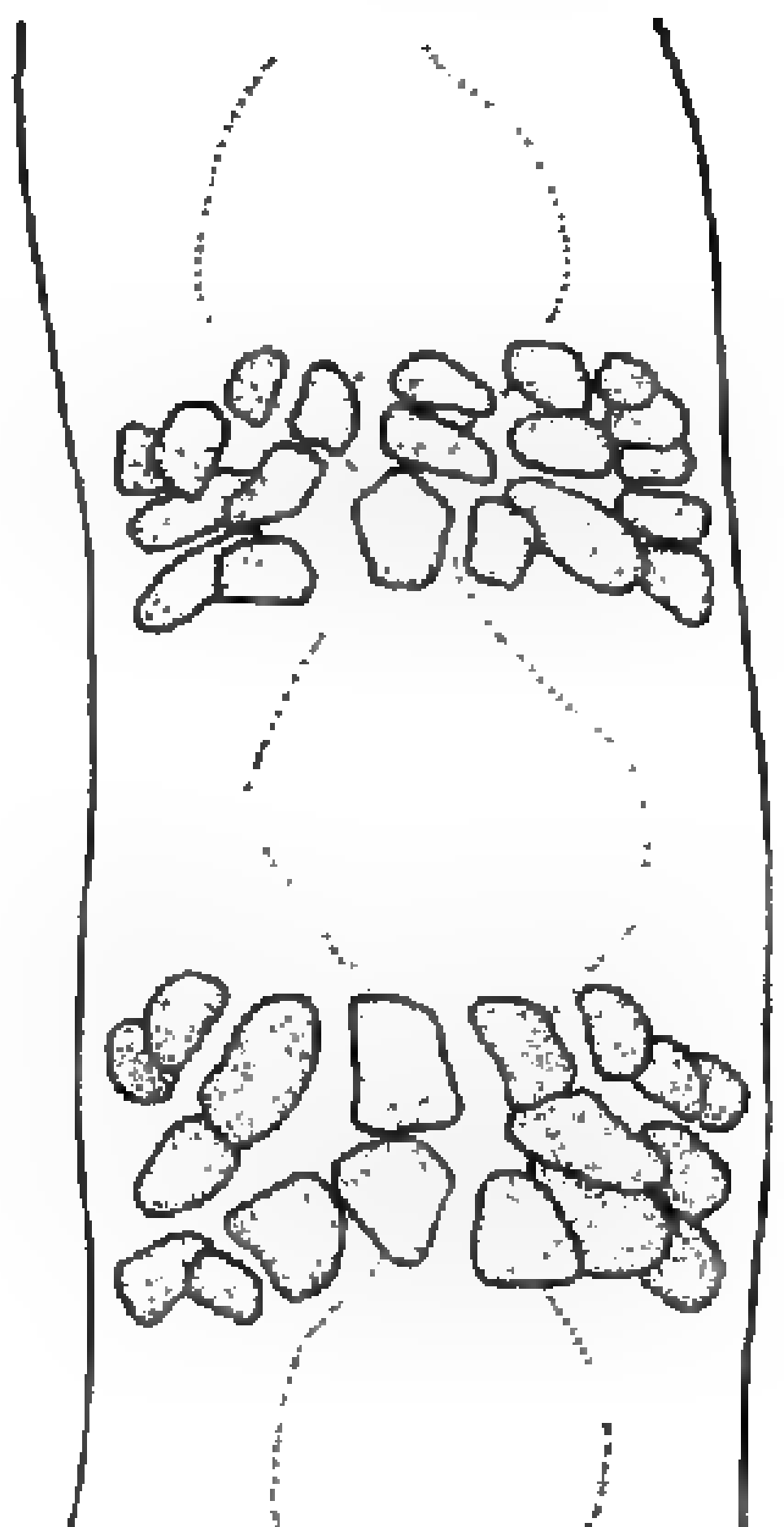

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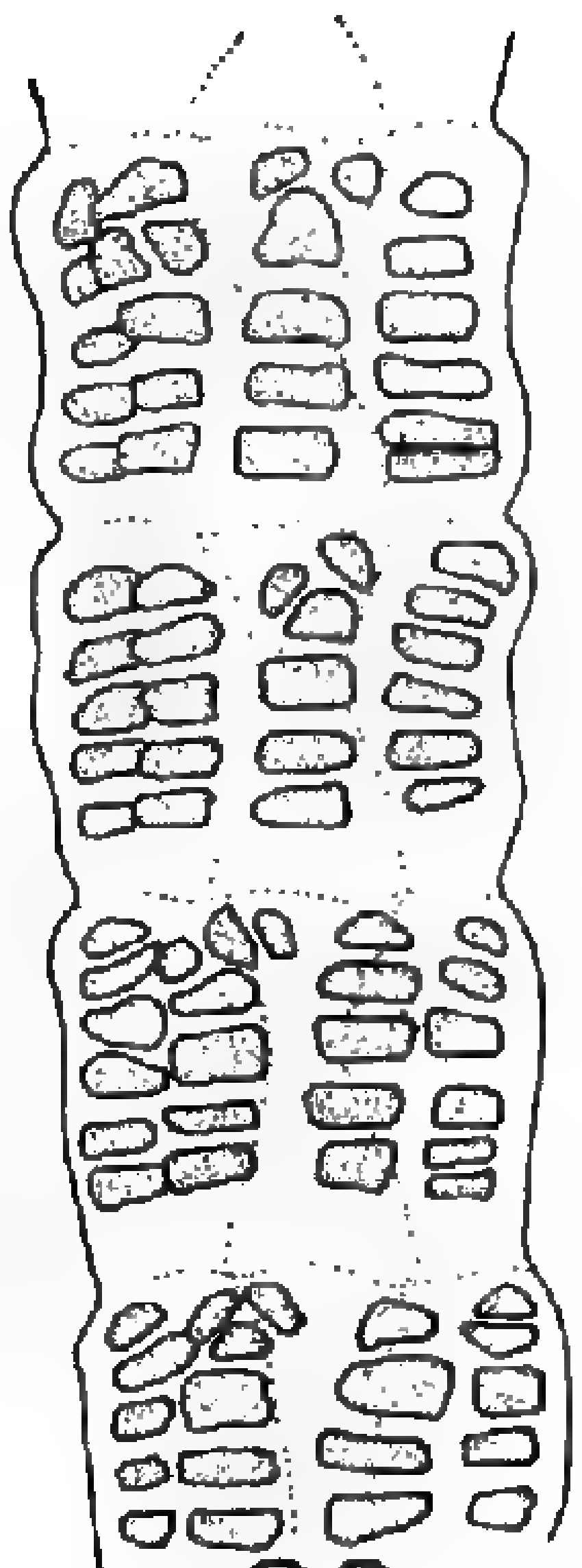

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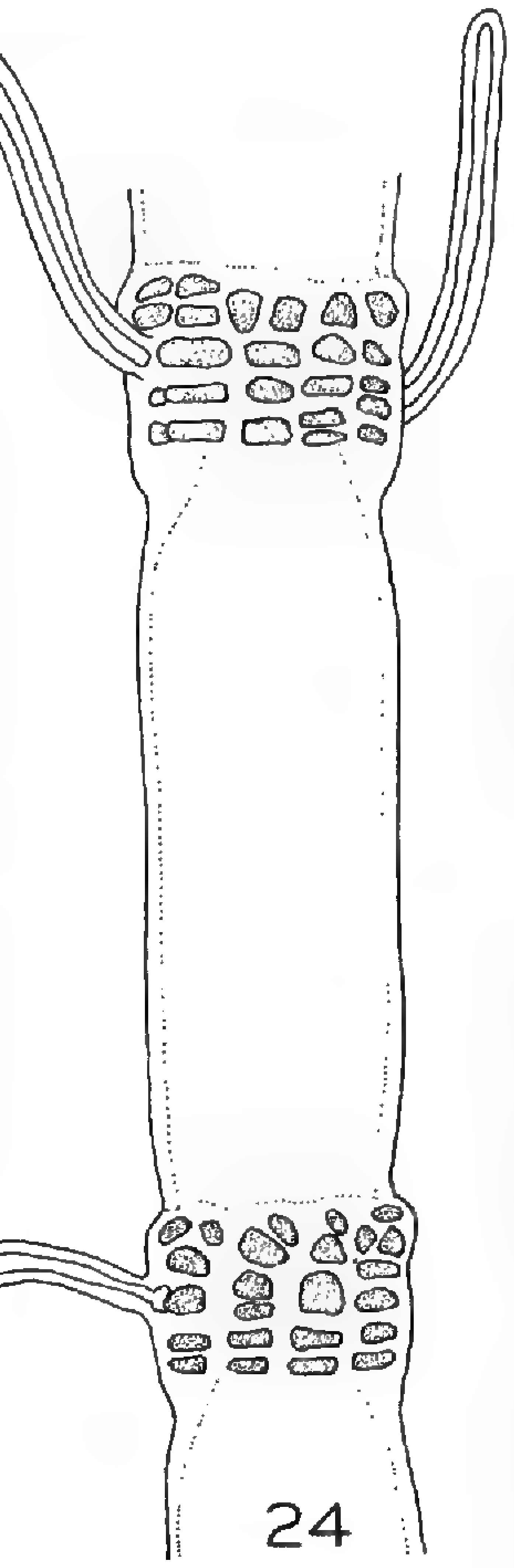

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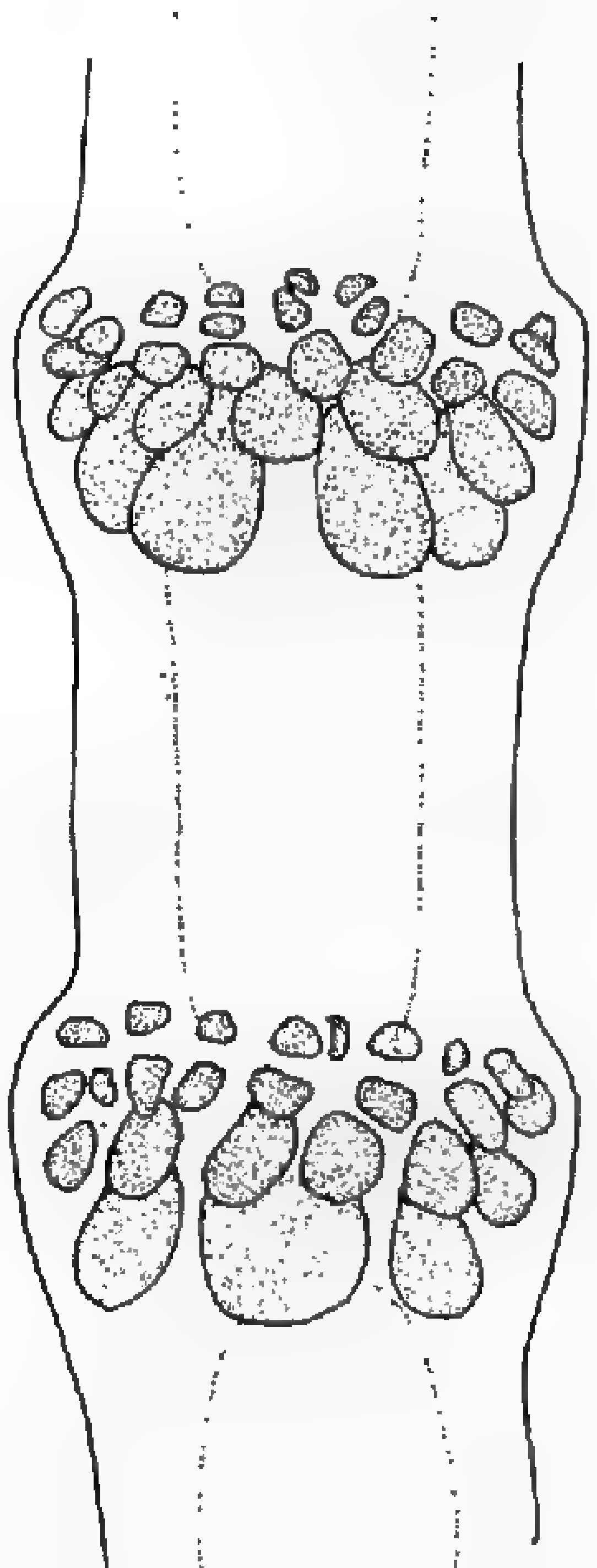

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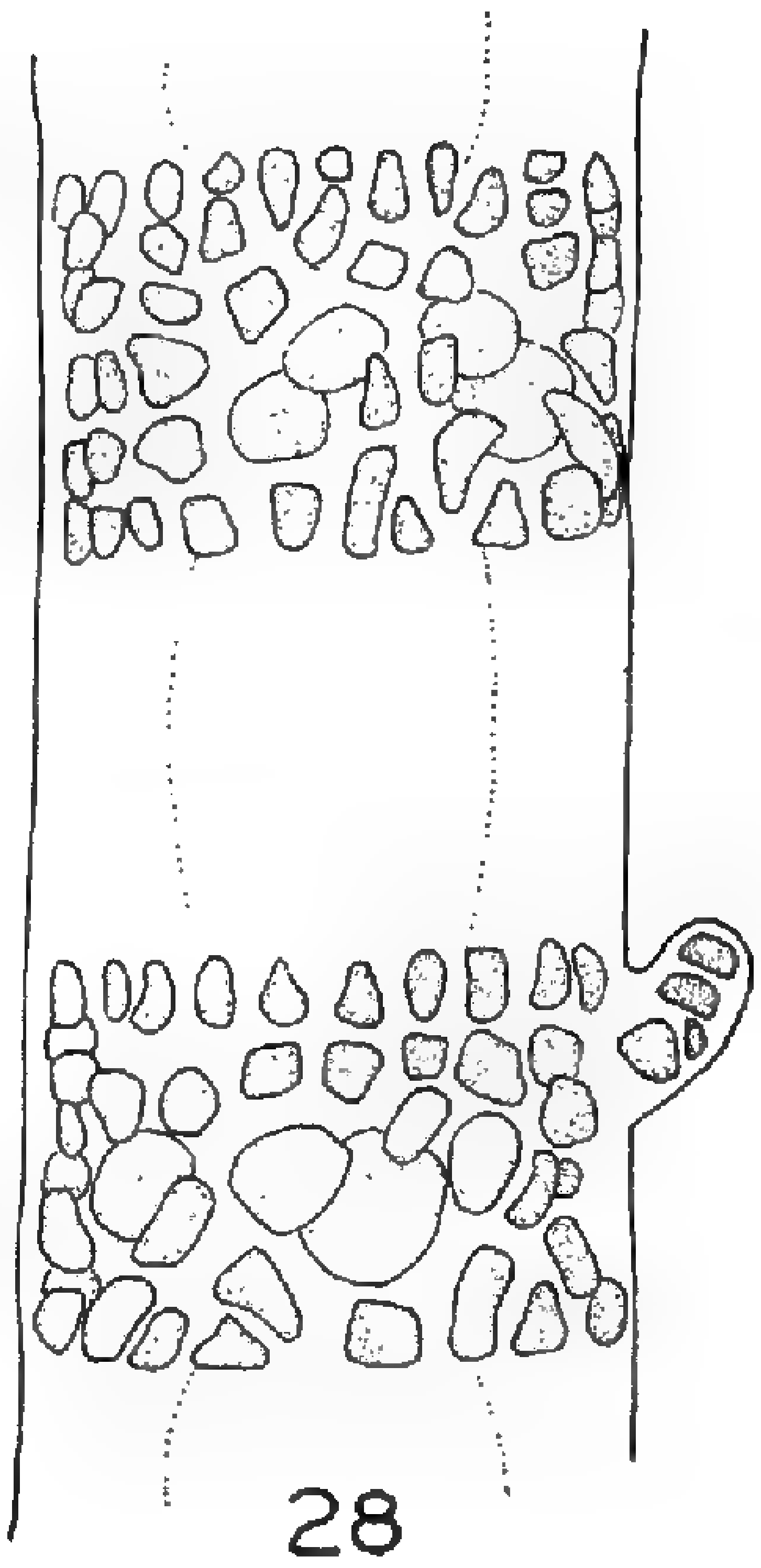

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of the branches, about 35 μ diam., half enveloped by a cortical involucre; antheridia in low, pulvinate masses at the nodes, partially or completely encircling them; cystocarps not seen.

TYPE: Dawson 3606, epiphytic on *Codium*, Mazatlán, Sinaloa, Mexico, December 8, 1946. HAHF 48798.

Additional material: Dawson 3815, 3819, at granite headland south of Salina Cruz, Oaxaca, Mexico, Jan. 1947; Dawson 40–657, rocky point just north of Kino, Sonora, July 16, 1940.

This species has a nodal structure suggestive of *Ceramium Gardneri* though the cortical bands are much shorter. The solitary, abaxial, involucrate tetrasporangia are further distinctive as well as the presence of creeping filaments "rooting down" to the host. The tetrasporangial specimens from Salina Cruz show regularly abaxial, strongly involucrate tetrasporangia, but do not have the circinately curved tips of the type. Their apices are more attenuate than those of the type and but slightly forcipate.

### 23. CERAMIUM AFFINE Setchell & Gardner

Plate 2, figs. 16–17.

Setchell & Gardner, 1930, p. 172; Dawson, 1944, p. 317, pl. 51, fig. 4.

The type material of *Ceramium affine* from Isla Guadalupe, Baja California apparently represents a slender variant of this species. Recent collections contain examples identical in form and reproduction with the type, but of larger size. The only specimens known in which the filament diameter is as small as in the type (24–28 μ) are those from Puerto Refugio in the Gulf of California (see Dawson, 1944). The large form of this species, found in several collections from Mexico and in one from southern California, exhibits vegetative characters of nodal cortication and internodal elongation virtually identical with the type, though the plants are of fully twice the size in all dimensions. Despite this range of size among vegetative parts of the two variants, the tetrasporangia are essentially the same in each: about 40 μ in diameter including the thick, hyaline envelope.

The name *Ceramium affine* var. **peninsularis** var. nov. is proposed for the large variant.

Cum speciei forma typica optime quadrante, at partis vegetativis duplo majore; tetrasporangiis pro ratione minoribus, formae typicae accedentibus.

Like the type of the species but twice the size in all vegetative dimensions, 60–70 μ diam.; tetrasporangia as in the type, approximately 40 μ diam.

TYPE: Williams, April 27, 1946, dredged in 4–6 m., Isla Concha, Scammon Lagoon, Baja California, Mexico. HAHF 48799.

Additional material: Williams, May 1946, Scammon Lagoon, Baja California; Dawson 6892, Punta Frailes, Baja Calif.; Hollenberg 1590, Corona del Mar, California, Nov. 1936.

The plant identified by Taylor, 1939, as *Ceramium fastigiatum* forma, from Punta Gorda, Baja California, is probably the same as the present plant.

It is proposed to designate the small variant represented by the type of the species as *Ceramium affine* var. **originale** nom. nov.

The plant from Ecuador referred questionably to *Ceramium affine* by Taylor, 1945, has been reëxamined. Although the tetrasporangial arrangement is similar, it appears to be an entirely distinct species.

### 24. CERAMIUM PERSONATUM Setchell & Gardner

Setchell & Gardner, 1930, p. 171, pl. 6, figs. 21–22.

Heretofore known only from Isla Guadalupe, this species has been detected in recent collections from the northern Bahía Viscaino. It seems closely related to *Ceramium Gardneri*, but may be distinguished by its tetrasporangia which are initially secund and abaxial, later becoming whorled. There may be considerable resemblance to *Ceramium zacae* in some instances, especially in tetrasporangial parts, but *C. zacae* differs by its short, lower internodes and non-tumid cortical bands, as well as by its non-bracteate tetrasporangia. The descending rhizoidal appendages within the internodal cells reported in the original description have been seen in each of the specimens and appear to provide a good specific character. Three collections from Pacific Baja California are referable here: Dawson 1511, Punta Santa Rosalía; 1575, 1594, Bahía Ositos. All have abaxial tetrasporangia more or less clearly involucrate by bracteate filaments. The Bahía Ositos collections include specimens up to 25 mm. high with quite tumid nodes and many secondary branchlets.

The specimens from Costa Rica referred questionably to this species by Taylor, 1945, are sterile and cannot be identified with certainty.

### 25. CERAMIUM AVALONAE Dawson

Plate 3, figs. 25–26.

Dawson, 1949, p. 17, pl. 5, fig. 31, pl. 14, fig. 56.

*Ceramium avalonae* shows considerable superficial, microscopic resemblance to *C. zacae* and has a similar tetrasporangial arrangement. The branching habit and the structure of the nodal cortication, however, are amply distinct. The disposition of the large cells in the lower part of the node, cutting off smaller cells above and toward the outside is a character which persists in older parts of the filaments. The outer cortical cells of *C. zacae* are irregularly arranged. In it the larger cells lie interior to the smaller ones and are ordinarily situated in the middle of the nodes rather than in the lower part. *C. zacae* is more abundantly branched above than *C. avalonae*, and the older nodes are not tumid as in the latter. The lower internodes of *C. zacae* are relatively shorter than in *C. avalonae*, being less than as long as wide, rather than 1.5 times as long as wide or more. New materials show that the tetrasporangia of *C. avalonae* are not necessarily solitary at the nodes as originally described, though the abaxial arrangement is maintained even when two or more tetrasporangia are produced at a node.

Several collections by the writer and by G. J. Hollenberg from the type locality, Santa Catalina Island, California have yielded *Ceramium avalonae*.

A tetrasporic specimen from Isla Guadalupe, Hubbs 12/7/46, extends its range into Mexican waters.

### 26. CERAMIUM ZACAE Setchell & Gardner

Plate 3, figs. 27–28.

Setchell & Gardner, 1937, p. 89, pl. 8, figs. 22a–22c; Dawson, 1945a, p. 62.

Recent collections by Hubbs, 8/20/46, from Isla Cedros near the type locality of *Ceramium zacae* at Bahía San Bartolomé, have yielded typical mature examples of this species. These plants show clearly the short internodes which distinguish *C. zacae* both from *C. avalonae* and *C. caudatum*. From *C. caudatum* it also differs by its non-tumid nodes which are not provided with whorled rhizoids or secondary uncinate branches as in that species.

The original description states that the tetrasporangia are arranged in two regular rows, one on each flank of the upper dichotomies, but re-examination of material from the type collection shows that the tetrasporangia are often whorled in groups of three or more at a node.

Some collections from southern California which serve to extend the known distribution of this species northward are: Dawson 343, La Jolla; Hollenberg 584.5, Corona del Mar; Dawson 5674, Santa Catalina Island.

### 27. CERAMIUM CAUDATUM Setchell & Gardner

Setchell & Gardner, 1924, p. 776, pl. 27, figs. 55–57; Dawson, 1944, p. 317.

*Ceramium caudatum* is a rather variable species which sometimes is difficult to determine by means of the key. It is in some ways similar to *C. zacae*, to *C. avalonae* and to *C. personatum*, particularly in its tetrasporangial parts. From *C. zacae* it is easily distinguished by its longer, lower internodes and tumid cortical bands. From *C. avalonae* it differs in larger size, in the irregular disposition of the cells of the cortical band, and in the whorled rather than typically abaxial tetrasporangia. From *C. personatum* it is distinct in its lack of descending appendages within the internodal cells and in the non-involucrate or non-bracteate tetrasporangia.

*Ceramium caudatum* is often provided with characteristic whorled rhizoids at the nodes and commonly produces uncinate accessory branchlets.

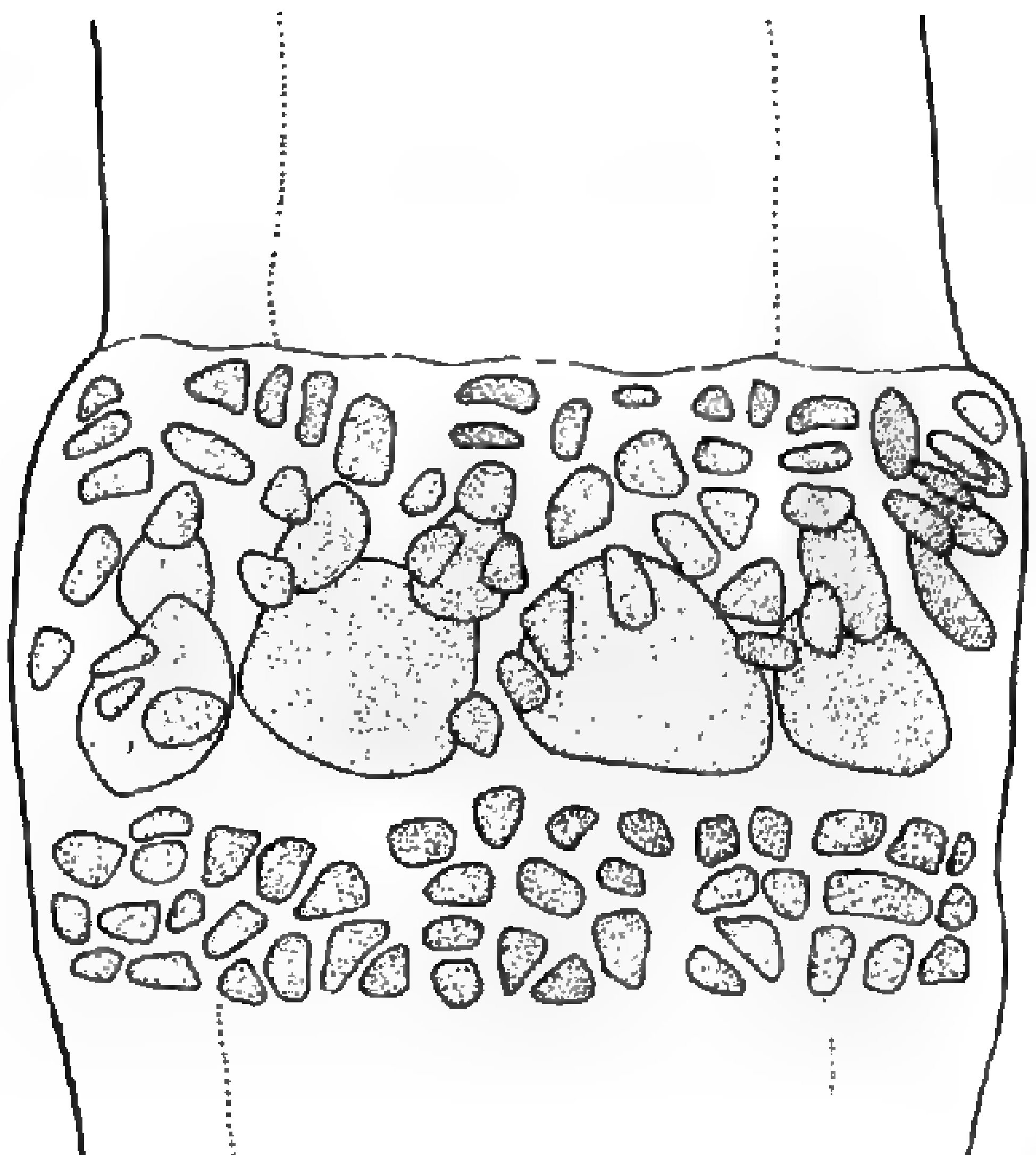
This species has recently been detected in several collections from the Gulf of California, the most typical being Dawson 3480, Bahía Empalme, Sonora, and 857, Isla Jorge, Sonora. Hollenberg has found typical material in southern California: Hollenberg 644, upper Balboa Harbor, and Hollenberg 820, Santa Catalina Island. A collection by Hubbs, 12/7/46, from Isla Guadalupe also appears to be referable here.

### 28. CERAMIUM CLARIONENSIS Setchell & Gardner

Plate 4, fig. 29.

Setchell & Gardner, 1930, p. 170, pl. 7, figs. 25–27.

The present study has shown that this plant is a common and easily recognized species both in the Gulf of California and along the Pacific Coast of southern California and Baja California. The moderately large



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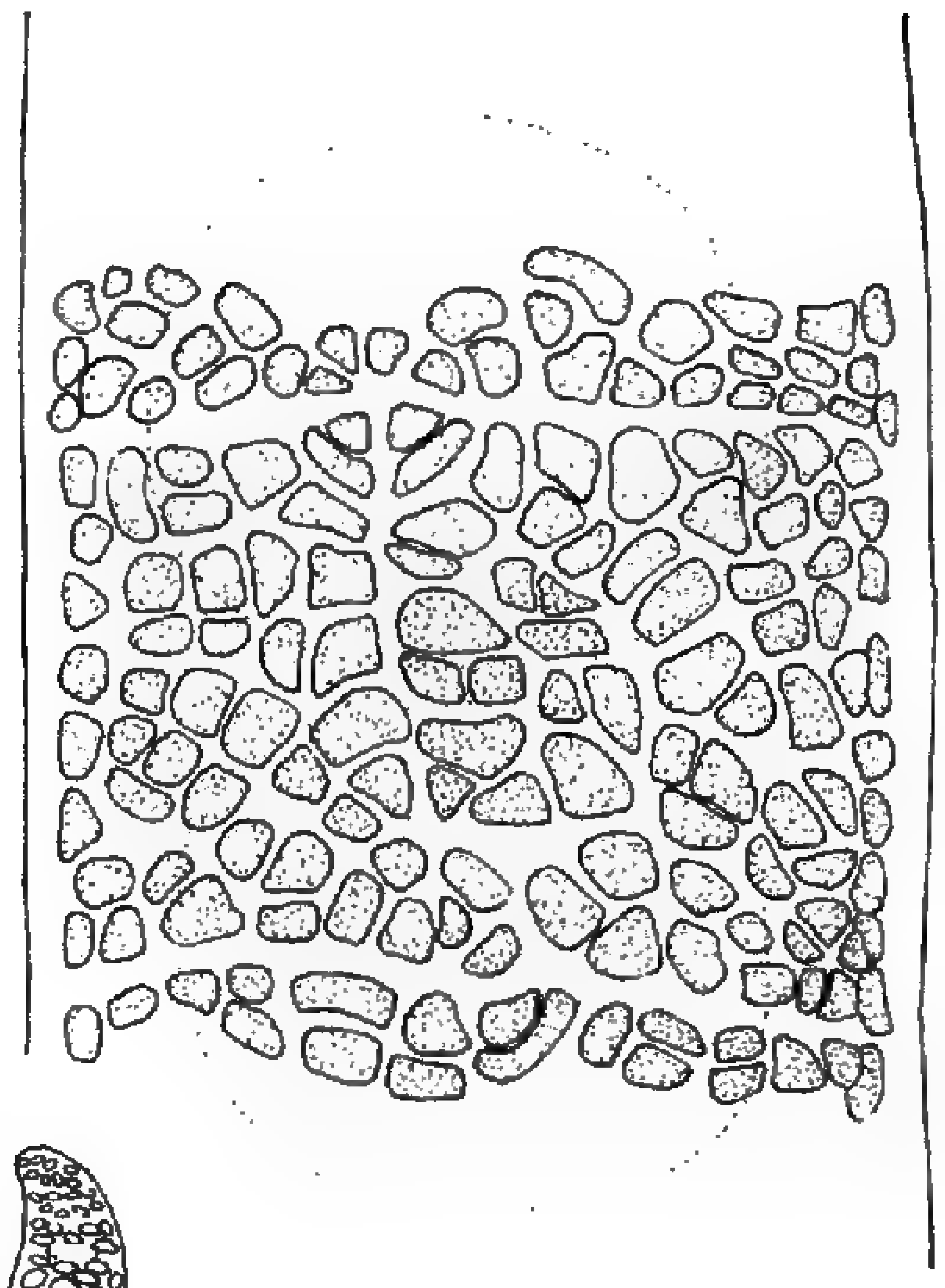

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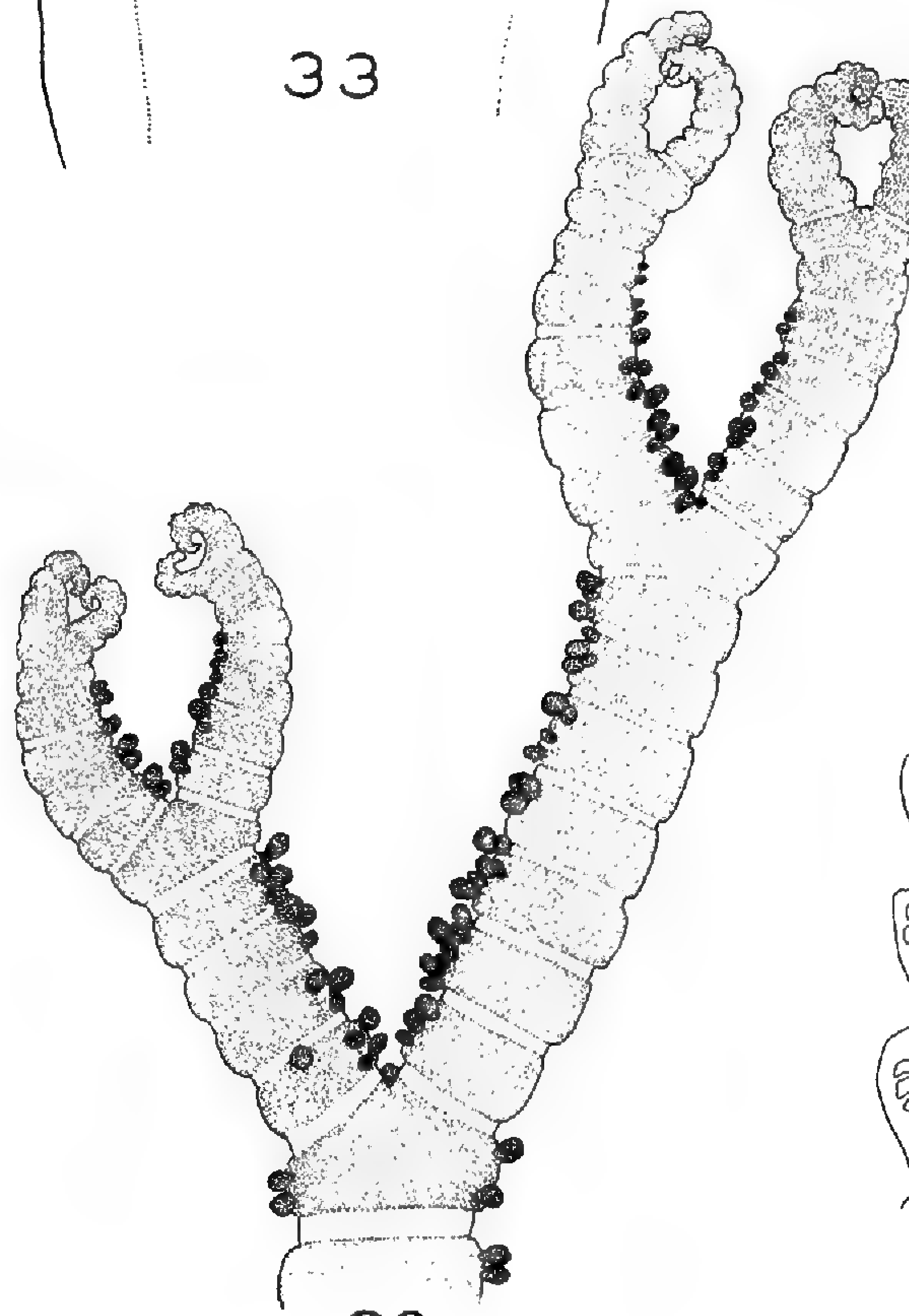

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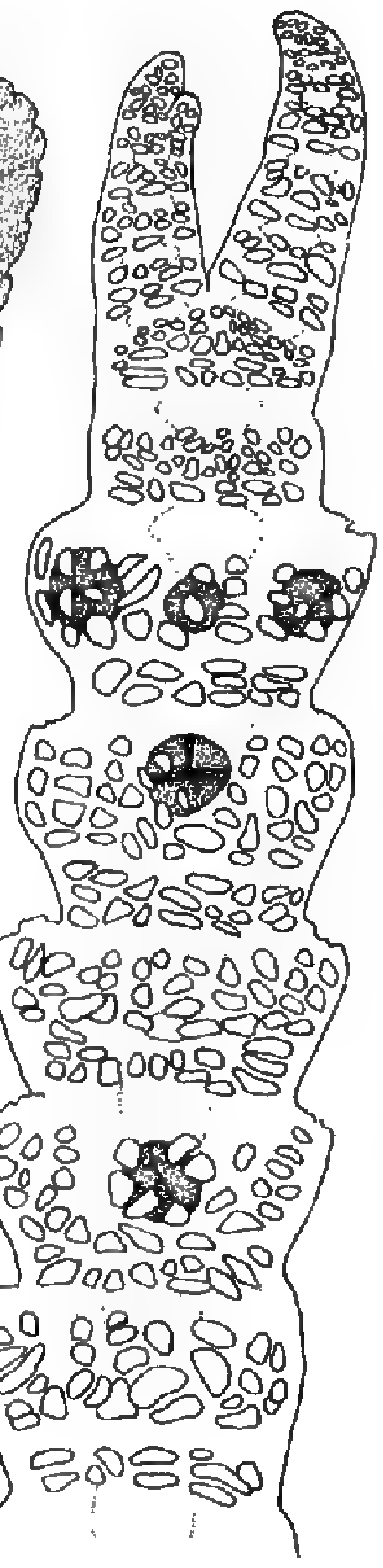

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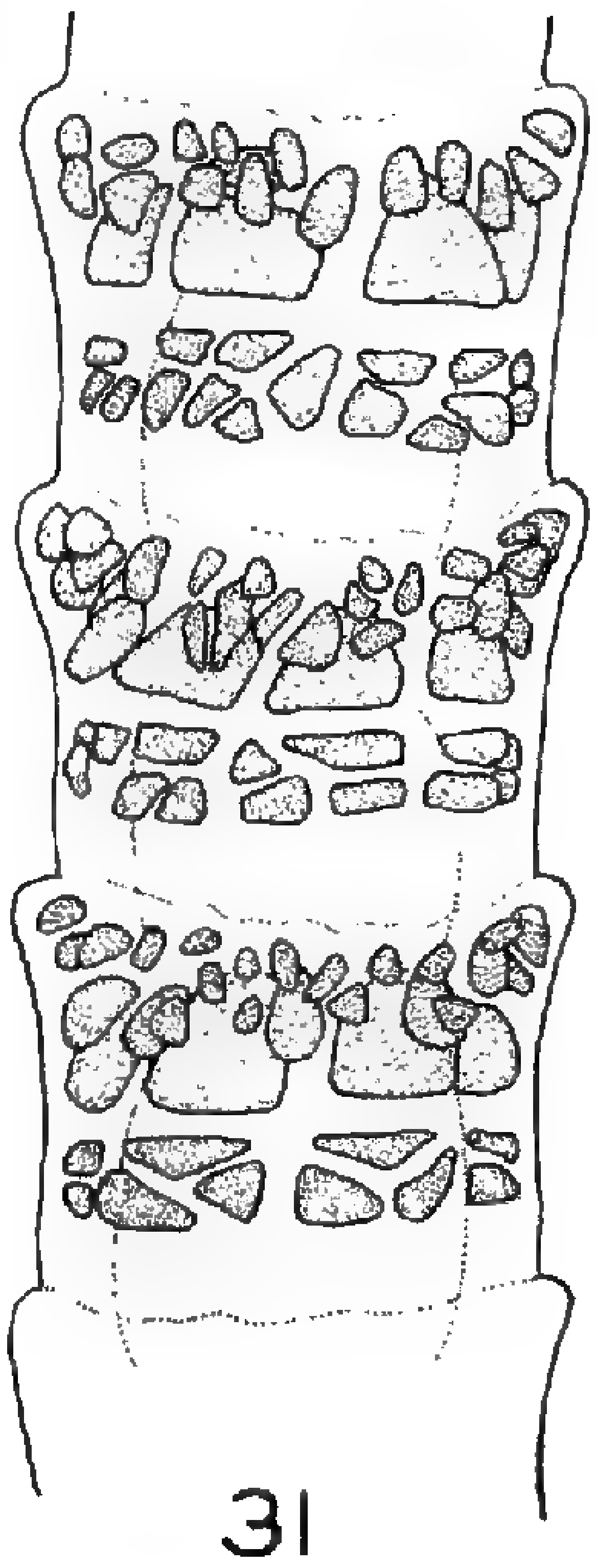

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PLATE 4

**Fig. 29.** *Ceramium clarionensis.* Profile of a terminal portion of a tetrasporangial plant from Guaymas, Sonora, showing adaxial fertile areas, × 55.

**Fig. 30.** *Ceramium pacificum.* A young node from Dawson 1610, Bahía Viscaino, × 235.

**Figs. 31–33.** *Ceramium Taylorii.* **31.** A series of young nodes from mithin 1 mm. of the apex of a filament, showing distinct division of the cortical band, × 250. **32.** Terminal part of a tetrasporangial branch showing involucrate condition, × 150. **33.** An older, lower node showing small, angular cells of lower portion of cortical band, × 250.

size, the strongly circinate apices and the truncate cortical bands becoming tumid below, are distinctive vegetative characters. The production of numerous, emergent tetrasporangia, sometimes all the way around the node, or commonly only on the adaxial side, without cortical modification, is a distinctive reproductive character. The tetrasporic characters of the type material have been reëxamined and found not to be represented clearly in the original description or illustration. The tetrasporangia are not as fully developed in numbers on the type as in some of the new material, but those present show a much more clearly emergent, projecting character than is indicated by the Setchell and Gardner illustration. Furthermore, the occurrence of bracteate filaments associated with the tetrasporangia are neither of regular nor of conspicuous occurrence in the type material reëxamined. Such filaments within the tetrasporangial wall are not ordinarily present in the other collections now at hand.

Although short hairs may be present or absent, almost every specimen exhibits to some degree the presence, external to the cortical cells, of small, often globular masses of material staining deeply with aniline blue. These globules are often extremely conspicuous and in some cases are obviously exudation products for they occur external to the cell membrane and in contact with the cortical cell by means of a slender extension of the cell contents through the wall to the exterior. Sometimes the globules are of such regular occurrence and of such uniform size as to give a highly ornamented aspect to the filament (in this regard see Setchell & Gardner, 1930, pl. 7, fig. 25). At other times they may be smeared, giving an unsightly appearance to the slide-preparation. Similar forms suggesting "gland cells" are commonly observed in *Ceramium Taylorii.*

Recorded heretofore only from Isla Clarion, the species is now at hand from many localities along the Pacific Coast. Its distribution may be outlined according to the following collections:

CALIFORNIA — Hollenberg 516, Corona del Mar; Hollenberg 549, Balboa Harbor; Dawson 2088, La Jolla. PACIFIC BAJA CALIFORNIA — Williams 4/30/46, Scammon Lagoon; Williams 5/14/46, Isla Cedros; Dawson 1393, Miller's Landing. GULF OF CALIFORNIA AND SOUTHWARD — Dawson 679, Puerto Libertad, Sonora; 850, Isla Jorge, Sonora; 745, Isla Patos, Sonora; 1018a, Isla Partida, Baja California; 612a, Ensenada de San Francisco, Sonora; 7028, Isla Espiritu Santo, Baja California; 6800, Cabeza Ballena, Baja California; 3696, Mira Mar, Nayarit.

In some instances field records show that these plants produce a brilliant green iridescence in nature. This was particularly true of several from northern localities in the Gulf of California.

A number of recent collections are tetrasporangial, but only those from summer stations. None collected earlier than March shows reproduction. The Mira Mar plant, collected in December, is antheridial, but cystocarpic plants have not yet been noted.

The degree of development of the small, angular cells which usually form a continuous, outermost layer of the cortical band is variable in this species. In a few cases, notably in Dawson 2813 from Punta Santa Rosalía, Baja California, they may be so scantily developed as to cause the underlying layer of larger cells to appear superficial, thus giving a different appearance to the cortical band.

Those parts of plants in which the tetrasporangia may occur all the way around the node give an appearance strikingly like that in *Ceramium ornatum.* The quite invariably circinate branch-tips of *C. clarionensis,* however, provide a ready distinction from the non-circinate *C. ornatum.*

### 29. CERAMIUM ORNATUM Setchell & Gardner

Plate 2, fig. 10.

Setchell & Gardner, 1930, p. 172.

This species has not again been detected and may be presumed to be a Guadalupe Island endemic. An examination of part of the type material reveals that the diameter of the main axes is 300–450 $\mu$, rather than 130 $\mu$ as given in the original description. Since no illustration has heretofore appeared for this species, a drawing is given from a plant of the type collection.

THE UNIVERSITY OF SOUTHERN CALIFORNIA
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Vol. 4 OCTOBER, 1952 No. 2

# FARLOWIA

## A JOURNAL OF CRYPTOGAMIC BOTANY

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# FARLOWIA

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# William Lawrence White

MAY 29, 1908

JULY 31, 1952

It is with the deepest sorrow that we record the death of William Lawrence White, Associate Professor of Botany and Director of the Farlow Library and Herbarium at Harvard University. He was an eminent mycologist and true friend and counselor to students.

FARLOWIA

A JOURNAL OF CRYPTOGAMIC BOTANY

VOL. 4 OCTOBER, 1952 NO. 2

# TAXONOMIC AND DISTRIBUTIONAL STUDIES OF MOSSES OF CENTRAL AND EASTERN PENNSYLVANIA

EDWIN THEODORE MOUL

Workers in the field of phytogeography and ecology of Bryophytes have been handicapped in recent years by the lack of up-to-date check lists and authentic distributional data concerning many moss species in states and other local areas. Because of this deficiency students of general ecology have generally disregarded the Bryophyte flora entirely or given it only slight attention. For these reasons, the problem of collecting mosses and studying their distribution and habitat preferences in Central and Eastern Pennsylvania seemed necessary and worth while.

In the historical sketch given below, it will be realized that Central and Northern Pennsylvania was, to all practical purposes an "unknown land" bryologically.

## HISTORY OF BRYOLOGICAL STUDY IN PENNSYLVANIA

The study of Bryophytes has not been neglected in Pennsylvania, but most of the work has been confined to the southeastern and northeastern counties and the district around Pittsburgh.

The most significant early collecting and study of mosses was made by Muhlenberg in Lancaster County. Because of his correspondence with eminent botanists in Germany, England, France and Sweden, many species of mosses have "Lancaster County" or "Pennsylvania" as their type locality. Muhlenberg's "Index Flora Lancastriensis," published in the Transactions of the American Philosophical Society, includes a list of the Bryophytes of Lancaster County.

Thomas P. James, a druggist of Philadelphia and co-author with Leo Lesquereux of the "Manual of Mosses of North America," lived part of his life in Delaware County near Radnor and made large collections in the counties surrounding the city. The section on mosses in Darlington's "Flora Cestrica" was prepared by James. Part of his herbarium is in the collection of the Academy of Natural Sciences of Philadelphia and is in excellent condition. Very little information other than locations and dates was given, as was the case with most of the early collections.

Dr. Thomas Conrad Porter, author of the "Bryophyta and Pteridophyta of Pennsylvania," collected mosses in several localities. In 1853 he became Professor at Franklin and Marshall College in Lancaster and made collections in that and nearby counties. In 1866 he was appointed Professor of Natural Science at Lafayette College in Easton and while there made most extensive collections in Northampton and Monroe Counties. That part of his herbarium not destroyed by fire in the science building at Lafayette College was deposited in the collection of the Academy of Natural Sciences of Philadelphia.

Rev. Francis Wolle of Bethlehem, better known for his work in algae, collected Bryophytes in the northeastern counties and many of his specimens are in the Herbarium of the University of Pennsylvania. Much of this material is of little use in distributional studies because exact localities and dates are vague and even lacking in many cases.

Eugene A. Rau, also of Bethlehem, was a contemporary of Wolle and worked in the same territory. His collections are distributed in a number of herbaria, but the bulk of them is in the New York Botanical Garden. Distributional data are lacking in much of the material.

Dr. John K. Small and Dr. A. A. Heller, while students at Franklin and Marshall College, made many interesting Bryophyte collections in Lancaster, Lebanon and Dauphin Counties in the fall of 1888 and spring of 1889.

The formation of the Philadelphia Moss Chapter of the Sullivant Moss Society in February 1899 with Dr. A. F. K. Krout as President and Josephine B. Lowe as Secretary, stimulated anew the interest in mosses in this vicinity. Material collected and identified by this group in the environs of Philadelphia and in Berks and Monroe Counties is deposited in the Herbarium of the University of Pennsylvania and is well documented. It has been of great value in the present study.

Mr. George B. Kaiser, at one time Curator of the Sullivant Moss Society Herbarium, collected and studied the mosses around Philadelphia and many of his specimens are to be found in the two local herbaria.

Through the efforts of D. A. Burnett, the moss flora of McKean County is well known and specimens are widely distributed in herbaria. W. C. Barbour has done the same for the area around Sayre in Bradford County. Dr. O. E. Jennings has surveyed the moss flora of the western half of the state and published the "Manual of Mosses of Western Pennsylvania" in 1913.

In 1933 Miss Grace Tees in partial fulfilment for a Master's Degree at the University of Pennsylvania, prepared a check list of mosses of the Philadelphia area including all the territory in New Jersey, Pennsylvania, Delaware and Maryland within a 100 mile radius of the city. This manuscript is in the Library of the University of Pennsylvania and has proved valuable in completing the present study.

A glance at the map of Pennsylvania will show immediately that up to the present writing the central and northern portions of the state have been bryologically unknown. With this in mind the author has concentrated his collecting in these areas, visiting 44 of the 67 counties of the state. Acknowledgment should be made to the following for their collecting of Bryophytes while doing field-work with other groups of plants: Robert L. Schaeffer, Jr. in Northampton County; Harold W. Pretz in Lehigh County; Hans Wilkens in Berks County, Paul R. Wagner in Schuylkill County. Others responsible for 20 or more collections utilized in this study are:

Adams, J. W.
Austin, C. F.
Barbour, W. D.
Bartram, E. B.
Beals, A. T.
Benner, W. M.
Best, G. N.
Britton, E. G.
Browne, C. H.
Borden, L. P.
Burnett, D. A.
Carter, J. J.
Cresson, E. T., Jr.
Devlin, Joseph
Dix, W. L.
Eby, Mrs. A. F.
Erisman, Mrs. Nellie
Fisher, H. L.
Fogg, John M., Jr.
Gadsby, E. B.
Garber, A. P.
Githens, T. S.
Harper, J. S.
Haydock, W. E.
Henry, H. K.
James, T. P.
Jennings, O. E.
Kaiser, G. B.
Krout, A. F. K.
Lippincott, C. D.
Leeds, A. N.
Lisi, A. G.
Long, Bayard
Lowe, J. D.
Macfarlane, J. M.
McMinn, J. M.
Muhlenberg, G. H. E.
Platt, R. B.
Pohl, R. W.
Porter, T. C.
Pretz, Harold W.
Proctor, G. R.
Rau, E. A.
Roberts, C. M.
Ruth, J. A.
Schaeffer, R. L., Jr.
Small, J. K.
Spencer, Mrs. Thomas
Taylor, W. R.
Tees, Grace M.
True, Rodney H.
Wagner, Paul R.
Wahl, H. A.
Wherry, E. T.
Wilkens, Hans
Windle, F.
Williams, Mrs. M.
Wolle, Francis

## ACKNOWLEDGMENTS

The writer is deeply indebted to Dr. John M. Fogg, Jr. for his advice, suggestions and criticisms and to Dr. J. R. Schramm and other members of the Botany Department of the University of Pennsylvania for their constant assurance and assistance. I wish to express my gratitude to Dr. William C. Steere for his friendly advice and encouragement, as well as his verification of determinations, and to Dr. Frances Wynne Hillier, Dr. Winona H. Welch and Dr. Margaret Fulford for their kind assistance in verifying and making determinations. I am grateful to Dr. Francis Drouet, at the Chicago Museum of Natural History, Dr. Donald P. Rodgers, at the New York Botanical Garden, and Dr. Francis W. Pennell and Mr. Bayard Long at the Academy of Natural Sciences of Philadelphia for the kindness and courtesy extended the writer in the use of herbarium material.

## COLLECTING PROCEDURE

In making collections for this study, individual species or groups of species growing together were placed in individual bags. Exact information regarding substrate, type of cover and habitat was recorded. During the first part of the study the pH of the soil was taken by the colorimetric method using a LaMotte Soil Testing Kit. Later, soil samples were collected and readings made on a Leeds and Northrup pH meter to check the previous results. Only when sufficient readings have been taken is this information included in the text. Exact locations and elevations of collecting spots were made with the aid of United States Topographic Maps. Associated species of plants, especially the Bryophytes, were noted in the field or later during the laboratory examination. Whenever the material examined was fertile, the condition of the antheridia and archegonia or the sporophyte was noted.

The method of recording the distribution of species by counties is that outlined by Fogg (1947) in his study of the methods applied to a state flora survey. In addition to the county records for each species, a summarizing form was kept, tabulating information from each individual specimen concerning habitat, substrate, pH range, elevation, associates or succession and reproduction. From these master records, the data for each individual species was easily organized.

## ECOLOGICAL STUDIES

In attempting to explain the distribution of mosses in Pennsylvania, all the ecological factors usually so important in influencing Phanerogamic distribution, such as Physiographic Provinces, glaciation, macroclimate, geographic relationships and forest types, have been investigated and do not provide an adequate explanation. But the factors controlling the microhabitat of the mosses, that is the temperature, moisture, light, edaphic and biotic conditions of the particular site, appear to be more important and offer the most reasonable explanation of distribution.

## PHYSIOGRAPHIC PROVINCES

The area under investigation covers 49 central and eastern counties of the state, extending to the western boundaries of McKean, Elk, Clearfield, Cambria and Somerset Counties.

The topography of this portion of Pennsylvania is divided into six major provinces (Fenneman, 1938), traversing the state in a northeasterly to southwesterly direction.

The Coastal Plain is confined to the extreme southeastern corner of the state and is limited on the west side by the Fall Line. The City of Philadelphia and its suburbs occupy much of this narrow belt, thus obscuring its original character.

Bounding this area on the north and extending from the Delaware River to the Mason and Dixon Line is the Piedmont Province. It consists of wide fertile limestone valleys, rolling hills of crystalline rock and the Triassic lowlands along the northern boundary.

The Blue Ridge Province extends northeastward into the state through parts of Adams, Franklin, Cumberland and York Counties, nearly to the Susquehanna River where it has its terminus. The Reading Prong of the New England Province extends into Pennsylvania in a southwesterly direction from the Delaware River through parts of Northampton, Carbon and Berks Counties. These areas consist of narrow belts of crystalline ridges forming the southern boundary of the "Great Valley" of the Ridge and Valley Province. In the region between them, the Ridge and Valley Province immediately adjoins the Triassic lowlands of the Piedmont Province, i.e., between the Schuylkill River and a point 10 miles west of the Susquehanna River.

The southern portion of the Ridge and Valley Province is known as the "Great Valley" and is underlain by Cambrian and Ordovician limestones and shales; it averages 10 to 20 miles in width. It is known under the local names of Lebanon Valley and Cumberland Valley; its southern extension into Virginia is the famous Shenandoah Valley. The northern portion of the Province is a succession of eroded valleys and hard, resistant, even-crested ridges of sandstones and shales. Their elevation increases westward from 1300 to 1600 feet.

The Allegheny Mountain section is characterized by high ridges, reaching an elevation of 3200 feet in southern Somerset County. These mountains are plateau-like and are separated by valleys which are, according to Fenneman (1938), deeply dissected plateaus and not lowlands. These ridges form the front escarpment of the Appalachian Plateau Province.

From elevations as high as 2000 feet, the Plateau Province decreases gradually toward the west and merges finally with the Central Lowlands. It is characterized by broad plateau areas deeply cut by narrow stream valleys. Only the northeastern and northwestern portions of this plateau were covered by the Wisconsin glaciation (Fig. 1).

These physiographic provinces are of minor importance in the distribution of mosses within the state. A few boreal species, such as *Mnium cinclidioides* and *Brachythecium Starkei,* have not been found to occur outside of glaciated territory up to the present writing. Two species of *Dicranum* have been collected from the Ridge and Valley Province westward, but there are no species confined to any one Province. The relatively slight range of elevation in Pennsylvania as compared to that farther north and south is probably a factor to be considered. The distribution of mosses is more closely associated with microclimates, as will be shown subsequently.

## MACROCLIMATE

The average annual precipitation ranges from 36 inches in the southern part of the Ridge and Valley Province, Bedford and Fulton Counties, and along the northern boundary in Bradford, Tioga and Potter Counties to

48 or 50 inches in Somerset County, where the highest elevations of the state are found. The rainfall for the eastern half of the state averages between 40 and 46 inches, with the highest precipitation in the southeastern corner. With abundant rainfall, well distributed throughout the year, mosses are common and abundant in the state. The individual species are restricted in their distribution by the evaporation rate of the particular site.

The temperature range in the state is not extreme. The average January temperatures are low at 22 degrees F. in the northern and central counties and 32 degrees F. in the counties of the southwestern and southeastern corners respectively. The average July temperatures vary from 66 degrees to 70 degrees F. in the northern and central part of the state to 74 degrees and 76 degrees F. in southwestern and southeastern Pennsylvania. The lower temperature area corresponds to the "cool" area of Livingston and Shreve (1921) and the higher temperature area to their "medium" (Fig. 1).

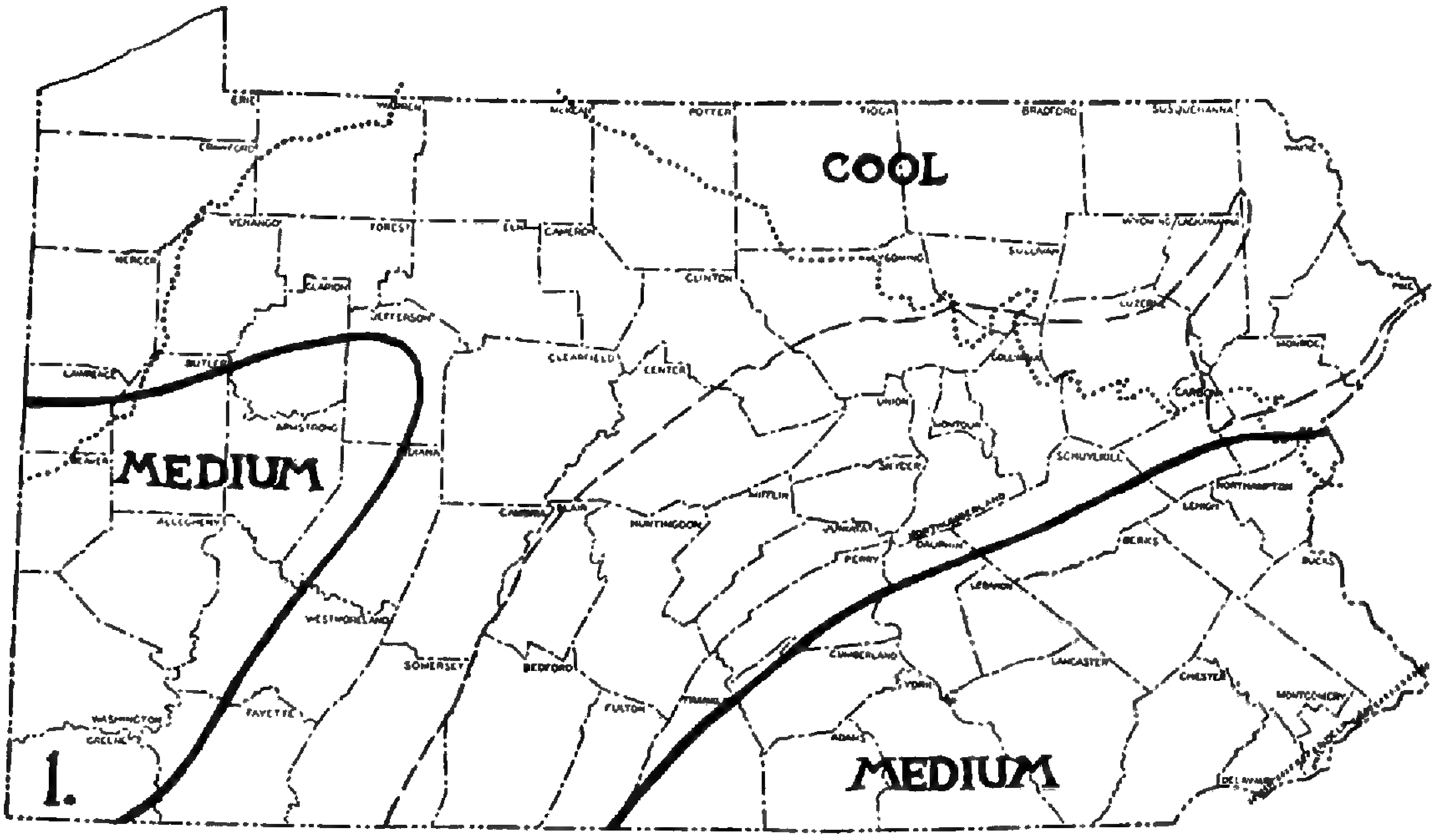


Fig. 1. Climatic zones in Pennsylvania. (Adapted from Livingston and Shreve).

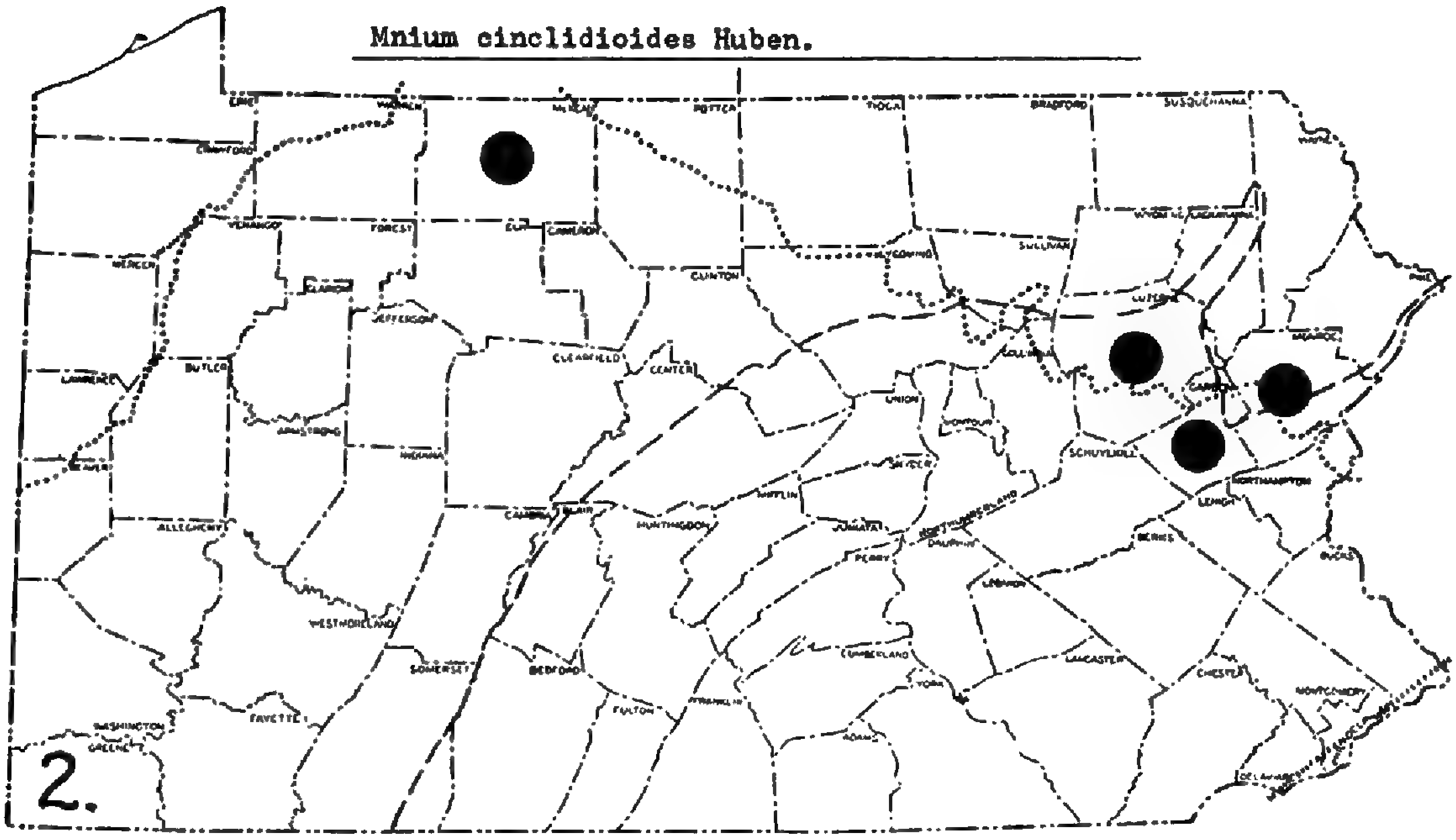
Some species of mosses prove to be more abundant in one or the other temperature belt, but are not sharply delimited. This can be accounted for by the fact that mosses are influenced by the microclimate of their immediate habitat, rather than by the macroclimate of the meteorologist (Richards 1932).

## GEOGRAPHIC RELATIONSHIPS

Utilizing the geographic distribution for mosses presented by Sharp (1939) as a basis for relationships, the flora of Pennsylvania shows four geographic affinities.

First is a group of mosses of boreal affinities, circumpolar in their distribution, and reaching their maximum development in the far north. They reach their southern limits in Pennsylvania and occur in the northern counties, chiefly in glaciated territory (Fig. 2 and 3).

*Brachythecium Starkei*
*B. velutinum*
*Climacium dendroides*
*Dicranella rufescens*
*D. rugosum*
*Mnium cinclidioides*
*Polytrichum formosum*
*P. gracile*
*P. juniperinum* var. *alpestre*
*Thuidium abietinum*



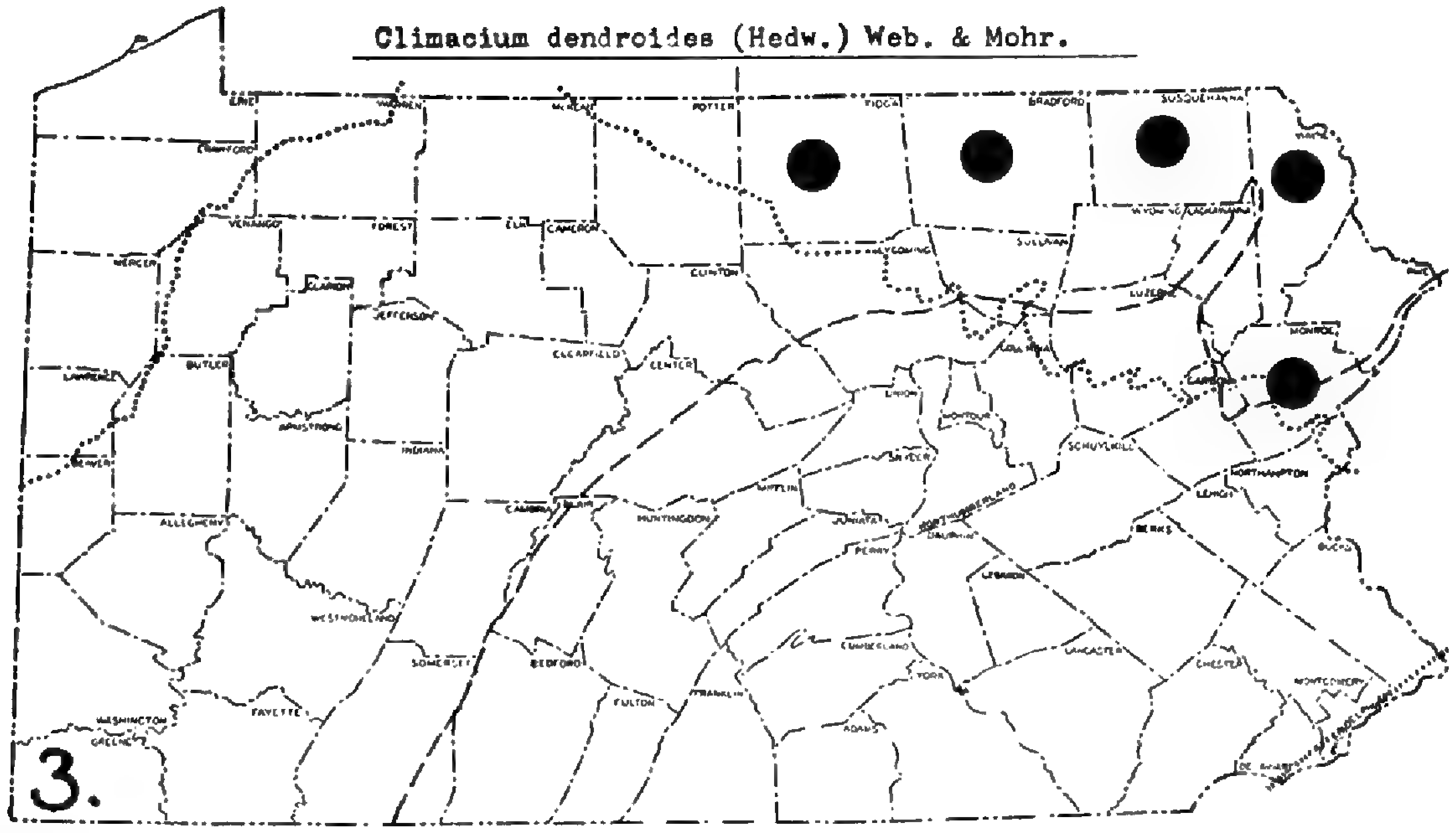
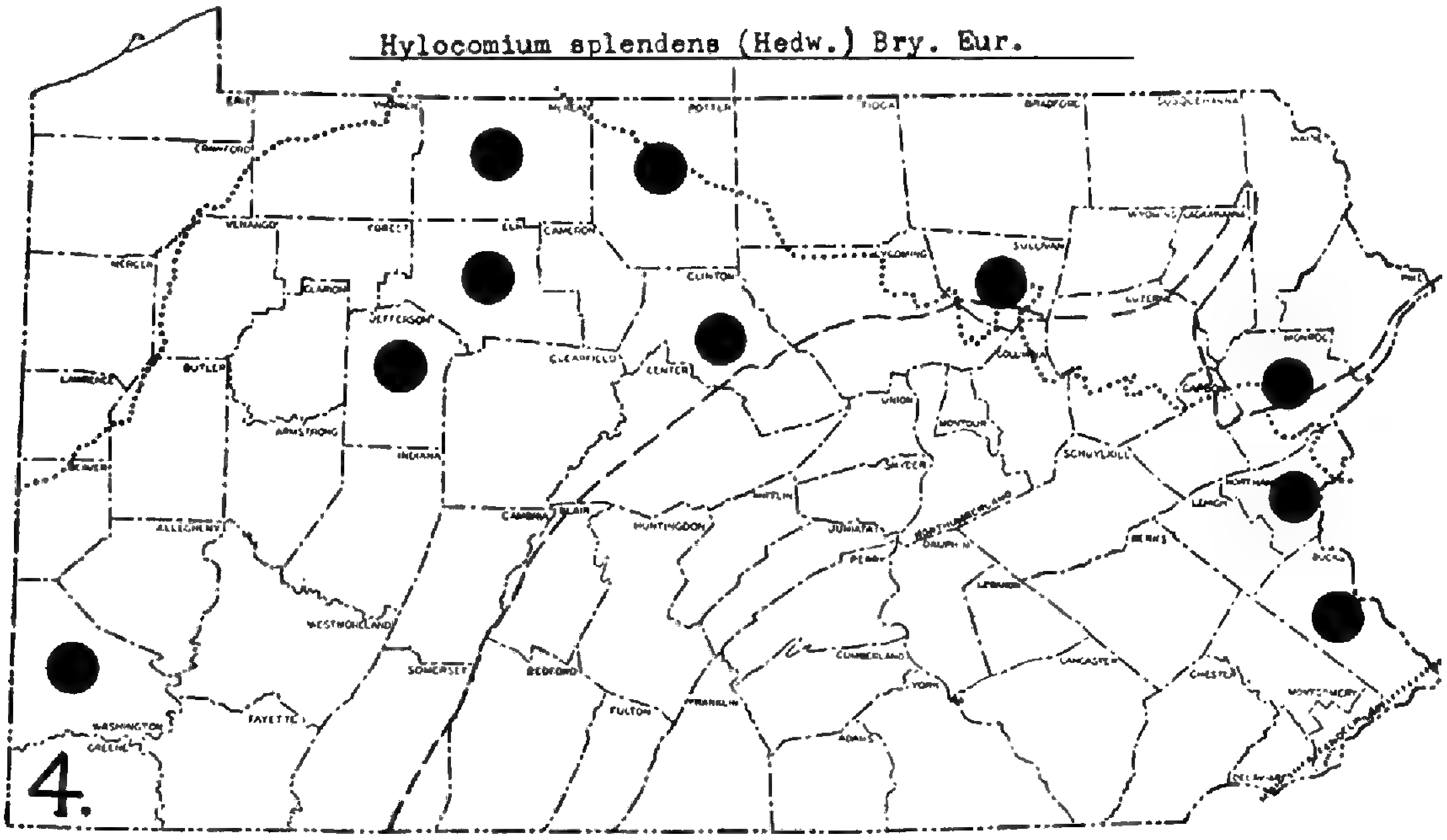


**Fig. 2.** Range of *Mnium cinclidioides* Huben. An example of mosses with Arctic affinities some of which reach their southern limits in the state.

**Fig. 3.** Range of *Climacium dendroides* (Hedw.) Web. & Mohr. An example showing range of a species with Arctic affinities.

Secondly, there are the moss societies which show relationship with those of the spruce-fir forest and entering Pennsylvania all along the northern boundary, funneling down the mountain chain through central Pennsylvania to the southern boundary and on into the Southern Appalachian Mountain system of Tennessee and North Carolina. Their distribution corresponds generally to the "cool" climatic zone of Livingston and Shreve (Fig. 1). They are found growing in the cool ravines and bottoms



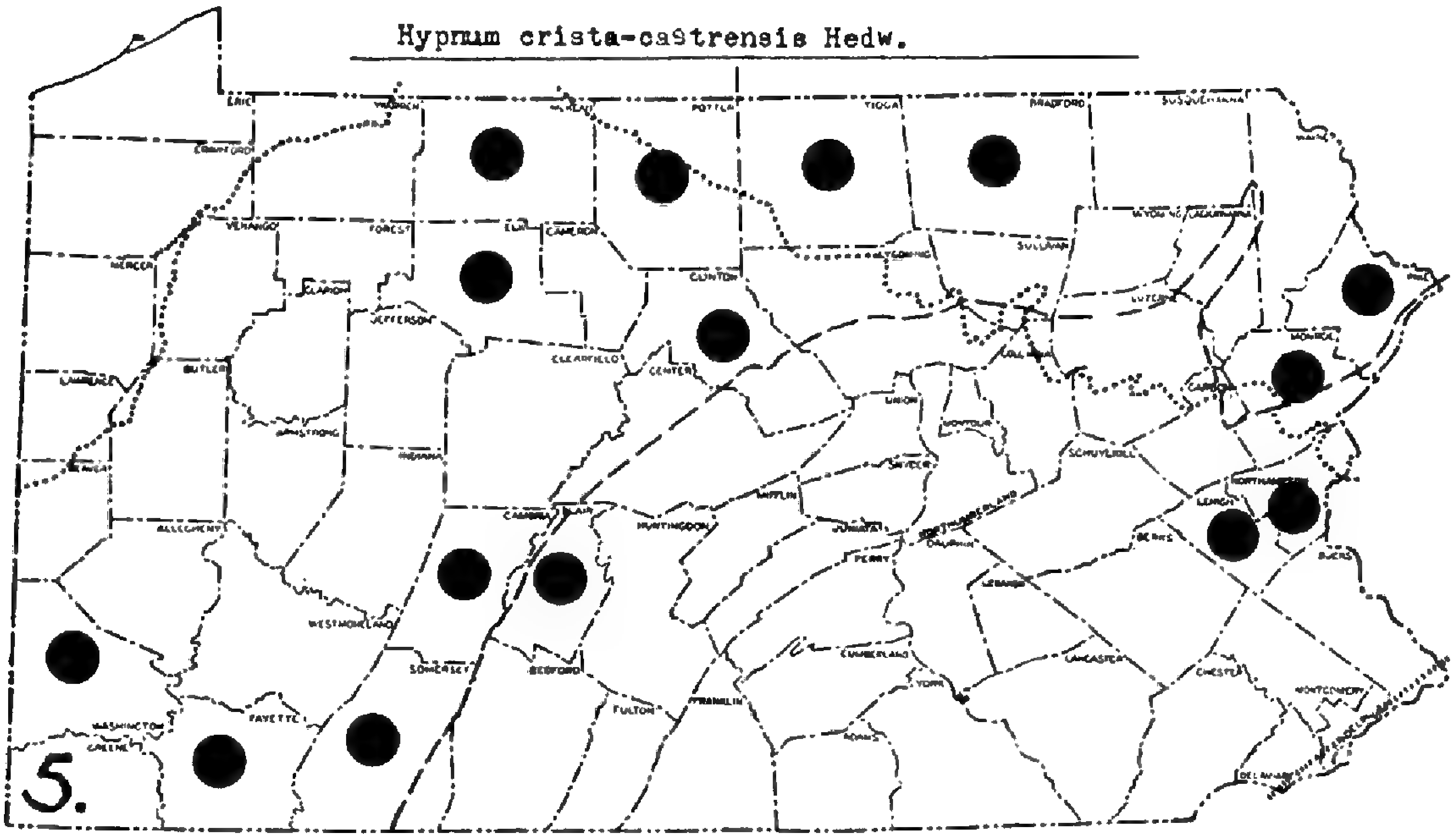
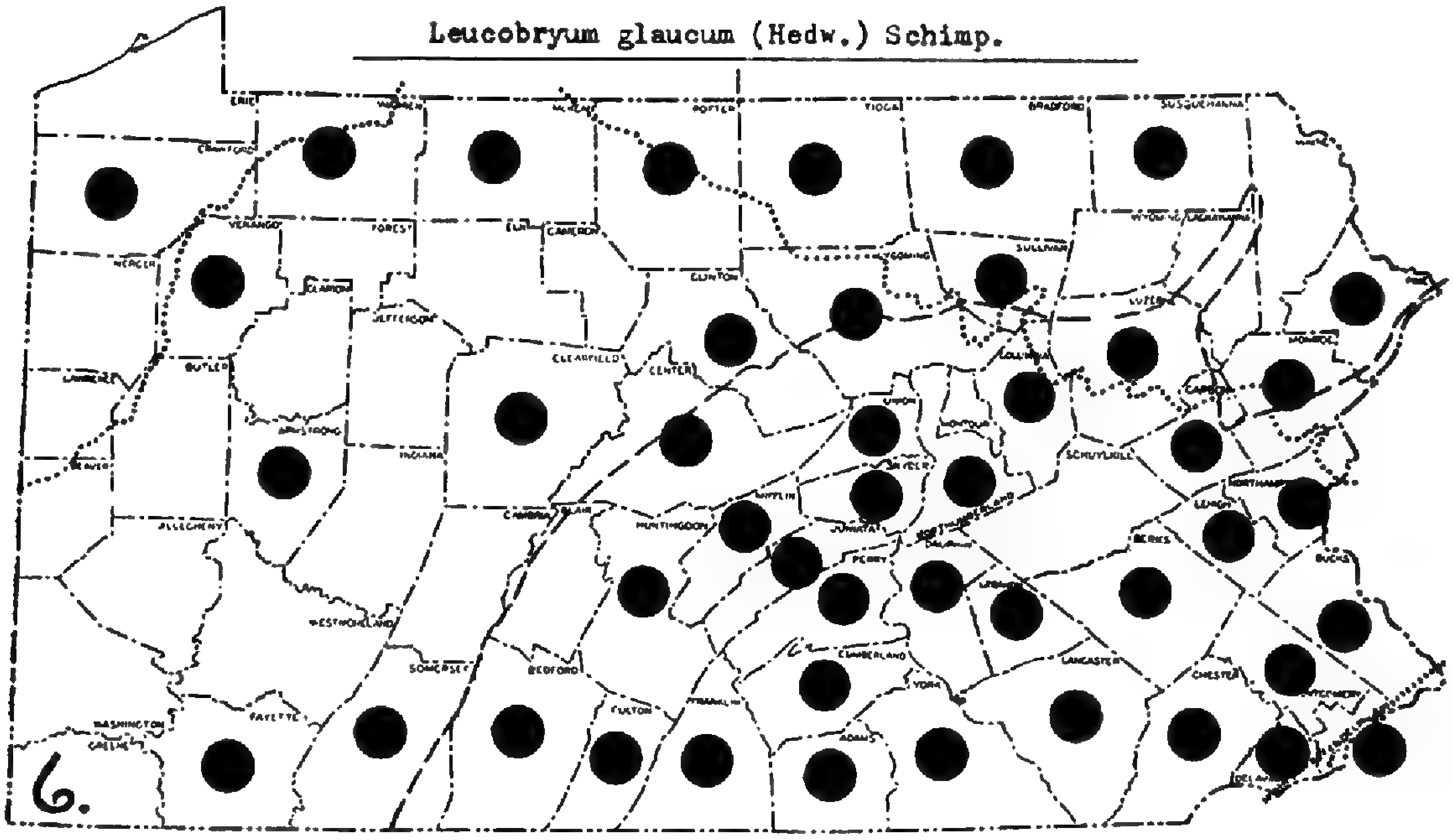


**Fig. 4.** Range of *Hylocomium splendens* (Hedw.) Bry. Eur. An example of a species showing relationship with the moss societies of the spruce-fir forests. Usually confined to the "cool" area of Livingston & Shreve.

**Fig. 5.** Range of *Hypnum crista-castrensis* Hedw. in Pennsylvania. Another example of distribution in the "cool" area of Livingston & Shreve.

occupied by the Eastern Hemlock Forest Formation of Nichols (1935). The fact that this type of microclimatic and forest conditions occur in parts of the state outside the "cool" zone, accounts for the occurrence of many species of mosses of this group in counties far removed from their normal range. The Wissahickon ravine in Philadelphia County and the hemlock ravines along the York County shore of the Susquehanna River are examples (Fig. 4 and 5).



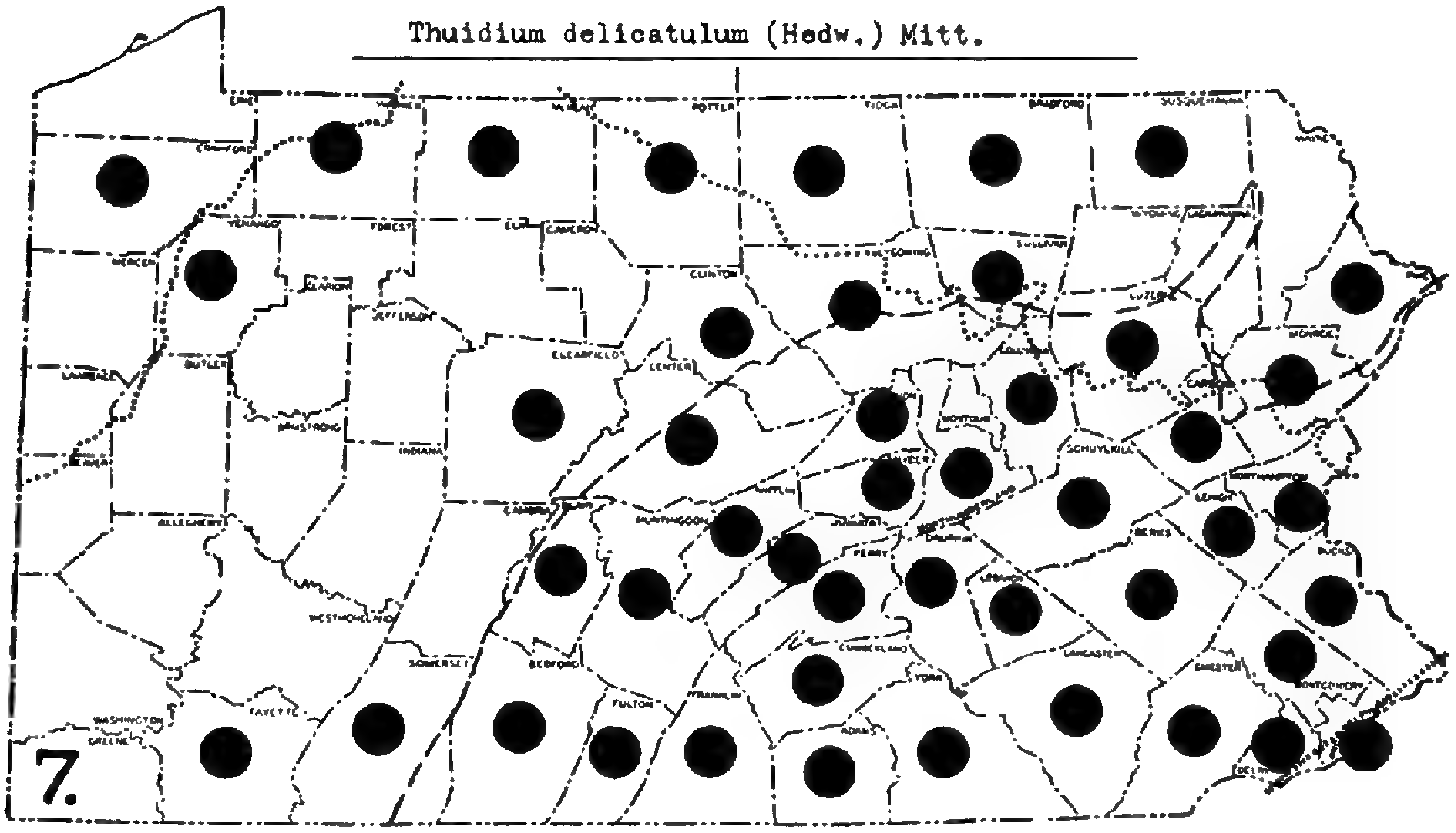


**Fig. 6.** Range of *Leucobryum glaucum* (Hedw.) Schimp. A widespread species and typical of the deciduous forests.

**Fig. 7.** Range of *Thuidium delicatulum* (Hedw.) Mitt. Another widespread species of the more mesic deciduous forests.

*Anomodon Rugelii*
*Calliergonella Schreberi*
*Cirriphyllum piliferum*
*Dichodontium pellucidum*
*Dicranum Bonjeani*
*D. flagellare*
*Hylocomnium brevirostre*
*H. splendens*
*H. umbratum*
*Hypnum crista-castrensis*
*Mnium punctatum* var. *elatum*
*Oreoweisia serrulata*
*Plagiothecium Mullerianum*

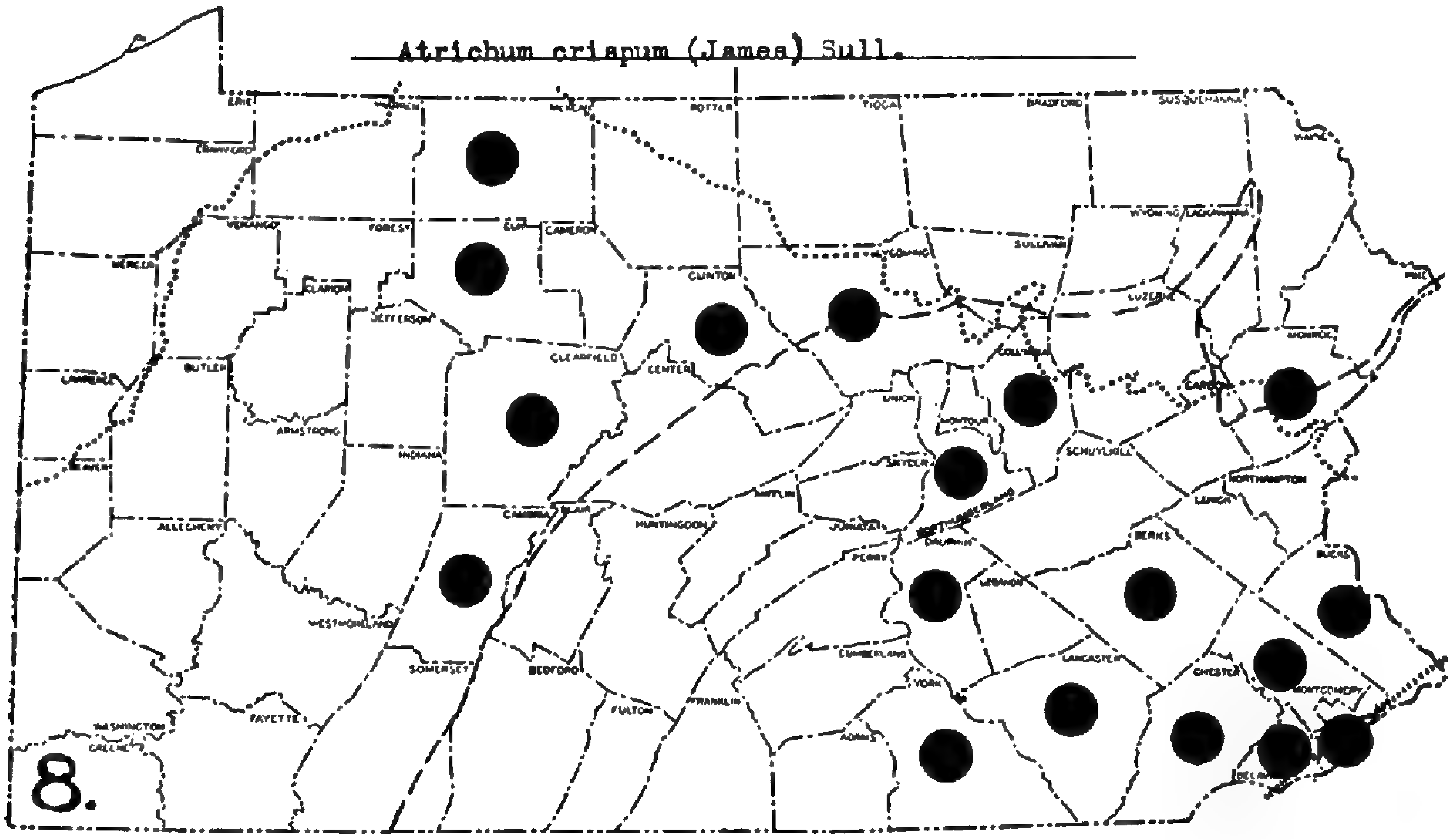
The third group of mosses are those that are widespread and occur in suitable habitats in most of the counties of the state. Lack of records for a county may usually be attributed to insufficient collecting. These are the characteristic species of the mesophytic deciduous forests of the state, principally the more xeric second-growth oak-hickory segregate. Communities belonging to this group are found on the sandstone-capped mountain ridges, their wooded slopes and the isolated oak-hickory woodlands of the cultivated fertile valleys (Fig. 6 and 7).

*Anomodon attenuatus*
*Atrichum Macmillani*
*Ceratodon purpureus*
*Dicranella heteromalla* var. *orthocarpa*
*Dicranum scoparium*
*Entodon seductrix*
*Funaria hygrometrica*
*Hypnum imponens*
*H. curvifolium*
*Leucobryum glaucum*
*Mnium affine*
*M. cuspidatum*
*Plagithecium denticulatum*
*Pohlia nutans*
*Polytrichum commune*
*P. juniperinum*
*P. ohioense*
*Thuidium delicatulum*

The fourth and smallest group in the Pennsylvania flora is that characteristic of the Coastal Plain. This group is separable into two elements, one including those species which migrated out from the Southern Appalachians onto the Coastal Plain (Sharp, 1939), extending their range northward to Massachusetts and beyond; and another including species having their metropolis in the Tropics and extending into southeastern United States and north along the coast, in many cases as far as Long Island or New Jersey.

The first element of the Coastal Plain group in Pennsylvania includes such species as *Fontinalis Sullivantii*, *Mnium hornum* and *Atrichum crispum* (Fig. 8 and 9), which grow commonly on the shores of the Piedmont rivers and their tributaries, where they find the sandy alluvium similiar to that of the soil of the Coastal Plain habitat on which they occur with greater frequency. There are two possible explanations for this type of distribution. Either they originally grew in the sandy alluvium along mountain brooks and moved into the more favorable habitat of the Coastal Plain after it emerged from the sea as indicated by Sharp (1939) as well as from evidence collected by Jennings (1945) which indicates the presence of *Mnium hornum* all through the Appalachian Plateau. Or, migrating northward along the Coastal Plain after its emergence, these mosses found the alluvial deposits on the banks of streams a suitable habitat and thus moved up the rivers and streams into the mountain and plateau regions.

*Leucobryum albidum*, *Pogonatum brachyphyllum*, *Thuidium minutulum* and *T. virginianum* (Fig. 10 and 11), examples of the second class of Coastal Plain species, enter the state in the counties of the southeastern corner and in Fayette County in the southwestern corner. This type of distribution is similar to that of a number of phanerogams found most frequently on the Coastal Plain which also extends up the Mississippi Embayment into western Pennsylvania. It will also be noted that this group is confined to the "medium" climatic zone of Livingston and Shreve (Fig. 1.).



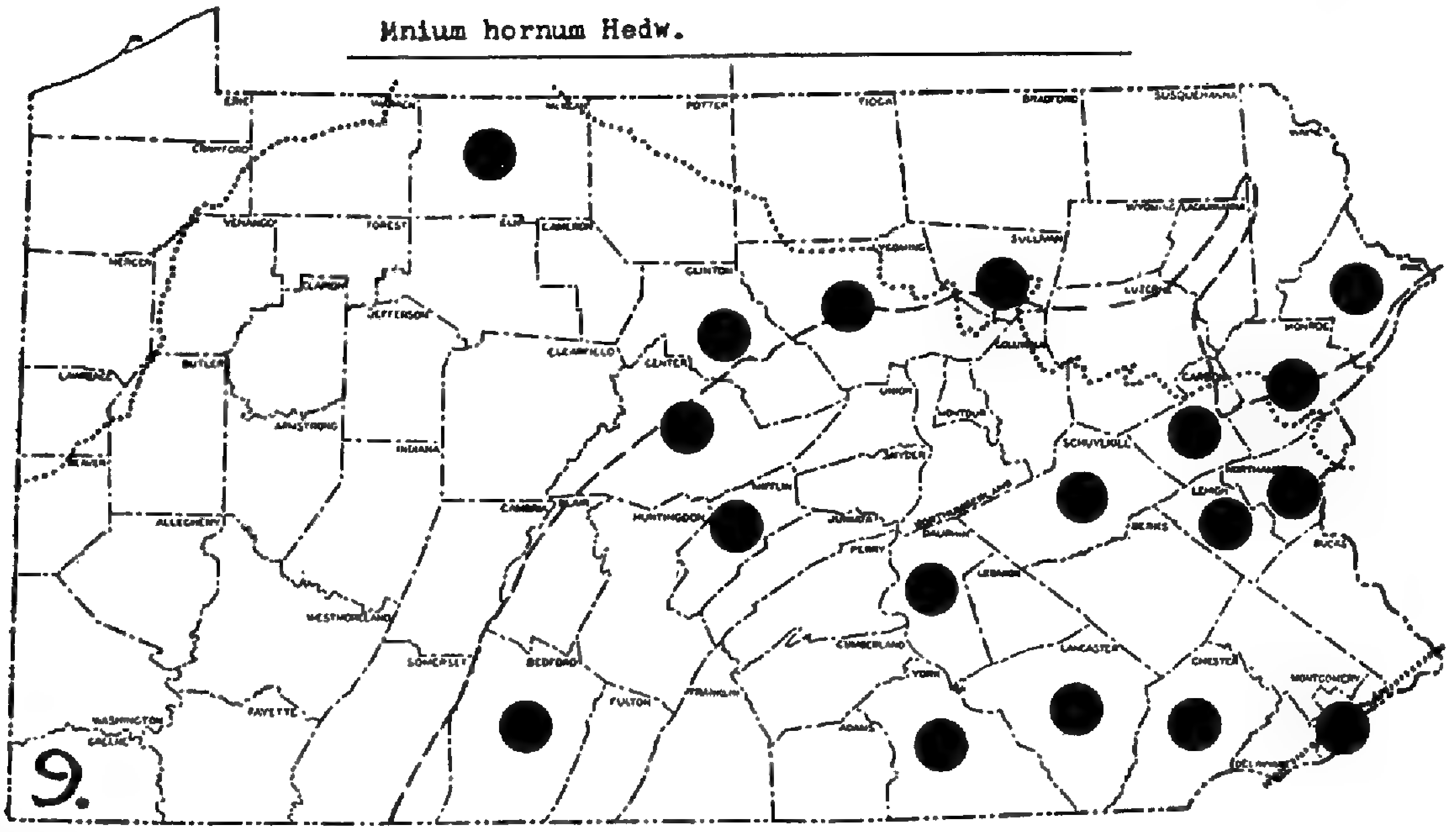
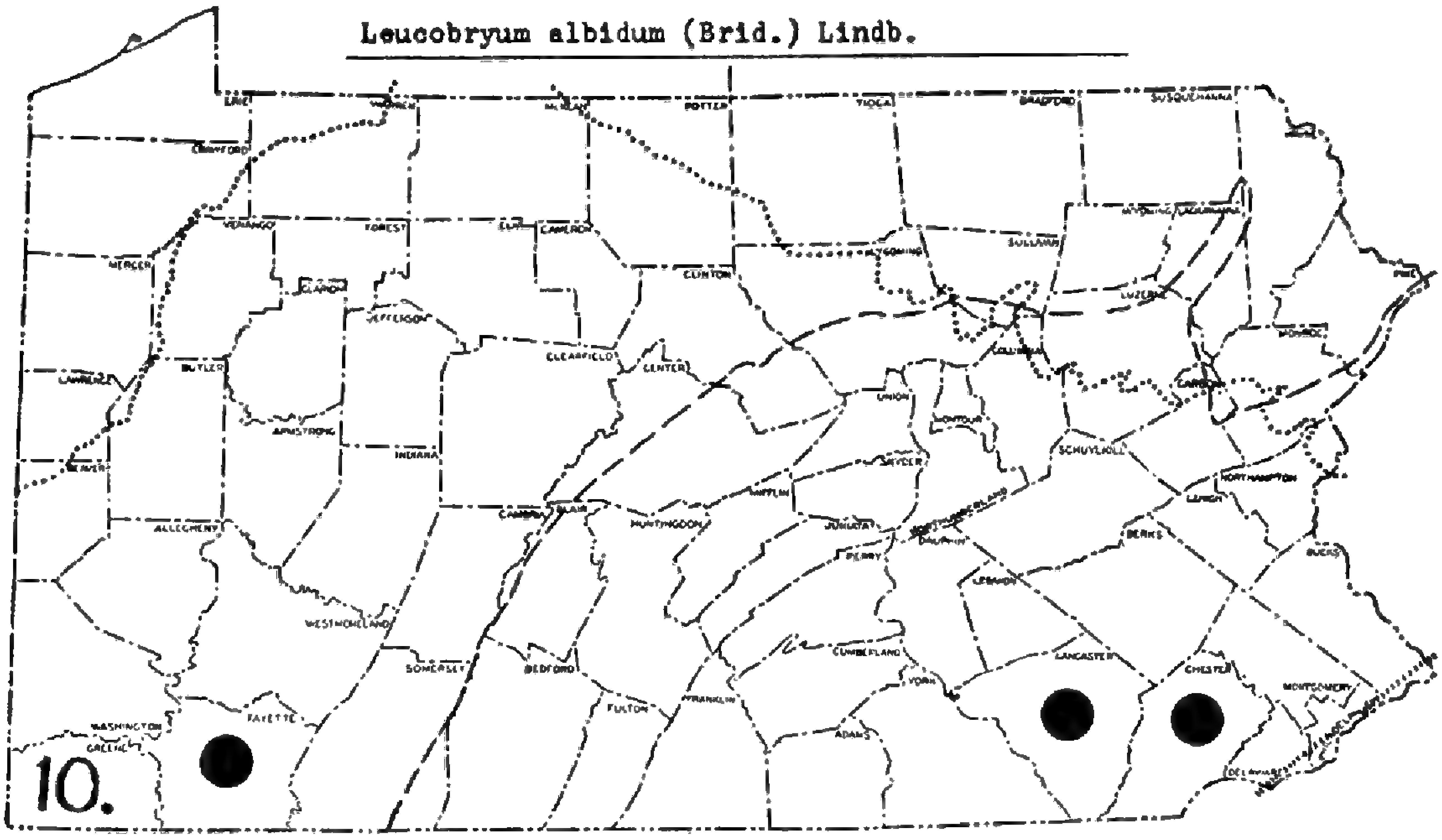


**Fig. 8.** Range of *Atrichum crispum* (James) Sull. A Coastal Plain species that has migrated northward from the southern Appalachians.

**Fig. 9.** Range of *Mnium hornum*. Another example of a Coastal Plain species.

## NATURAL VEGETATION

In order to show relationship between moss distribution and forest cover it is first necessary to decide upon an accepted ecological classification of forest types. Illick (1928) has divided the forest vegetation of Pennsylvania into nine types, many of which grade into one another. These distinctions are finer than is required for the present purpose. Since Nichols' (1935) classification is simpler and more appropriate, I have chosen to



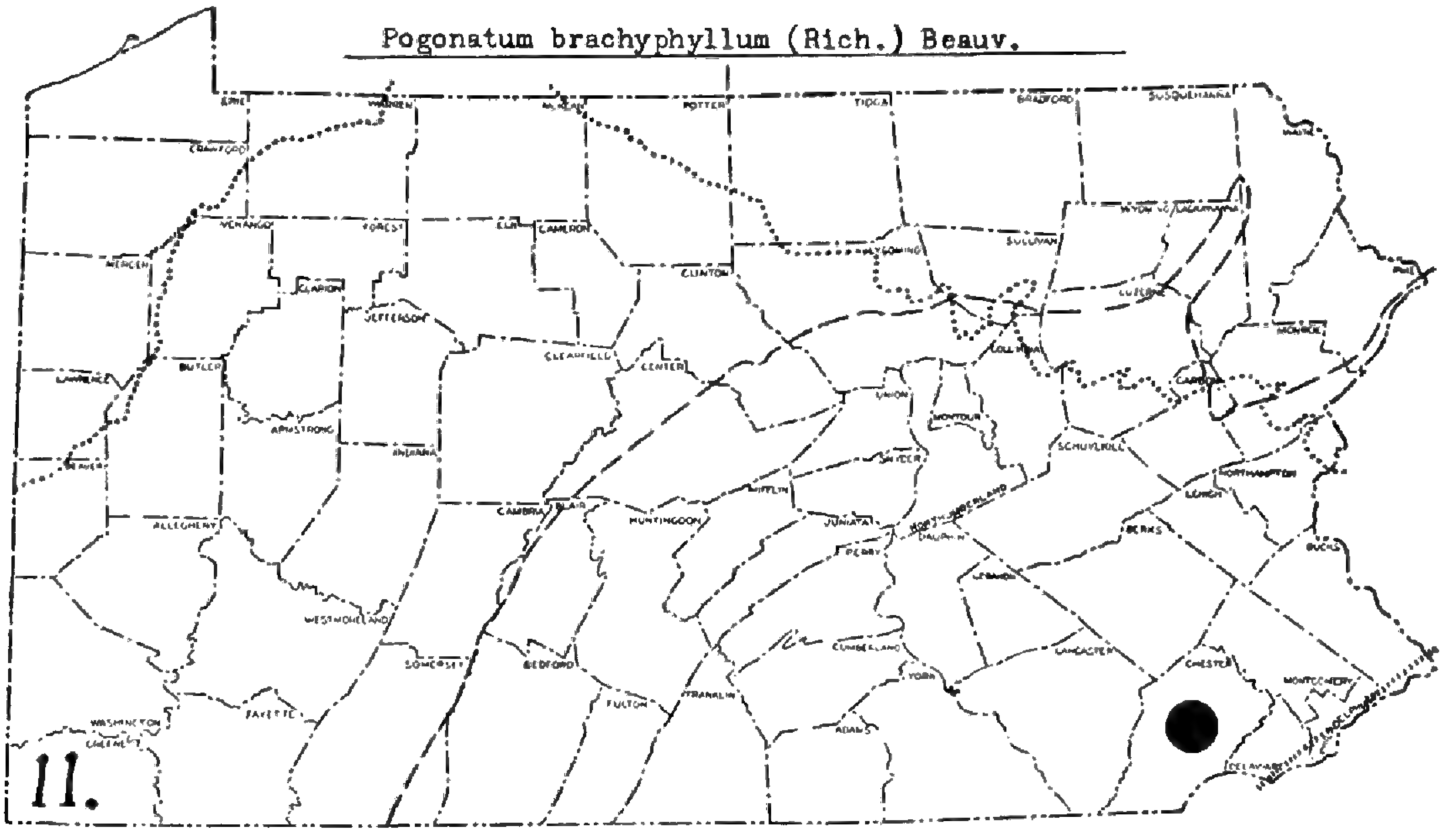


**Fig. 10.** Range of *Leucobryum albidum* (Brid.) Lindb. A southern Coastal Plain species extending north to southern Pennsylvania. Related to tropical species.

**Fig. 11.** Range of *Pogonatum brachyphyllum* (Rich.) Beauv. A southern Coastal Plain species extending north to Pennsylvania.

utilize it for this study. Thus Central and Eastern Pennsylvania lie in part of two formations, the Eastern Hemlock Forest of Nichols and the Eastern Deciduous Forest of Sargent (Nichols, 1935).

## EASTERN HEMLOCK FOREST

The Eastern Hemlock Forest is a convenient name used by Nichols for a climax that could be more appropriately called "eastern hemlock-white pine-northern hardwood region." It corresponds roughly with the "Northern Pine Belt" of Sargent and the "Lake Forests" of Weaver and Clements. The more characteristic species involved are *Tsuga canadensis*, *Acer saccharum*, *Fagus grandifolia*, *Betula lutea*, *Pinus strobus*, *Tilia glabra*, *Ulmus americana*, *Fraxinus americana*, *Quercus borealis*, *Prunus serotina*, *Picea rubra*, *Abies balsamea*, *Picea glauca*, *Acer rubrum* and *Pinus resinosa*. The moss and liverwort flora of this formation is reported by Nichols as being very extensive both in quantity and number of species. The evidence from collections made in this forest area bears out this conclusion for Pennsylvania.

The characteristic species of the Hemlock Forest constitute the cover of the major portion of the forested area in the northern counties and in suitable habitats down the "cool" funnel of the central mountainous section. Tongues of this forest are also found on north-facing slopes and in deep cool ravines in many other portions of the state. The composition of this forest, as to species and their relative abundance, is observed to vary both in different parts of the region and locally so that it can be separated into "segregates" in which one group or another of tree species dominate.

In the high, drier portions of this forest, where the birch-beech-maple segregate predominates, the moss species which commonly carpet the soil are:

*Atrichum Macmillani*
*Brachythecium* spp.
*Dicranella heteromalla*
*Dicranum Bonjeani*
*D. rugosum*
*D. scoparium*
*Eurhynchium* spp.
*Leucobryum glaucum*
*Mnium affine*
*M. cuspidatum*
*Plagiothecium* spp.
*Polytrichum commune*
*P. juniperinum*
*P. ohioense*
*Thuidium delicatulum*

In the same forest segregate on slopes and in depressions where conditions are more mesic, species of mosses that require slightly more moisture are found growing with the above named species.

*Amblystegium* spp.
*Bartramia pomiformis*
*Fissidens adiantoides*
*Hypnum imponens*
*H. pratense*
*Mnium orthorhynchum*

Where sandstone rocks are exposed, but shaded by the forest cover, and soil and humus has accumulated, *Dicranum fulvum* finds a desirable habitat.

The corticolous flora of the Eastern Hemlock Forest is sparse. Several species occur occasionally on the lower and more moist portion of the tree trunks, but only *Thelia asprella* is common and universally present.

Dead logs and stumps are common, in all stages of decay. Where the environmental conditions are conducive to growth, one finds these logs and stumps more or less covered with mosses and liverworts. The dominant species on such subtrates are:

*Brotherella recurvans*
*Dicranum flagellare*
*D. scoparium*
*Heterophyllium Haldanianum*
*Hypnum imponens*
*Mnium cinclidioides*
*Tetraphis pellucida*

In the cool ravines and bottoms, where hemlock is the dominant species of tree, occurs the *Hylocomium* union of moss species approaching that characteristic of the northern spruce-fir forests (Sharp, 1939). The low temperature, high humidity and deeper shade of such a habitat seems to favor their lush growth. The species commonly present are:

*Atrichum undulatum*
*Brachythecium salebrosum*
*Calliergonella Schreberi*
*Climacium americanum*
*C. dendroides*
*Dicranum scoparium*
*Drepanocladus uncinatus*
*Hylocomnium brevirostra*
*H. splendens*
*Hypnum crista-castrensis*
*Mnium affine*
*M. longirostrum*
*M. punctatum* var. *elatum*
*Rhodobryum roseum*
*Sphagnum* spp.
*Thuidium delicatulum*

On rocks, exposed and submerged, in the cold streams that flow through these glens and ravines, are growing semi-aquatic and aquatic species of mosses. Those usually present are:

*Eurhynchium rusciforme*
*E. strigosum* var. *robustum*
*Fontinalis antipyretica* var. *gigantea*
*F. dalecarlica*
*Hygroamblystegium fluviatile*
*Pohlia nutans*
*Rhacomitrium aciculare*

## EASTERN DECIDUOUS FOREST

The Eastern Deciduous Forest is highly complex in its structure and varies greatly from place to place. Prominent species in this climax are *Quercus* spp., *Hicoria* spp., formerly *Castanea dentata*, *Liriodendron tulipifera*, *Fagus grandifolia*, *Acer saccharum*, *Fraxinus americana*, *Prunus serotina*, *Tilia* spp., *Betula lenta*, *Aesculus octandra*, *Magnolia acuminata* and *Juglans nigra*. The trees in this forest climax tend to be large and long-lived, the forest canopy is usually several storied with one or more layers of small trees and shrubs. According to the writer's observations, this forest type tends to be more xeric than the Hemlock Formation, especially in the area of second and third growth. The Deciduous Forest, through its varied forest types, orginally covered the remainder of the state treated in this discussion. Much of the area formerly occupied by this formation is now devoted to agriculture or industrial and urban developments, thus completely eliminating the woodland.

Mosses and liverworts tend to be quantitatively less abundant here than in the Hemlock Forest. Nichols (1935) holds that their growth is checked by the accumulation of leaves and debris which covers the forest floor in autumn. I believe, however, that repeated disturbance of these areas by lumbering and fires, as well as the existence of relatively xeric and acid conditions, are additional factors that must be considered.

In the dry uplands of the oak and hickory segregate, widely scattered patches or cushions of mosses occur. They grow on the acid soil and humus, frequently at the bases of trees or rocks. The following species are most frequent in such habitats:

*Atrichum Macmillani*
*Aulacomnium heterostichum*
*Bartramia pomiformis*
*Cirriphyllum Boscii*
*Dicranella heteromalla* var. *orthocarpa*
*Dicranum scoparium*
*Diphyscium foliosum*
*Ditrichum pallidum*
*Eurhynchium serrulatum*
*Hypnum imponens*
*Leucobryum glaucum*
*Mnium affine*
*M. cuspidatum*
*Plagiothecium denticulatum*
*Polytrichum commune*
*P. ohioense*
*Thuidium delicatulum*
*T. virginianum*

On the top of the sandstone ridges in the scrub-oak forest, *Polytrichum piliferum* occurs along with the more xeric species listed above.

The exposed rock surfaces in the oak-hickory segregate support a moss flora, which in time, accumulates fine soil and humus. These prepare the substrate for the invasion of mesic species of mosses. Those commonly found in this type of habitat are:

*Anomodon rostratus*
*Dicranum fulvum*
*D. fuscescens*
*Grimmia pilifera*
*Hedwigia ciliata*

Decaying logs and stumps support a distinctive moss flora. The species universally present are:

*Dicranum scoparium*
*D. flagellare*
*Hypnum imponens*

In stream valleys on the alluvial soil where the maple-tulip-oak segregate predominates, another group of moss species are common:

*Amblystegium* spp.
*Atrichum crispum*
*A. undulatum*
*Aulacomnium palustre*
*Brachythecium rivulare*
*Eurhynchium rusciforme*
*Fissidens taxifolius*
*Heterophyllium Haldanianum*
*Mnium affine*
*M. hornum*
*M. punctatum*
*Pohlia nutans*
*P. Wahlenbergii*
*Thuidium delicatulum*

Rock outcroppings along the shores of these streams and submerged rocks in the streams serve as the substrate for the following species:

*Fontinalis novae-angliae*
*Grimmia alpicola* var. *rivularis*
*Hygroamblystegium fluviatile*
*Rhacomitrium aciculare*

Corticolous mosses are even less abundant than in the Hemlock Forest, but scattered growths do occur in more humid situations. The following are the common species:

*Fissidens subbasilaris*
*Leskea gracilescens*
*L. obscure*
*Platygyrium repens*
*Thelia asprella*

On eroded banks and newly made cuts along roads through the deciduous forest, the bare soil is colonized by a typical moss flora, including:

*Atrichum Macmillani*
*Dicranella heteromalla*
*Ditrichum pusillum*
*Philonotis fontana* (in wet ditches)
*Pogonatum pensilvanicum*
*Polytrichum juniperinum*
*P. ohioense*

Where former cultivated fields have been allowed to lie fallow for a number of years, a growth of weeds and shrubs starts the ecological succession back to the forest climax. Here a distinct group of mosses are found covering the soil at the base of the weeds and shrubs or in open exposed situations. They are principally the following species:

*Ceratodon purpureus*
*Eurhynchium serrulatum*
*Funaria hygrometrica*
*Leucobryum glaucum*
*Mnium cuspidatum*
*Physcomitrium turbinatum*
*Polytrichum juniperinum*
*P. commune* var. *perigonale*

In some parts of the area covered by the Deciduous Forest, limestone is the underlying rock. When this and other calcareous rock are exposed or just under the surface and covered by acid humus, the following mosses are common and show vigorous growth:

*Amblystegium* spp.
*Anomodon attenuatus*
*A. minor*
*A. rostratus*
*Brachythecium* spp.
*Bryum argenteum*
*Cirriphyllum Boscii*
*Climacium americanum*
*Fissidens adiantoides*
*Orthotrichum strangulatum*
*Rhodobryum roseum*
*Thuidium recognitum*

Besides the larger ecological formations discussed above, there are two distinct edaphic climaxes within the state that should be mentioned, the serpentine barrens of Delaware, Chester and Lancaster Counties and the shale bluffs and hillsides found on south-facing slopes of Brailler, Chemung and other shales in Bedford and Fulton Counties.

The serpentine barrens, from all available evidence, were never covered with forests, but were natural grassland. Their phanerogamic flora is quite unique and contains a few endemic species. To the present writing no endemic species of mosses have been found there, but those commonly occurring on these serpentine outcroppings are:

*Anomodon attenuatus*
*A. rostratus*
*Aphanorhegma serratum*
*Bartramia pomiformis*
*Brachythecium oxycladon*
*Cirriphyllum Boscii*
*Climacium americanum*
*Dicranum rugosum* (Lancaster Co.)
*Eurhynchium serrulatum*
*Grimmia pilifera* (on rocks)
*Hedwigia ciliata* (on rocks)
*Plagiothecium denticulatum*
*Polytrichum ohioense*
*Thuidium delicatulum*
*Tortella humilis* (on log)
*Weisia viridula*

The shale bluffs and hillsides are more wooded in the northern parts of Bedford and Fulton Counties and pass gradually into the shale barrens proper, which extend southward in the Ridge and Valley Province from the southern part of Bedford County to southwest Virginia. They are covered with a sparse stand of oak, juniper and scrub pine, with a scattered growth of shrubs and herbs. The soil consists of large and small flaky particles of shale with little humus. The mosses listed below, which occur on these areas, are very similar to those found on the tops of the sandstone-capped ridges throughout the state:

*Anomodon attenuatus*
*A. rostratus* (at base of the bluffs)
*Atrichum Macmillani*
*Aulacomnium heterostichum* (more wooded slopes)
*Bartramia pomiformis* (more wooded slopes)
*Dicranum scoparium*
*D. spurium*
*Ditrichum pallidum*
*Grimmia apocarpa* (on rocks)
*G. pilifera* (on rocks)
*Hedwigia ciliata* (on rocks)
*Leskea gracilescens* (on juniper trees)
*Leucobryum glaucum*
*Orthotrichum strangulatum* (on rocks)
*Platygyrium repens* (bark at bases of trees)
*Polytrichum juniperinum*
*P. piliferum*
*Thelia Lescurii* (on shaley soil)
*Thuidium delicatulum* (shaded areas)
*T. virginianum* (more exposed spots)
*Tortella humilis*

Many species of *Cladonia* are associated with these mosses, commonest being *Cladonia verticillata* and *C. rangiferina*. *Cetraria islandica* occurs in the bare exposed areas.

## HABITAT AND ENVIRONMENTAL FACTORS

In the local distribution of mosses, it is evident from observations made in the field and the study of distributional data, that factors other than topography, macroclimate and vegetational cover are involved, and are indeed more important. These factors are the microclimatic, edaphic and biotic conditions of the particular growing site of the individual moss plant.

The microclimate is determined by the light, temperature and humidity of the relatively small area in which the plant grows. Fluctuations of these conditions are caused by the slope of the soil, exposure and minor irregularities in the surface (Braun-Blanquet, 1932). The slight variation of any one of these features causes a marked change in the moss flora within a slight radius at a single locality.

Because of the interaction of the conditions of light, temperature and humidity, it is difficult to determine the effects of each of them individually on the different species of mosses. An increase in the amount of light brings with it a rise in temperature and the more rapid evaporation of moisture (Richards, 1932). Only with controlled conditions, where temperature and moisture can be kept constant, would it be possible to determine the true relationship of the light factor to the growth of mosses.

Mosses seem to be generally more shade-tolerant than higher plants. There are a greater number of species as well as more individual plants or cushions in shaded areas than in bright light. It is difficult to say whether they are just tolerant of shade in order to escape competition or actually grow best in a low light intensity. On the other hand there are some species of mosses growing on rocks and barrens which withstand high light intensities. Most of these are relatively dark in color, blackish or reddish-brown, presumably to protect them from the high light intensity. Species which might invade such territory may be excluded because of the high temperature and moisture deficit, rather than the fact that they cannot tolerate strong illumination. The *Hylocomium* union described above always occurs in deep shade. Sharp (1939) tells of its disappearance whenever trees are cut or blown down. Light is admitted, raising the temperature and increasing the rate of evaporation, thus making the habitat unsuitable for this union.

Some species of *Polytrichum* grow in exposed positions. *Polytrichum piliferum* is found almost exclusively in the sun on sterile barrens or sandy mountain tops. *P. commune* and *juniperinum* flourish more frequently along sunny roadsides, covering large areas in old fields and open sand pits. Because of their growth in huge cushions it is possible they can retain a great amount of moisture by capillarity and thus withstand the drying effects of the higher temperature of an exposed situation.

In dealing with temperature we do not know if the limiting factor is the mean annual, absolute maximum or minimum, or average daily maximum or minimum (Richards, 1932). We do know, however, that the temperature near the soil surface shows greater variation than the temperature 5 to 10 cm. above the ground where the air movement tends to equalize it (Braun-Blanquet, 1932). The temperature of the substrate itself varies, particularly with the exposure and direction of slope. It has been found however that moss cushions and tufts usually maintain a temperature slightly higher than the surrounding air and the substrate upon which they grow (Richards, 1932).

There is no experimental evidence available as to the upper limits of temperature at which mosses will grow and survive. Sharp (1939) gives the example of Hedwigia growing on exposed rocks in eastern Tennessee, withstanding a summer temperature of 50 degrees C. and a winter temperature of −34 degrees C. Observations made in the field while collecting have not been sufficient to justify final conclusions as to the effect of temperature on the distribution of Pennsylvania mosses. What appears to be the result of low or high temperature, may be caused by the light or humidity factors.

Mosses vary widely in their relationship to moisture. They range from species that are exclusively aquatic to those that live in the extreme xeric conditions found on bare, exposed rock surfaces.

Terrestrial and epiphytic mosses are sensitive to the saturation deficit, wind velocity and other factors affecting the rate of evaporation. However, their ability to absorb atmospheric moisture and retain it within the tuft or cushion is not only important in continuing the metabolism of the plant, but may frequently result in changing the habitat (Richards, 1932). Stream banks, humid glens and ravines, depressions or any other irregularity of the ground surface that aids in the retention of moisture are abundantly covered with a moss flora rich in species and quantity.

Many studies have been made of the water-holding ability of the bark of various trees and its effect on the epiphytic species present. It has generally been concluded that epiphytes, to flourish, need a low rate of evaporation combined with efficient water-holding ability of the bark of trees (Richards, 1932). This combination of conditions occurs in the cool shady ravines and glens in Pennsylvania and it is only in this type of habitat that corticolous mosses are found abundantly.

The response of Bryophytes to edaphic factors is sharper and clearer than in flowering plants (Richards, 1932 and Sharp, 1939). The fact that mosses are close to the substrate and apparently absorb moisture and mineral substances through their delicate rhizoids, may account for this marked response. Many species are narrowly limited to specific substrates. The very physical nature of the soil itself, whether it is clayey or sandy, seems to determine the presence or absence of some species of moses (Richards, 1932). *Pogonatum pensilvanicum* prefers bare clay soil while many species of *Polytrichum* appear to flourish best in sandy soil. Humus, rotting-wood, bark of trees and various types of rock surfaces are populated frequently by some species of mosses that occur on no other substrate.

Some mosses, known as calcicoles, prefer a substrate containing soluble lime; several of these are listed above. Some other species are definitely calcifuge, while a few like *Ceratodon purpureus* and *Cirriphyllum Boscii* seem to have no preference one way or another. Care must be taken in the analysis of the substrate, as frequently acid humus on top of limestone may lead to the designation of a calcifuge species growing on this humus, as a calcicole.

This brings up the question of hydrogen-ion concentration. As pointed out by Sharp (1939) there is no substrate character that has been more thoroughly investigated than that of pH. In Pennsylvania, as elsewhere, the mosses growing on the humus and debris of the forest floor are distinctly acid, ranging from a pH of 4 to 6. The mosses which prefer this acid substrate are the *Polytrichaceae*, many of the *Hypnaceae* and related families, the genera *Dicranum* and *Leucobryum*. On the other hand *Funaria hygrometrica*, *Physcomitrium turbinatum*, *Rhodobryum roseum*, species of *Bryum*, *Anomodon* and *Orthotrichum* are circumneutral and examples of a class of mosses growing from pH 6 to 8. As might be anticipated, there are a few species like *Ceratodon* and some *Mniums* which are found growing over a wide range of pH.

Attention should be called to the distribution of mosses on slopes in respect to the pH of the soil. Glenn and Welch (1931) have pointed out that the pH rises from a low of 4 or 5 at the top of a wooded slope to 6 or 7 and even 8 at the bottom, usually along a stream bank. The species of mosses present change from acid-loving, xeric species at the top to circumneutral, mesic and aquatic species at the bottom. This has been found to be generally true in stream valleys in Pennsylvania. However, where hemlock is the dominant tree, the pH at the bottom of the slope may not go above the neutral point (pH 7). Consequently there is a transition from the acid-xeric types of moss communities at the top of the slope to the more circumneutral-mesic communities at the foot.

## ASSOCIATES AND SUCCESSION

The influence of living organisms in the environment of the various species of mosses constitutes the biotic factor. In this study attention has been focused primarily on the vegetation. A discussion of the relationships of higher plants to certain moss communities has already been given. From observation it seems that lichens, liverworts and the mosses have a closer and more intimate effect among themselves in matters of invasion and succession than the higher plants have upon them. Certain relations observed again and again are worth recording at this point.

It has been generally observed that in many successions the *Pleurocarpous* species will in time overgrow and crowd out the *Acrocarpous* mosses. The creeping habit of the *Pleurocarps* gives them an advantage over the erect habit of the other group. In the tight cushions and tufts of *Acrocarpous* species, it is rare that one does not find some *Pleurocarpous* species invading.

It has been demonstrated that most moss succession is from alkaline to acid condition (Glenn and Welch, 1931). Field notes made from observation throughout the part of Pennsylvania covered, uphold this statement. The moss plants themselves, by accumulating soil and humus and by building a deep cushion of dead and decaying plants under their new growth, aid considerably in changing the pH of their own environment, frequently making it unsuitable for themselves, but more attractive for invading species. The leaching of calcium or other minerals from rock surfaces sometimes accounts for the change (Glenn and Welch, 1931).

On bare rock surfaces *Grimmia pilifera* seems to be the pioneer in many cases. After this species has accumulated a small amount of soil, *Anomodon attenuatus* invades, eventually crowding out the *Grimmia*. This species accumulates a fine textured, black soil at the base of the thick carpet-like growth. When these mats of *Anomodon* grow on a moist shaded rock face, *Thuidium delicatulum* invades the mat. *Anomodon rostratus* also gets started in these mats and restricts *A. attenuatus* to the periphery of the mass.

The association of *Aulacomnium heterostichum* and *Bartramia pomiformis* is quite common and has been observed by Steere (1933). *Dicranella heteromalla* seems to like the same habitat condition and has been noticed frequently growing with the above species.

In many collections of *Thuidium delicatulum*, made in swampy hemlock bottoms, it has been found interwoven with the hepatic *Trichocolea tomentella* (Ehrh.) Dumort. The superficial resemblance of the two species is quite striking.

On eroded clay banks or where fresh cuts have been made along roads, trails and stream banks there occurs an interesting succession involving *Pogonatum pensilvanicum* and the lichen *Baeomyces roseus*. This has been brought to the attention of bryologists by Conard (1939) and is treated in detail under the species *P. pensilvanicum*.

Additional treatment of associations and successions is given whenever possible under each individual species.

## CONCLUSION

In concluding the discussion on distribution, it is apparent to the writer that microhabitat is the important factor in the distribution of mosses in Pennsylvania. The moss communities found occurring in the various provinces and forest types are the direct results of the factors controlling the microhabitat. These factors of light, temperature, moisture, soil and biological competition are naturally influenced by the macroclimate, topography, forest cover and glaciation, but it is the microhabitat of the site itself which finally determines the moss species that shall grow there.

## TAXONOMIC STUDIES

On the following pages are reported all the species of mosses (Bryales) which are known from Central and Eastern Pennsylvania. For each species are included notes relative to its frequency, substrate, habitat, associates, reproduction and a list of the counties from which material has been seen. All specimens seen from east of the line formed by the western boundary of McKean, Elk, Clearfield, Cambria and Somerset Counties and new records for the counties west of that line are cited. The writer has also added published records, east of the above line, for which he has been unable to locate specimens. In the citation of individual specimens, the collectors' names are given with their field collection number or date. A number, unaccompanied by a collector's name, indicates the author's collections. The following abbreviations are utilized in the citations:

| | |
|---|---|
| A. | Academy of Natural Sciences, Philadelphia. |
| C. | Chicago Museum of Natural History. |
| J. | Jennings, Manual of Mosses of Western Pennsylvania. |

| | |
|---|---|
| NY | New York Botanical Garden. |
| PC | Porter Catalogue. |
| SMS | Sullivant Moss Herbarium. |
| TM | Manuscript of Miss Grace M. Tees. |

No letter following a citation indicates the Herbarium of the University of Pennsylvania.

The arrangement of the classes, orders and families adopted in this list follows that of Schaffner (1938) and Sharp (1939). The number of species of mosses reported in this list is 249 with 32 varieties, but with more intensive collecting in that part of the state not previously worked, this number will be increased.

Keys to classes, orders, families, genera and species are provided and are adapted from various sources. These keys apply only to the species occurring in the area covered by this paper.

## BRYALES (*Odontocarpae*)

(Adapted from Sharp, 1939)

A. Sporangium without a columella; spores very large; operculum and peristome none; small acrocarpous mosses . . . . . . . . . . . . I. *Archidiales.*

A. Sporangium with a definite columella; spores relatively small; mostly with an operculum and peristome, but some cleistocarpous; acrocarpous and pleurocarpous . . . . . . . . . . . . . . . . . . . . . . . . . B.

  B. Peristome teeth thin, derived from the cell-walls of a single layer of cells, always transversely barred; sometimes entirely wanting . . . . . . C.

  B. Peristome teeth cellular, rarely absent, if present derived from several layers of cells, not transversely barred, or, if faintly barred, then the capsule decidedly dorsiventral and zygomorphic . . . VII. *Polytrichales.*

C. Peristome single, rarely wanting; usually acrocarpous mosses . . II. *Dicranales.*

C. Peristome double or sometimes wanting; endostome thin and membranous, sometimes lacking . . . . . . . . . . . . . . . . . . . . . . . D.

  D. Endostome mostly imperfectly developed or sometimes wanting; thickening of outer surface of exostome teeth greater than that of the inner; mostly pleurocarpous mosses . . . . . . . . . . III. *Leucodontales.*

  D. Peristome distinctly double and the endostome usually well developed, except in Astomous groups; pleurocarpous or acrocarpous . . . . . E.

E. Endostome segments absent or, when present, alternating with the teeth of the exostome; hypophsis lacking or minute; pleurocarpous or acrocarpous . . . F.

E. Endostome processes when present, opposite the teeth of the exostome, either free or united with them, but the peristome sometimes entirely wanting; hypophsis sometimes highly developed; acrocarpous mosses . VI. *Splanchnales.*

  F. Cilia usually wanting, gametophyte usually flattened, the leaves inequilateral; alar cells not differentiated; calyptra usually mitriform; mostly pleurocarpous . . . . . . . . . . . . . . . . . . IV. *Hookeriales.*

  F. Cilia usually present; gametophyte occasionally flattened, leaves variable in shape; calyptra cucullate; alar cells variable; pleurocarpous and acrocarpous . . . . . . . . . . . . . . . . . . . V. *Hypnobryales.*

## ORDER I. ARCHIDIALES

**Archidium ohioense** Schimp. Very rare.

Published record not seen: Lancaster, along the Tucquan Creek, Porter, PC.

## ORDER II. DICRANALES

A. Leaves in more than 2 rows on the stem . . . . . B.

A. Leaves in two rows on the stem . . . . . VIII. *Fissidentaceae.*

B. Gametophytes gray-green, with colorless cells in the thick leaves II. *Leucobryaceae.*

B. Gametophytes light green to almost black; leaves usually one-cell in thickness; colorless cells infrequent . . . . . C.

C. Calyptra covering the entire capsule . . . . . VII. *Encalyptaceae.*

C. Calyptra not covering the entire capsule . . . . . D.

D. Gametophyte dark, brownish or blackish, growing on rocks; seta short, peristome teeth red or brown . . . . . V. *Grimmiaceae.*

D. Gametophyte usually green, on various substrate; seta long or short, peristome teeth variously colored . . . . . E.

E. Gametophyte and sporophyte 1 cm. or less; found on rocks; leaves smooth, usually awned . . . . . IV. *Seligeriaceae.*

E. Gametophyte and sporophyte usually exceeding 1 cm.; found on various substrate; leaves frequently papillose, sometimes awned . . . . . F.

F. Gametophytes of most species with falcate-secund leaves; peristome teeth usually triangular-lanceolate and bifid half their length . . . I. *Dicranaceae.*

F. Gametophytes of few species with falcate-secund leaves; peristome teeth usually linear, or split to the base, or lacking, or capsules astomous . . . G.

G. Leaves very slender; leaf-cells smooth . . . . . III. *Ditrichaceae.*

G. Leaves broad to slender depending on the species; leaf-cells papillose VI. *Tortulaceae.*

### I. DICRANACEAE

A. Alar cells not conspicuously enlarged . . . . . B.

A. Alar cells conspicuously enlarged . . . . . F.

B. Leaf-cells papillose . . . . . C.

B. Leaf-cells essentially smooth . . . . . D.

C. Peristome teeth undivided and without median line . . . . . 3. *Oreoweisia.*

C. Peristome teeth divided . . . . . 5. *Dichodontium.*

D. Leaf crisped when dry . . . . . E.

D. Leaf not crisped when dry . . . . . 1. *Dicranella.*

E. Gametophytes less than 5 mm. high; capsule erect and not strumose 2. *Rhaodoweisia.*

E. Gametophytes more than 5 mm. high; capsules inclined and strumose 4. *Oncophorus.*

F. Costa with bands of stereid cells . . . . . G.

F. Costa without bands of stereid cells . . . . . 8. *Paraleucobryum.*

G. Costa relatively narrow, capsule with stomata . . . . . 6. *Dicranum.*

G. Costa relatively broad; capsule without stomata . . . . 7. *Dicranodontium.*

### 1. DICRANELLA Schimp.

A. Seta yellowish, sometimes becoming dark with age . . . . . B.

A. Seta red . . . . . C.

B. Capsule sulcate, mouth incurved when dry . . . . . *heteromalla.*

B. Capsule scarcely plicate, mouth erect when dry . *heteromalla*, var. *orthocarpa.*

C. Leaves entire . . . . . D.

C. Leaves serrate or denticulate . . . . . *varia.*

D. Leaves subsquarrose, from a sheating base . . . . . . . . . . *Schreberi.*
D. Leaves secund or erect, pellucid by reason of very large thin-walled cells *rufescens.*

(*Dicranella crispa* (Hedw.) Schimp. Excluded because of its western range. Published, not seen: Carbon, Rau, PC; Lancaster, Dillerville Swamp, James, PC; Lehigh, Rau, PC.)

**Dicranella heteromalla** (Hedw.) Schimp. Common. Widespread throughout the state, but more common in the mountainous areas.

SUBSTRATE: Soil and decaying logs. Ph4 to 5.3.

HABITAT: All forest types of the state. Wooded hillsides, wood roads and stream banks. Elevation from 150 to 2200 feet.

ASSOCIATES: Growing with *Pohlia nutans* and *Tetraphis pellucida.*

REPRODUCTION: Antheridia and archegonia shriveled and brown by July. Capsules mature and closed in September, November and December collections. Open and spores still present in March. (32 specimens examined, 12 fruiting.)

COUNTIES: Berks, Carbon, Clinton, Delaware, Elk, Lehigh, Luzerne, McKean, Monroe, Montgomery, Montour, Northampton, Northumberland, Potter, Schuylkill, Susquehanna. (16 counties). Published, not seen: Center, Matternville and Bear Meadow, J.

**Dicranella heteromalla** (Hedw.) Schimp., var. **orthocarpa** (Hedw.) Paris. Commoner than the species and generally distributed in eastern half of the state.

SUBSTRATE: All types of soils, rotting logs and rocks covered with humus. pH range from 4 to 6. More frequently 4 to 5.

HABITAT: All forest types of the state. Mountain tops, wooded hillsides, roadbanks, streambanks, lake shores, old fields and bases of trees. Elevation from 50 to 2567 feet.

ASSOCIATES: With *Atrichum* spp., *Polytrichum* spp., *Leucobryum glaucum, Aulacomnium heterostichum, Bartramia pomiformis, Hypnum* spp., *Ditrichum pallidum* and species of *Cladonia.*

REPRODUCTION: Immature capsules in August. Mature capsules closed until December and January, open and shedding spores from February until March. (142 specimens examined, 119 fruiting.)

COUNTIES: Adams, Bedford, Berks, Blair, Bradford, Bucks, Carbon, Center, Chester, Clearfield, Clinton, Columbia, Crawford, Cumberland, Dauphin, Delaware, Elk, Franklin, Huntingdon, Juniata, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mifflin, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Potter, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Venango, Warren, York. (43 counties.)

**Dicranella rufescens** (Smith.) Schimp. Rare. On wet soil along streams and at the edge of swamps.

COUNTIES: Cambria, Galitzen, James (A); Lancaster, Dillerville Swamp, Porter (A); McKean, 6 collections of Burnett (NY & A); Philadelphia, Wissahickon, James (A). (4 counties). Published, not seen: Delaware, Painter's Arboretum, Krout, TM; Elk, McMinn, PC; Huntingdon, Porter, PC; Monroe, James, PC.

**Dicranella Schreberi** (Hedw.) Schimp. Rare. On clayey stream banks and wet cliffs. (3 specimens.)

COUNTIES: Lancaster, Dillerville, James (A); Monroe, Bushkill, Bartram 8/17/21 (NY). (2 counties.)

(*Dicranella subulata* (Hedw.) Schimp. Excluded species. Reported by Porter from Lancaster County, but no specimens are preserved. Mrs. Britton refers those from the above locality to *D. heteromalla* — the form with the curved pedicels. See Porter Catalogue, footnote p. 16.)

**Dicranella varia** (Hedw.) Schimp. Not common. Scattered over the state. On soil and rock surfaces. (16 specimens.)

COUNTIES: Delaware, Lancaster, Lehigh, McKean, Montgomery, Northampton, Philadelphia. (7 counties). Published, not seen: Chester, James, PC and Chester Valley, Kaiser, SMS.

### 2. RHABDOWEISIA B.S.G.

A. Leaves serrulate above . . . . . . . . . . . . . . . . . . . . *denticulata.*

A. Leaves narrowly acute and almost entire . . . . *denticulata* var. *americana.*

**Rhabdoweisia denticulata** (Brid.) Bry. Eur. Rare. Confined to the northern counties.

SUBSTRATE: Sandstone and conglomerate.

HABITAT: Shaded ledges and crevices of rocks.

COUNTIES: Carbon, Onoko Glen, Wolle (NY) and Stony Creek, Wolle (NY); McKean, Hawkins, Burnett 585 (NY) and Toad Hollow, Burnett 2591 (NY); Northampton, Easton, Rau (NY) and Porter, 11/10/68 (A); Pike, East Branch Falls, Rau (NY) and Little Bushkill Creek, Bartram, (NY). Published, not seen: As *R. crispata* (Dicks.) Kindb., Philadelphia, Kaiser, Bryologist **19.**

**Rhabdoweisia denticulata** (Brid.) Bry. Eur., var. **americana** Culmann. Rare. Published as *R. fugax* in previous publications.

COUNTIES: Carbon, Stony Creek, Rau (NY); McKean, Toad Hollow, Burnett 8/1/97 (NY) and Hawkins, Burnett (A); Northampton, Easton, 9/82 (NY) and Delaware Water Gap, Musci Appl. Austin 71 (A); Pike, Bushkill, Wolle 7/1/74.

### 3. OREOWEISIA De Not.

**Oreoweisia serrulata** (Funck.) De Not. Rare. On moist rock faces and in crevices.

COUNTIES: Bucks, Narrowsville, James 11/67 (A & NY); Monroe, Delaware River below Bushkill, Bartram (NY), Indian Rock, Bartram 653 (NY), Buck Hill Falls, Wolle 6/74 (NY), Delaware Water Gap, Musci Appl. Austin 70 (A); Pike, Bushkill, Wolle 7/74 and Wolle 8/73. Published, not seen: Carbon, Rau, PC; Franklin, Mercersburg, Porter, PC.

### 4. ONCOPHORUS Brid.

A. Leaf base ovate; alar cells usually quite distinct; leaf margins mostly of two layers of cells and recurved . . . . . . . . . . . . . . . . . . . *virens*

A. Leaf base obovate; alar cells usually not distinct; leaf margin often not recurved . . . . . . . . . . . . . . . . . . . . . . . . . B.

  B. Plants light green, usually on decayed wood; upper lamina of leaf unistratose . . . . . . . . . . . . . . . . . . . . . *Wahlenbergii.*

  B. Plants fulvous, usually on rocks; upper leaf lamina bistratose . . . *Rauei.*

**Oncophorus Rauei** (Aust.) Grout. Very rare.

Type locality: Carbon County, Onoko Glen near Mauch Chunk, 700 feet, on shaded dry rocks, A. T. Beals (A).

**Oncophorus virens** (Hedw.) Brid. Rare.

COUNTIES: Cambria, Wilmore, James 7/61 (A); Monroe, Tobyhanna, Porter 11/68 (A); Pike, Salsbury, Rau 7/18/80 (NY). (3 counties.)

**Oncophorus Wahlenbergii** Brid. Rare. On rocks, soil and logs in shaded situations.

COUNTIES: McKean, five collections by Burnett (NY). Published, not seen: Lehigh, Rau, TM.

### 5. DICHODONTIUM Schimp.

**Dichodontium pellucidum** (Hedw.) Schimp. Rare. Rocky streams in cool moist places.
COUNTIES: Monroe, Wolle, 8/21/73.

### 6. DICRANUM Hedw.

A. Capsules straight and erect or nearly so, never strumose . . . . . . . . B.

A. Capsules curved and cernuous, strumose in some species . . . . . . . . E.

B. Leaves papillose on the back about ½ the way down, crisped when dry, not secund . . . . . . . . . . . . . . . . . . . . . *montanum.*

B. Leaves smooth on the back or slightly rough near the apex, straight, or more or less secund and crisped . . . . . . . . . . . . . . . . C.

C. Costa excurrent in all leaves . . . . . . . . . . . . . . . . . . . . . D.

C. Costa not excurrent; stems usually bearing flagellae in the axils of the upper leaves . . . . . . . . . . . . . . . . . . . . . . . . . . *flagellare.*

D. Margin and costa of leaves entire; apex usually broken . . . . . . *viride.*

D. Margin and costa of leaves serrulate . . . . . . . . . . . *fulvum.*

E. Upper leaf cells 1–2:1, rarely more, their walls not pitted . . . . . . . F.

E. Upper leaf cells more elongated, more or less pitted . . . . . . . . . J.

F. Plants robust, leaves undulate or rugose . . . . . . . . . . . . G.

F. Plants medium sized to slender; leaves not rugose (except occasionally in *condensatum*) . . . . . . . . . . . . . . . . . . . . . . . I.

G. Leaves erect-open when dry, rarely somewhat crisped, obtuse . . . . . *Bergeri.*

G. Leaves more or less crisped when dry, acute . . . . . . . . . . . . H.

H. Leaves ovate to ovate-lanceolate, widest a little below the middle, finely papillose over all the upper dorsal surface; setae solitary . . . . *spurium.*

H. Leaves oblong-lanceolate; broadest at or near the base, more or less roughened with coarse papillae on the upper dorsal surface; setae usually aggregate . . . . . . . . . . . . . . . . . . . *Drummondii.*

I. Leaves strongly falcate-secund and crisped when dry . . . . . . *fuscescens.*

I. Leaves not secund, often straight . . . . . . . . . . . . *condensatum.*

J. Leaves undulate; setae aggregate . . . . . . . . . . . . . . *rugosum.*

J. Leaves not undulate (sometimes slightly so in *Bonjeani*) . . . . . . K.

K. Leaves with a slender strongly serrate apex, strongly falcate-secund, never undulate . . . . . . . . . . . . . . . . . . . . . . . *scoparium.*

K. Leaves laxly spreading, rarely secund, sometimes slightly undulate, with broad, often obtuse apex . . . . . . . . . . . . . . . . . . . . *Bonjeani.*

**Dicranum Bergeri** Bland. Rare. Confined chiefly to the "cool" area, reaching its southern limit in the state. In bogs.

COUNTIES: Northampton, Rau (A); Pike, Wolle, 1873. (2 counties). Published, not seen: Bucks, Rau, PC; Chester, "Flora Cestrica," PC; Delaware, Smith, PC.

**Dicranum Bonjeani** De Not. Fairly common. Chiefly confined to the "cool" area.
SUBSTRATE: Wet soil and humus.
HABITAT: Principally in the eastern hemlock formation. Peat bogs, swamps, stream banks, moist thickets and wet shaded roadsides. Elevation from 500 to 2500 feet.
ASSOCIATES: With *Polytrichum* spp., *Plagiothecium* spp., and twice in the shade of *Lycopodium* spp.
REPRODUCTION: Capsules mature and closed in July collections. (14 specimens examined, 1 fruiting.)
COUNTIES: Bedford, Bradford, Carbon, Center, Chester, Cumberland, Franklin, Lycoming, Potter, Snyder, Somerset, Wayne, York. (13 counties.)

**Dicranum condensatum** Hedw. Rare. More common on Coastal Plain of New Jersey.

SUBSTRATE: Sandy soil.

Type locality: Lancaster County, but the co-type found in the herbarium seems to be *D. spurium* Hedw. (4 specimens.)

COUNTIES: Dauphin, Peters Mountain, Small 11/1/92 (NY & A); Lebanon, Mountains about cold spring, Small 9/1894 (NY); Northampton, Bushkill Gap, James 10/69 (A). (4 counties.)

**Dicranum Drummondii** C. Mull. Rare. The "cool" mountainous area of the state.

SUBSTRATE: On moist soil in shaded places. (6 specimens.)

COUNTIES: Bedford, Chaneysville, True 60; Monroe, Pocono Mountains, Porter (NY & A); Naomi Pines, Small 6/7–11/89 (NY); Pike, N. of Bushkill, Bartram 4/30/21 (NY). (3 counties.)

**Dicranum flagellare** Hedw. Common in Ridge and Valley, Allegheny Mountain and Plateau Provinces.

SUBSTRATE: Rotting wood and humus. pH4.

HABITAT: All forest types of the state. Swamps, thickets, roadsides, wooded slopes and shale bluffs. Elevation from 600 to 2100 feet.

ASSOCIATES: *Polytrichum* spp., *Hypnum* spp., and various lichens, usually *Cladonia.*

REPRODUCTION: Flagellae usually present at all seasons. The majority of the capsules open and shedding spores in September. (55 specimens examined, 17 fruiting.)

COUNTIES: Bedford, Cambria, Clarion, Clearfield, Clinton, Columbia, Cumberland, Elk, Huntingdon, Indiana, Juniata, Luzerne, McKean, Monroe, Northampton, Potter, Snyder, Somerset, Sullivan, Tioga, Warren. (21 counties.) Published, not seen: Blair, Porter, PC; Carbon, Rau, PC; Chester, "Flora Cestrica," PC; Delaware, Smith, PC; Lancaster, Muhlenberg, TM; and Small, PC; Philadelphia, Wissahickon, Kaiser TM; Pike, Eich's Pond, Moldenke 3332.

**Dicranum flagellare** Hedw., var. **minutissimum** Grout. Differs from the species chiefly by its small size.

COUNTIES: Clearfield, ½ mile northeast of Bigler, 4553; Brooks Rock, no county given, Wynne 7 (NY).

**Dicranum fulvum** Hook. Common. Chiefly in the mountainous "cool" area.

SUBSTRATE: Rocks. (Sandstone, shale and quartzite.)

HABITAT: All forest types. On rocks and boulders along stream banks, roads, shale bluffs, lake shores, in ravines and on wooded slopes. Elevation from 400 to 2320 feet.

ASSOCIATES: Commonly with some species of *Cladonia.* Also with a wide variety of mosses.

REPRODUCTION: Capsules open as early as August, but the majority shedding spores in September. (42 specimens examined, 5 fruiting.)

COUNTIES: Bedford, Berks, Carbon, Chester, Clinton, Columbia, Cumberland, Delaware, Fulton, Juniata, Lancaster, Lebanon, Luzerne, Lycoming, McKean, Monroe, Northampton, Pike, Potter, Snyder, Somerset, Union, Venango, Warren, Wayne. (25 counties). Published, not seen: Montgomery, Zieglersville, Tees 528 TM; Philadelphia, James, PC and Wissahickon, Kaiser, TM.

**Dicranum fuscescens** Turn. Fairly common in the "cool" mountainous region.

SUBSTRATE: Soil, litter and soil accumulation on sandstone.

HABITAT: Chiefly in eastern hemlock formation. Bases of trees, shaded road banks, boulders, ravines and thickets. Elevation from 650 to 2200 feet.

ASSOCIATES: *Dicranum scoparium*, *Pohlia nutans*, *Hypnum imponens*, and species of *Cladonia.*

REPRODUCTION: Capsules mature and closed in October. (14 specimens examined, 1 fruiting.)

COUNTIES: Bradford, Columbia, Fayette, Luzerne, Lycoming, Monroe, Perry, Pike, Snyder, Sullivan, Union. (11 counties.) Exsiccati examined: Austin, Musci Appal. Supp. I 472. Mountains of Pennsylvania to New England and northward and westward (NY).

(*Dicranum majus* Smith. Excluded species. Published records, specimens not seen: Blair, Porter, PC. Very doubtful, E. G. Britton.)

**Dicranum montanum** Hedw. Rare. On logs and roots of trees in the mountains.

COUNTIES: Bucks, Nockamixon, 5694; Elk, Bennet Branch, McMinn 10/65 (A); Monroe, Pocono Summit, Britton 6/7/89 (NY), Naomi Pines, Britton 8/1/93 (NY); Philadelphia, Wissahickon, Tees 662 (A). (4 counties.) Published, not seen: Huntingdon, Porter, PC.

**Dicranum rugosum** (Hoffm.) Brid. Not common. Confined mostly to the "cool" area.

SUBSTRATE: On moist shaded soil and rocks.

HABITAT: Chiefly in the eastern hemlock formation. Shaded mountain sides, stream banks and wet woods. Serpentine barrens in Lancaster County. Elevation from 350 to 2320 feet.

ASSOCIATES: *Hypnum* spp. (18 specimens.)

COUNTIES: Bedford, Bucks, Fayette, Huntingdon, Juniata, Lancaster, Lehigh, Monroe, Northampton, Snyder, Tioga, Warren, Wayne. (13 counties). Published, not seen: Chester, Chester Valley, James PC; Fulton, Porter, PC.

**Dicranum scoparium** Hedw. Commonest species of Dicranum. Widespread.

SUBSTRATE: Soil, rotting wood, humus and soil accumulation on rock surfaces. pH4 to 5.

HABITAT: All forest types of the state. Mountain tops, wooded slopes, stream banks, trails, road banks, ravines, bases of trees, shale bluffs and serpentine barrens. Elevation from 100 to 2320 feet.

ASSOCIATES: Chief associates are *Leucobryum glaucum*, *Hypnum* spp., *Polytrichum* spp., *Thuidium delicatulum* and a wide variety of acid woodland mosses. Also associated with species of *Cladonia*.

REPRODUCTION: Young sporophytes 2 to 3.5 cm. long in June. Capsules mature and shedding spores from September to November. Capsules mostly empty by December. (133 specimens examined, 39 fruiting.)

COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Cambria, Carbon, Center, Chester, Clearfield, Columbia, Crawford, Cumberland, Dauphin, Delaware, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mifflin, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Warren, York. (42 counties). Published, not seen: Clinton, near Loch Haven, J.

**Dicranum spurium** Hedw. Not common. Confined to bare rocky slopes and wind gaps of the Ridge and Valley Province.

SUBSTRATE: Shaley and rocky soil.

HABITAT: Oak woods. Barren slopes and shale bluffs.

ASSOCIATES: Chiefly with species of *Cladonia*.

COUNTIES: Bedford, Carbon, Dauphin, Franklin, Fulton, Huntingdon, Lehigh, Monroe, Northampton. (9 counties.)

**Dicranum viride** (Sull. & Lesq.) Lindb. Rare. Counties of the "cool" mountain area.

SUBSTRATE: Rotting wood and humus.

HABITAT: Birch-beech-maple forests. (9 specimens.)

COUNTIES: Bradford, Columbia Cross Roads, 4038; Cambria, Allegheny Mountains, James 11/62 (A); McKean, Burnett, three records (NY); Monroe, Pocono Plateau, Britton 7/24/93 (NY) and Pocono Mountain, James 11/65 (A); Northampton, Bethlehem, Rau (NY); Pike, Rau (NY). (5 counties.)

### 7. DICRANODONTIUM

**Dicranodontium denudatum** (Brid.) E. G. Britton. Limited to the northern mountain counties. Mostly on wet rocks. Elevation from 1600 to 2100 feet. Associated with *Plagiothecium* spp. and *Tetraphis pellucida.* (13 specimens.)

COUNTIES: McKean, Guffey, 5674 and eleven records of Burnett (A & NY); Monroe, Pocono, Porter 8/23/59 (A). (2 counties.)

### 8. PARALEUCOBRYUM (Lindb.) Loeske

**Paraleucobryum longifolium** (Hedw.) Loeske. Not common. Locally in a few eastern counties.

SUBSTRATE: Rocks and bases of trees. (6 specimens.)
COUNTIES: Berks, Flying Hill, Wilkens 11/12/27 (A); Bucks, Morrisville, James 10/3/49 (A); McKean, Bradford, Burnett (NY); Monroe, Tobyhanna Mills 9/13/92 (NY) and Pocono Mountain, James 10/69 (A); Northampton, Easton, Porter, 11/67 (A). Published, not seen: Carbon, Rau, PC; Chester, "Flora Cestrica," PC.

## II. LEUCOBRYACEAE

### LEUCOBRYUM Hampe.

A. Gametophyte generally over 2 cm. long; upper tubular part of leaf longer than the flattened basal portion . . . . . . . . . . . . . . . *glaucum.*

A. Gametophyte generally less than 2 cm. long; upper tubular part of leaf shorter than the flattened basal portion . . . . . . . . . . . . . . . *albidum.*

**Leucobryum albidum** (Brid.) Lindb. Rare. Coastal Plain species confined to southeastern and southwestern counties. (5 specimens.)

COUNTIES: Carbon, Stony Creek, Rau (NY) this specimen is questionable; Chester, Chester Valley, James (A); Fayette, Ohio Pyle, Browne 639 (C); Lancaster, Eagle Tavern, Porter (A). (4 counties). Published, not seen: Berks, Hiester, PC; Delaware, James, PC; Huntingdon, Porter, PC; Philadelphia, James, PC.

**Leucobryum glaucum** (Hedw.) Schimp. Abundant. Forms thick cushions. Occurs in all the Physiographic Provinces.

SUBSTRATE: Soil and humus, rocks and well rotted logs and stumps. pH4 to 5.
HABITAT: All types of woodlands within the state, from the summits of the mountains and dry shaley slopes to wet swampy bottoms, less frequently in old fields and weedy meadows. At elevations from 100 to 2100 feet.
ASSOCIATES: Commonly with species of the following mosses: *Polytrichum, Dicranum, Thuidium* and *Atrichum.* Also with species of *Cladonia.*
REPRODUCTION: Earliest appearance of sporophytes in collected material on August 19th with setae 1 cm. long. Mature capsules appearing from November through December. (153 specimens examined, 13 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Carbon, Center, Chester, Clearfield, Clinton, Columbia, Cumberland, Dauphin, Delaware, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mifflin, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango, Warren, York. (42 counties.)

## III. DITRICHACEAE

A. Capsule cleistocarpous, dehiscing irregularly and without peristome . . . . B.
A. Capsule with operculum and peristome . . . . . . . . . . . . . . . . . . C.
B. Capsules ovoid, beaked, immersed . . . . . . . . . . 1. *Pleuridium.*
B. Capsule pyriform or long-necked, immersed to long-exserted . . 2. *Bruchia.*
C. Capsule with a slender neck as long as the urn or much longer . . 3. *Trematodon.*
C. Capsule without obvious neck . . . . . . . . . . . . . . . . . . . . D.
D. Leaves distinctly 2-ranked, with sheathing bases . . . . . 4. *Distichium.*
D. Leaves not 2-ranked . . . . . . . . . . . . . . . . . . . . . . . . E.
E. Capsules strongly sulcate, slightly strumose . . . . . . . . . 5. *Ceratodon.*
E. Capsules (except *D. pallidum*) not sulcate . . . . . . . . . . 6. *Ditrichum.*

### 1. PLEURIDIUM Brid.

A. Calyptra mitrate; stomata near the middle of the capsule-wall . . . *palustre.*
A. Calyptra cucullate; stomata basal . . . . . . . . . . . . . . *subulatum.*

(*Pleuridium acuminatum* Lindb. Excluded species. Only the following records with no specimens available: Northampton and Lehigh Counties, Rau, PC.)

**Pleuridium palustre** (Bruch. & Schimp.) Bry. Eur. Rare. Old fields.

COUNTIES: Philadelphia, Moyamensing, James 5/66 (A). Published, not seen: Chester, Chester Valley, James, PC.

**Pleuridium subulatum** (Hedw.) Lindb. Rare. Fallow fields. (5 specimens.)

COUNTIES: Delaware, Radnor Township, Kaiser 4/7/10; Lehigh, Rau (A); Northampton, Bethlehem, Porter 1864 (A); Philadelphia, Moyamensing, James 5/31/66 (A) and Kingsessing, Swedes Church, James 5/51 (A). Published, not seen: Chester, Darlington, TM.

### 2. BRUCHIA Schwaegr.

A. Neck of capsule about the length of the spore-producing region . . . *Sullivanti.*
A. Neck of capsule very short, at times almost inconspicuous . . . . . *flexuosa.*

**Bruchia flexuosa** (Sw.) C. Mull. Rare, probably overlooked. Meadows, soil under the grass. (3 specimens.)

Type locality: Lancaster, Muhlenberg, type specimen (NY).
COUNTIES: Lancaster; Philadelphia, James 5/66 (NY) and Moyamensing, James 5/31/66 (A). (2 counties). Published, not seen: Bucks, James, PC; Chester, James, PC.

**Bruchia Sullivanti** Aust. Rare. Meadows. Published, not seen: Philadelphia, James, PC.

### 3. TREMATODON Mx.

A. Neck as long as urn of capsule . . . . . . . . . . . . . . . . *ambiguus.*
A. Neck twice as long as urn . . . . . . . . . . . . . . . . . . *longicollis.*

**Trematodon ambiguus** (Hedw.) Hornsch. Rare. Probably overlooked. Moist grassy places and exposed clay banks. (3 specimens.)

COUNTIES: Cambria, Allegheny Mountains, Porter and James (A); Luzerne, near Hazelton, Rau 6/73 (NY); Pike, Rau 8/73 (NY & A). (3 counties). Published, not seen: Carbon, Rau, PC.

**Trematodon longicollis** Mx. Rare. Moist woodlands. With *Funaria hygrometrica* and *Pohlia nutans.* (3 specimens.)

COUNTIES: Cambria, 1852 (NY); Northampton, Centerville, Schaeffer 8/5/47; Philadelphia, near Tacony, James 6/20/50 (A). (3 counties.)

### 4. DISTICHIUM Bry. Eur.

**Distichium capillaceum** (Hedw.) Bry. Eur. Very rare. Shaded limestone ledges.
COUNTIES: Monroe, along the Delaware River, Bushkill, Bartram 6/21/21 (NY).

### 5. CERATODON Brid.

**Ceratodon purpureus** (Hedw.) Brid. Very common. Widespread.
SUBSTRATE: Soil, rocks (limestone and shale), cinders, sand and wood. pH range 4 to 7, no preference.
HABITAT: Forests, thickets, old fields, dumps, railroad embankments, walls and curbing along city streets. Elevation from 50 to 1900 feet.
ASSOCIATES: With *Polytrichum commune*, *P. piliferum*, *Funaria hygrometrica*, *Dicranella heteromalla*, and species of *Cladonia*.
REPRODUCTION: Sporophytes 1 mm. long in March, growing to 1.5–2 cm. in length by April. Capsules mature and shedding spores May to August. (74 specimens examined, 43 fruiting.)
COUNTIES: Adams, Bedford, Berks, Blair, Bucks, Carbon, Chester, Columbia, Delaware, Franklin, Fulton, Lehigh, Luzerne, Lycoming, McKean, Monroe, Montgomery, Northampton, Philadelphia, Potter, Schuylkill, Snyder, Somerset, Sullivan, York. (25 counties). Published, not seen: Cambria, Cresson, J; Center, 2 records, J; Clinton, Loch Haven, J; Lancaster, Muhlenberg, PC; and Small SMS.

### 6. DITRICHUM Hampe.

A. Seta of sporophyte bright yellow . . . . . . . . . . . . . . . . *pallidum.*
A. Seta of sporophyte red to brown . . . . . . . . . . . . . . . . . . B.
  B. Awn of perichaetial leaf as long as the widened base . . . . . . . *pusillum.*
  B. Awn of perichaetial leaf much shorter than the sheathing base . . . *lineare.*

**Ditrichum lineare** (Sw.) Lindb. Not common. Probably overlooked. Widespread.
SUBSTRATE: Soil pH5 to 6.
HABITAT: All forest types and meadows. Shady banks, ditches, roadsides and alluvial bottoms. Elevation from 150 to 1600 feet.
REPRODUCTION: Young sporophytes appearing in April. Capsules mature and closed in September through to November. (15 specimens examined, 5 fruiting.)
Type locality: Lancaster County.
COUNTIES: Adams, Cumberland, Dauphin, Delaware, Lehigh, McKean, Monroe, Northampton, Philadelphia, Warren. (10 counties.)

**Ditrichum pallidum** (Hedw.) Hampe. Common. Widespread.
SUBSTRATE: Soil. pH4 to 5.
HABITAT: All forest types and old fields. Wooded slopes, roadsides, fallow slopes, shale bluffs, serpentine barrens, quarries and rocks along streams. Elevation from 100 to 1550 feet.
ASSOCIATES: *Dicranella heteromalla*, *Funaria hygrometrica* and *Atrichum Macmillani*. Also with species of *Cladonia*.
REPRODUCTION: Capsules mature in April and shedding spores then and through May. (51 specimens examined, 26 fruiting.)
COUNTIES: Adams, Bedford, Bradford, Bucks, Chester, Columbia, Delaware, Elk, Lehigh, McKean, Monroe, Montgomery, Northampton, Perry, Philadelphia Schuylkill, Somerset, Sullivan, Warren, York. (20 counties). Published, not seen: Center, Scotia, Tussey's Mountain and Matternville, J; Lancaster, Muhlenberg, TM and Smithville, Small PC.

**Ditrichum pusillum** (Hedw.) E. G. Britton. Fairly common. Widespread.
SUBSTRATE: On moist bare soils. pH5 to 6.
HABITAT: Open hardwood and hardwood-pine forests and old fields. Moist wooded hillsides, shores of ponds, along roads and on disturbed soils. Elevations from 75 to 1500 feet.
ASSOCIATES: *Dicranella heteromalla*, *Ceratodon purpureus* and *Bryum* spp.
REPRODUCTION: Capsules mature in September. Open and shedding spores in October and November. Empty capsules present until May. (25 specimens examined, 16 fruiting.)
COUNTIES: Bradford, Center, Chester, Columbia, Delaware, Huntingdon, Lancaster, Lehigh, Montour, Northampton, Philadelphia, Schuylkill, York. (13 counties). Published, not seen: Berks, Fernersville, Tees 280, Mt. Neversink, Wilkins 11/18/27 and Gibraltar Hill, Wilkins 9/15/27 TM; Montgomery, Fraser's Bog, Wismer 1/29/33 and Marble Hall, Tees 348 TM.

## IV. SELIGERIACEAE

A. Alar cells of leaves not enlarged . . . . . . . . . . . . . . 1. *Seligeria.*
A. Alar cells of leaves enlarged . . . . . . . . . . . . . . . . . 2. *Blindia.*

### 1. SELIGERIA Bry. Eur.

A. Seta straight or nearly so; capsules broadest at the mouth . . . . . . . B.
A. Seta recurved when moist; capsules slightly narrowed at the mouth, or at least no wider than in middle . . . . . . . . . . . . . . . . . . *recurvata.*
  B. Leaves finely serrulate, the awn long, slender, tapering . . . . . . *pusilla.*
  B. Leaves entire or nearly so, the awn short, thick and abrupt . . . *calcarea.*

**Seligeria calcarea** (Hedw.) Bry. Eur. Very rare. On wet limestone rocks.
Published, not seen: Huntingdon, Warrior's Ridge, Porter PC.

**Seligeria pusilla** (Hedw.) Bry. Eur. Very rare. Damp shaded limestone cliffs.
COUNTIES: Monroe, Indian Rocks, Bartram 580 (NY).

**Seligeria recurvata** (Hedw.) Bry. Eur. Very rare. Moist shaded limestone rocks.
COUNTIES: Northampton, College Hill, Easton, Porter 11/1863 (A) and Spruce Hill, Easton, Porter 5/16/60 (A).

### 2. BLINDIA Bry. Eur.

**Blindia acuta** (Hedw.) Bry. Eur. Very rare. Wet sloping rock faces.
COUNTIES: Monroe, Bushkill, Bartram 836 (NY) and Delaware Water Gap, James 10/71 (A).

## V. GRIMMIACEAE

A. Leaf-cells not sinuose or sinuose only in the basal portion of the leaf 1. *Grimmia.*
A. Leaf-cells sinuouse throughout most of the leaf . . . . . . 2. *Rhacomitrium.*

### 1. GRIMMIA Hedw.

A. Columella usually attached to the lid and deciduous with it; capsule immersed, symmetrical, larger than the straight seta . . . . . . . . . . . . . . B.
A. Columella free from the lid and persistent . . . . . . . . . . . . . . C.
  B. Leaves muticous, not hyaline-hair pointed, more or less repand or dentate at apex . . . . . . . . . . . . . . . . . . . *alpicola* var. *rivularis.*
  B. Leaves with more or less developed hyaline points . . . . . . . *apocarpa.*
C. Lower leaf cells sinuose, but shorter than in *Rhacomitrium* . . . . . *pilifera.*

C. Lower leaf cells not sinuose . . . . . . . . . . . . . . . . . . . . D.
  D. Seta straight or nearly so, and nearly always longer than the capsule *laevigata.*
  D. Seta arcuate or flexuose, nearly always longer than the capsule which is often longitudinally sulcate when dry . . . . . . . . . . . . *Olneyi.*

**Grimmia alpicola** Hedw., var. **rivularis** (Brid.) Broth. Rare.

SUBSTRATE: Rocks in or by streams. pH 8.
COUNTIES: Berks, Stonersville 5901, N. of Reading, Wilkens 12/25/27 (A) and E. of Spangsville, Wilkens 10/30/27 (A); Dauphin, Pillow 5536 and Halifax 5491a; Lancaster, Millersville 2597 & 2592. (3 counties). Published, not seen: Cumberland, Small, PC.

**Grimmia apocarpa** Hedw. Fairly common. Widespread. (Including varieties **ambigua** and **conferta**.)

SUBSTRATE: Rock. (Limestone, shale and syenite.)
HABITAT: Open woods, vacant lots, quarries and exposed rock surfaces. Shale bluffs, shores of rivers, railroad embankments and face of dam. Elevation 50 to 1100 feet.
COUNTIES: Bedford, Berks, Carbon, Center, Chester, Delaware, Lancaster, Monroe, Northampton, Philadelphia. (10 counties). Published, not seen: Bucks, Richlandtown, Tees 566 TM; Cumberland, Small, PC; Lehigh, Rau, PC; McKean, Burnett, PC; Montgomery, Zieglersville, Tees 525 TM.
(*Grimmia Doniana* Smith. Excluded species. Only records not substantiated by specimens: Northampton County, James and Porter, PC.)

**Grimmia laevigata** (Brid.) Brid. Very rare. Non-calcareous rocks.

COUNTIES: Lancaster, along the Conestoga Creek, Porter 4/62 (A). Published, not seen: Blair, Tyrone, James PC.

**Grimmia Olneyi** Sull. Rare. Eastern Pennsylvania. Rocks along stream banks.

COUNTIES: Bucks, Tohickon Creek, Gadsby 7/1/11; Northampton, Pen Argyl, Schaeffer 7/10/47, Easton, Wolle 1893 and Porter 11/67 & 8/70 (A); Philadelphia, Wissahickon, James 8/51 (A). Published, not seen: Chester, French Creek, James PC; Lancaster, Small PC.

**Grimmia pilifera** Beauv. Commonest species in the state. Widespread.

SUBSTRATE: Rock. (Limestone, conglomerate, quartzite and syenite.)
HABITAT: All type of woodland and old fields. Shale bluffs, shores of lakes and serpentine barrens. Elevation 200 to 2000 feet.
REPRODUCTION: Capsules open and spores present in April. (34 specimens examined, 2 fruiting.)
Type locality: Lancaster, Muhlenberg.
COUNTIES: Adams, Bedford, Berks, Bucks, Chester, Delaware, Franklin, Fulton, Lancaster, Monroe, Northampton, Pike, Sullivan, Susquehanna, York. (15 counties.)
(*Grimmia trichophylla* Grev. Excluded species. Published record but no specimens available: Chester, Darlington TM; Lancaster, Dillerville, Porter 6/60 TM.)

### 2. RHACOMITRIUM Brid.

A. Leaf with broad, obtuse apex . . . . . . . . . . . . . . . . *aciculare.*
A. Leaf with slender, acute apex . . . . . . . . *heterostichum* var. *sudeticum.*

**Rhacomitrium aciculare** Brid. Not common. "Cool" mountainous area of the state.
SUBSTRATE: Rocks.
HABITAT: Eastern hemlock formation. Rocks along stream banks. Elevation from 220 feet to 1850 feet. (13 specimens.)
COUNTIES: Carbon, Dauphin, Lehigh, McKean, Mifflin, Montgomery, Sullivan, York. (8 counties). Published, not seen: Cambria, James PC; Lehigh, Rau, TM.

**Rhacomitrium heterostichum** (Hedw.) Brid., var. **sudeticum** (Funck.) Jones. Rare. Southern part of the state.

HABITAT: Rocks in hemlock woods along stream banks and shores of ponds. (5 specimens.)

COUNTIES: Lehigh, Rau (A); Philadelphia, Wissahickon, James 5/53 (A); York, Long Level 2012. (3 counties). Published, not seen: Chester, Darlington, TM.

## VI. TORTULACEAE

A. Leaf usually narrow, often linear-lanceolate, not broadest above the middle; margin if differentiated, never so above the middle . . . . . . . . . B.
A. Leaf usually broad, ovate-oblong, spatulate or lingulate, sometimes differentiated . . . . . . . . . . . . . . . . . . . . . . . . . K.
B. Basal leaf-cells hyaline, extending up the margin in a distinct band 6. *Tortella.*
B. Basal leaf-cells hyaline, not extending up the margin in a distinct band . C.
C. Leaf involute . . . . . . . . . . . . . . . . . . . . . . . D.
C. Leaf not involute . . . . . . . . . . . . . . . . . . . . . E.
D. Basal leaf-cells (especially of the upper leaves) 5–10 times as long as wide; upper leaf-cells distinct; sporophyte immersed . . . 1. *Astomum.*
D. Basal leaf-cells (especially of the upper leaves) 2–6 times as long as wide; upper leaf-cells dense and indistinct; sporophyte exserted . 2 *Weisia.*
E. Leaf long, 2–3 mm., often reaching 4 mm., strongly papillose above; margin undulate and open sinuose . . . . . . . . . . . 5. *Trichostomum.*
E. Leaf not generally longer than 2 mm.; margins plane or revolute . . . . F.
F. Leaf-margins plane (*Barbula convoluta* almost so, slightly recurved at base) . . . . . . . . . . . . . . . . . . . . . . . . . G.
F. Leaf-margins recurved at base or along one side . . . . . . . . . H.
G. Leaf not crisped when dry; peristome lacking . . . . . 3. *Gymnostomium.*
G. Leaf crisped when dry, peristome of 32 filiform teeth . . . *Barbula convoluta.*
H. Margin revolute near the middle; stem not more than 2 mm. high; leaf piliferous; sporophyte immersed . . . . . . . . . . . . 9. *Phascum.*
H. Margin revolute near the base or along one side; stems more than 2 mm. high; leaf not piliferous; sporophyte exserted . . . . . . . . . . . I.
I. Stem sparsely radiculose, never tinged with reddish-brown, triangular in cross section; upper leaf cells distinct; papillae low and few; peristome lacking 4. *Hyemnostylium.*
I. Stem radiculose, often tinged with reddish-brown, never triangular in cross section; upper leaf cells papillose (not strongly so in *Didymodon*); peristome 16 or 32 teeth . . . . . . . . . . . . . . . . . . . . . . J.
J. Peristome of 16 teeth, more or less divided or perforate along median line, erect or twisted to right; upper leaves short, obtuse-lingulate 7. *Didymodon.*
J. Peristome of 32 filiform teeth, strongly twisted to left; upper leaves not as above . . . . . . . . . . . . . . . . . . . . 8. *Barbula.*
K. Leaves without evident papillae or propagula; peristome none . . . . . L.
K. Leaves with evident papillae or propagula or both; peristome of filiform teeth M.
L. Plants minute, bulbiform, protonema persistent, capsule cleistocarpous 10. *Acaulon.*
L. Plants larger, not as above . . . . . . . . . . . . . . 11. *Pottia.*
M. Peristome teeth from a narrow basal membrane, usually short and untwisted, never twisted more than 1 turn . . . . . . . . . . . . 12. *Desmatodon.*
M. Peristome teeth from a wide basal membrane, usually twisted more than 1 turn . . . . . . . . . . . . . . . . . . . . . . . 13. *Tortula.*

### 1. ASTOMUM Hampe.

A. Leaf margins strongly involute; setae solitary . . . . . . . . . . . . . B.
A. Leaf margins mostly plane; setae often clustered . . . . . . *ludovicianum.*
  B. Seta much shorter than the capsule . . . . . . . . . . *Muhlenbergianum.*
  B. Seta as long as the perichaetial leaves . . . . . . . . . . . . *phascoides.*

**Astomum ludovicianum** Sull. Rare. No specimens seen.

Published records: Chester, "Flora Cestrica," PC; Delaware, Glenolden, Krout 4/28/07 TM; Northampton, Monocacy, Rau PC.

**Astomum Muhlenbergianum** (Sw.) Grout. Rare. Old pastures.

Type locality: Probably eastern North America.
COUNTIES: Bucks, Narrowsville, James 4/59 (A); Northampton, Monocacy, Rau 3/73 (A) and Easton, Porter 1868 (A); Philadelphia, Moyamensing, James 5/66 (A). Published, not seen: Berks, Kaiser 5/2/12 SMS; Delaware, Smith TM; Lancaster, Muhlenberg TM; Lehigh, Rau TM.

**Astomum phascoides** (Hook.) Grout. Rare. Old fields. No specimens seen.

Published records: Chester, James PC; Lehigh, Rau, PC; Northampton, Bethlehem, Rau PC.

### 2. WEISIA Hedw.

**Weisia viridula** Hedw. Fairly common. Widespread.

SUBSTRATE: Bare soil, slag and rock surfaces.
HABITAT: Hardwood forests, thickets, old fields and meadows. Frequently in sunny situations on road banks, slag piles, in weedy tangles and on rock outcrops.
REPRODUCTION: Capsules mature in February. Open in March and April. (25 specimens, 8 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bucks, Chester, Delaware, Lancaster, Lehigh, McKean, Montgomery, Northampton, Philadelphia, York. (12 counties). Published, not seen: Chester, James, PC.

### 3. GYMNOSTOMUM Hedw.

**Gymnostomum aeruginosum** Smith. Rare. Northeastern part of the state. On moist rocks in limestone regions.

COUNTIES: Bucks, Nockamixon, Rau 6/1/74 (A); Northampton, Bingen, Wolle 11/73, Easton, Porter 11/68 (A) and Porter 6/67 (A); Pike, Bushkill, Wolle 8/26/73. (3 counties). Published, not seen: Huntingdon, Spruce Creek, Porter PC; Lehigh, Rau, PC; Philadelphia, Morris Arboretum, Tees 666 TM.

### 4. HYMENOSTYLIUM Brid.

**Hymenostylium recurvirostrum** (Hedw.) Dix. Rare. Wet limestone rocks.

COUNTIES: Bucks, Tinicum, Ruth 167 (A); Lehigh, Rockdale, Wolle 7/28/74 and Rau (A). Published, not seen: Carbon, Parryville, Rau, PC.

### 5. TRICHOSTOMUM Bruch.

**Trichostomum cylindricum** (Bruch.) C. Mull. Rare. On moist rocks.

COUNTIES: Cambria, Allegheny Mountains, Porter (A); Chester, James 12/50 and Coventryville 12/30/50 (A). Published, not seen: Carbon, Onoko Glen, Rau and Austin PC; Huntingdon, Alexandria, Porter PC; Lehigh, Bear Creek, Wolle PC; McKean, Toad Hollow, Burnett, J; Monroe, Delaware Water Gap, Rau PC; Northampton, Bear Creek, Wolle PC.

### 6. TORTELLA (C. Mull.) Limpr.

A. Leaf long, linear-lanceolate, with a very acute apex . . . . . . . . *tortuosa.*
A. Leaf oblong-acuminate, obtusely acute, abruptly mucronate by the excurrent costa . . . . . . . . . . . . . . . . . . . . . . . . . *humilis.*

**Tortella humilis** (Hedw.) Jennings. Fairly common. Widespread.

SUBSTRATE: Rocks, bases of trees and decaying wood.
HABITAT: Mixed hardwoods, crevices of rocks, stone walls, shaley banks and decaying logs.
ASSOCIATES: *Cladonia.*
REPRODUCTION: Capsules maturing in spring. (18 specimens, 5 fruiting.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Berks, Bucks, Cambria, Center, Fulton, Lancaster, McKean, Monroe, Montgomery, Northampton, Philadelphia. (11 counties). Published, not seen: Chester, James PC; Delaware, James PC; Huntingdon, Pennsylvania Furnace, J.

**Tortella tortuosa** (Turn.) Limpr. Rare. On rocks.

COUNTIES: Carbon, Stony Creek, Wolle 8/74; Lancaster, Porter (A); Lehigh, Rau (A); Northampton, Easton, Porter 11/1/68 (A). (4 counties). Published, not seen: Bucks, Nockamixon, James PC; Cambria, Cresson, James PC; Pike, Rau PC; Philadelphia, Kaiser, Bryologist XIX.

### 7. DIDYMODON Hedw.

**Didymodon recurvirostris** (Hedw.) Jennings. Very rare. Usually on calcareous rocks.
COUNTIES: Lehigh, Rockdale, Wolle 7/25/74 (A) and Rau (A). Published, not seen: Montgomery, Zieglersville, Tees 544 TM; Philadelphia, Germantown, Tees 739 TM; Delaware, Darby, Krout 9/26/08 TM.

### HYOPHILA Brid.

(*Hyophila Tortula* (Schwaegr.) Hampe. Excluded species. Only published records, no specimens: Lehigh, Rau, PC; Monroe, Pocono Plateau, Austin, PC; Northampton, Bethlehem, Rau PC.)

### 8. BARBULA Hedw.

A. Leaves squarrose-recurved, reddish; stem reddish-brown . . . . . . . . B.
A. Leaves not squarrose-recurved, gametophyte light or dull yellowish-green *fallax.*
  B. Perichaetial leaf long, sheathing, convoluted; stem-leaf very slightly recurved along proximal margin, less than 3 mm. long . . . . . . *convoluta.*
  B. Perichaetial leaf not convoluted, sheathing, or conspicuously different from rest; stem-leaf margins recurved proximally; leaf generally over 3 mm. long . . . . . . . . . . . . . . . . . . . . *unguiculata.*

**Barbula convoluta** Hedw. Rare. On calcareous soils. In woodlands and the open.

COUNTIES: Northampton, Easton, Porter 5/68 (A); Snyder, Troxelville 5506a. Published, not seen: Berks, Reading, Wilkens TM: Lycoming, McMinn, PC.

**Barbula fallax** Hedw. Rare. On moist rocks.

COUNTIES: Lehigh, Rau (A); Monroe, Analomink Creek, James 11/65 (A); Montgomery, Collegeville, Wagner 28 (A); Northampton, Easton, Porter 11/69 (A), and Bingen, Rau 4/74 (A). Published, not seen: Bucks, Narrowsville, James PC; Northumberland, James PC.

**Barbula unguiculata** Hedw. Rare. On calcareous soil frequently disturbed. Also conglomerate and limestone rocks. Old fields.

ASSOCIATES: *Grimmia pilifera.*
COUNTIES: Berks, Stonersville 5857, three collections of Wilkens (A); Lehigh, West Bethlehem, Ruth 34 (A); Northampton, Weygat, Porter 11/1/62 (A); Easton, Porter 10/21/68 (A) and Easton, James (A); Philadelphia, Cresheim Lane, Kaiser 3/26/10 and Lawrence Hill, James (A); York, James 2/65 (A). Published, not seen: Bucks, Upper Blacks Eddy, True 7/15/25 TM; Chester, James PC; Center, Porter PC; Delaware, James PC; Huntingdon, Porter PC; Lancaster, Small PC; McKean, West Branch Swamp, Burnett J; Montgomery, Plymouth Meeting, Tees 751 TM.

### 9. PHASCUM Hedw.

**Phascum cuspidatum** Hedw., var. **americanum** Ren. & Card. Rare. Soil in fields. COUNTIES: Delaware, Glenalden, Krout 5/12/03; Northampton, Bethlehem, Rau 10/75 (A) and Easton, Porter 11/68 (A); Philadelphia, Bustleton, James 4/66 (A). Published, not seen: Bucks, Morrisville, James PC; Chester, "Flora Cestrica" PC; Lehigh, Rau PC.

### 10. ACAULON C. Mull.

A. Plants subglobose, more or less three-cornered; seta larger than the vaginule; spores mostly under 30 microns, finely and sharply papillose . . . *triquetrum.*

A. Plants ovoid-bulbose; seta shorter; spores over 30 microns, smooth or finely granulated . . . . . . . . . . . . . . . . . . . . . . . *rubrum.*

**Acaulon rubrum** (Rohl.) Grout. Very rare. On bare soil.

COUNTIES: Chester, Coventryville, James 12/50 (A); York, Porter 5/77 (A). Published, not seen: Lehigh, Rau PC; Northampton, Rau PC.

**Acaulon triquetrum** (Spruce) C. Mull. Very rare. On soil.

COUNTIES: Philadelphia, Bustleton, James 10/66 (A).

### 11. POTTIA Furnr.

**Pottia truncata** (Hedw.) Furnr. Rare. Soil in fields, under grass and shrubs.

COUNTIES: Philadelphia, Moyamensing, James 12/65 (A). Published, not seen: Bucks, Lehnenburg, Ruth TM; Delaware, Lima, Tees 675 TM; McKean, Bradford, J; Montgomery, Ogontz, Kaiser TM; Northampton, Bethlehem and Oakland Park, Ruth TM.

### 12. DESMATODON Brid.

A. Leaves not bordered, ending in long hair points; capsule erect and symmetric or nearly so . . . . . . . . . . . . . . . . . . . . . . *plinthobius.*

A. Leaves bordered by a broad band of lighter cells little different or slightly more elongate, leaves acute . . . . . . . . . . . . . . . . . . . *Porteri.*

**Desmatodon plinthobius** Sull. & Lesq. Rare. On limestone rocks.

COUNTIES: Lancaster, Porter (A).

**Desmatodon Porteri** James. Rare. Limestone rocks.

Type locality: Easton, Pennsylvania, James.
COUNTIES: Northampton, Easton, Wolle and Monocacy, James 5/10/74 (A) and Musci Appal. Austin (A).

### 13. TORTULA Hedw.

A. Growing on trunks of trees; leaves very concave with costa very short-excurrent and bearing propagula . . . . . . . . . . . . . . . . . *papillosa.*

A. Growing on soil and stones . . . . . . . . . . . . . . . . . . B.

- B. Hair point on leaf rough; basal membrane nearly equaling the teeth in length . . . . . . . . . . . . . . . . . . . . . . . *ruralis.*
- B. Hair point smooth or nearly so; basal membrane narrow . . . . *muralis.*

**Tortula muralis** Hedw. Rare. On moist stones and brick walls.

COUNTIES: Bucks, Narrowsville, Ruth 146 & 144 (A); Northampton, Easton, Wolle, Porter 1889 and Musci Appal. Austin; Philadelphia, Wissahickon, Long 717 (A). Published, not seen: Lancaster, Levan's Mill, Eby PC.

**Tortula papillosa** Wils. Very rare. Bark of trees.

COUNTIES: Blair, Tyrone, James 11/52 (A); Philadelphia, Bustleton, James (A).

**Tortula ruralis** (Hedw.) Smith. Rare. On soil and rocks.

COUNTIES: Bucks, Narrowsville, Porter 11/67 (A); Center, State College, Taylor 12/1/22; Northumberland, James 8/67 (A).

## VII. ENCALYPTACEAE

### ENCALYPTA (Schreb.) Hedw.

**Encalypta streptocarpa** Hedw. Rare. On calcareous rocks.

COUNTIES: Lancaster, Porter 4/54 (A); Monroe, Analomink, James (A); Northampton, Easton, James, Musci. Appal. Austin (A). Published, not seen: Cambria, Cresson, James PC; Lehigh, Rau, PC.

## VIII. FISSIDENTACEAE

### FISSIDENS Hedw.

- A. Gametophyte slender, aquatic . . . . . . . . . . . . . . . . . *Julianus.*
- A. Gametophyte not aquatic . . . . . . . . . . . . . . . . . . . . . B.
  - B. Leaf with at least a partial border of narrow, elongated cells . . . . . C.
  - B. Leaf without evidence of a border of narrow, elongated cells . . . . . D.
- C. Border usually confluent at apex with the percurrent costa; antheridial buds axillary . . . . . . . . . . . . . . . . . . . . . . . . *bryoides.*
- C. Border at apex narrow or wanting; antheridial buds at base of stem . *minutulus.*
  - D. Leaf bordered by several rows of paler, short cells . . . . . *adiantoides.*
  - D. Leaf, if bordered by paler, shorter cells, with only a single row . . . . E.
- E. Costa excurrent into a short point . . . . . . . . . . . . . . *taxifolius.*
- E. Costa failing to reach the tip of the leaf . . . . . . . . . . . . . . F.
  - F. Costa almost reaching the leaf apex; cells 17–20 microns in diameter *osmundoides.*
  - F. Costa usually ending 8–10 cells below the leaf apex; cells 7–10 microns in diameter . . . . . . . . . . . . . . . . . . . . . . . *subbasilaris.*

**Fissidens adiantoides** Hedw. Fairly common. Widely distributed over the state.

SUBSTRATE: Soil and rock exposures. (Shale and limestone.) Occasionally on bases of trees and exposed roots.

HABITAT: All forest types of the state. On stream banks, on rock walls, at bases of trees and at the bottom of wooded slopes. Elevation 500 to 1400 feet.

REPRODUCTION: Capsules approaching maturity in August and still closed in October. Empty capsules present in April. (20 specimens examined, 5 fruiting.)

COUNTIES: Bedford, Berks, Bucks, Franklin, Huntingdon, Juniata, Lancaster, Lehigh, McKean, Northampton, Schuylkill, Sullivan, Tioga. (13 counties). Published, not seen: Cambria, Cresson, James and Porter, PC.

**Fissidens bryoides** Hedw. Rare. On soil.

COUNTIES: Lehigh, Rau (A); Northampton, Spruce Hill and College Hill, Easton, Porter (A); Philadelphia, Bustleton, James (A). (3 counties). Published, not seen: Chester, James, PC; Elk, James, PC; Lancaster, Muhlenberg, PC.

**Fissidens bryoides** Hedw. var. **incurvus** (Starke) Monken. Commoner than the species.

SUBSTRATE: Wet rocks and soil.
HABITAT: Densely shaded stream banks and springs. (9 specimens.)
COUNTIES: Berks, Delaware, McKean, Northampton, Philadelphia. (5 counties). Published, not seen: Lancaster, Muhlenberg, PC; Lehigh, Rau, PC.

(*Fissidens Bushii* Card. & Ther. No specimens seen. Reported in Grout (1936) 1:19 from near Easton in Northampton County, Small.)

(*Fissidens cristatus* Wils. All specimens found so designated prove to be *F. adiantoides* upon microscopic examination.)

**Fissidens Julianus** (Mont.) Schimp. Rare. Attached to rocks and timber submerged in swift water. (8 specimens examined.)

COUNTIES: Berks, Bucks, Delaware, Lancaster, Lehigh, Northampton, Philadelphia. (7 counties). Published, not seen: Huntingdon, Porter, PC.

**Fissidens minutulus** Sull. Rare. On wet rock surfaces in cool shaded habitats. (5 specimens examined).

COUNTIES: Blair, Kittanning Gap, Porter (A); Bucks, Riegelsville, True 9/13/25; Carbon, Stony Creek, Wolle 8/74; Northampton, Easton, Porter 11/1868 (A); Philadelphia, near Schuylkill, James 1864 (A). (5 counties). Published, not seen: Chester, Darlington, PC; Lancaster, Muhlenberg, PC; Lehigh, Rau, PC; McKean, Hawkins Hollow, Burnett, J; Monroe, James, PC.

**Fissidens osmundioides** Hedw. Rare. Soil and bark of trees along shady brooks and in ravines. (7 specimens examined.)

COUNTIES: Carbon, Onoko Glen, Wolle 1873; Huntingdon, Porter 6/22/90 (A); Lancaster, Dillerville, True 9/11/24 and S. of Lancaster, Tees 656 (A); Lehigh, Rau (A); Monroe, Delaware Water Gap, James (A); Northampton, Easton, Porter (A). Published, not seen: Pike, Rau, PC.

**Fissidens subbasilaris** Hedw. Rare. Bark at the base of trees in hardwood forests.
HABITAT: Elevation 100 to 850 feet. (3 specimens.)
COUNTIES: Delaware, Crum Creek, Krout 4/18/03; Northampton, Easton, Porter (A); Snyder, Troxelville 5504. (3 counties). Published, not seen: Carbon, Onoko Glen, Rau, PC; Lancaster, Muhlenberg, PC; McKean, Quintuple, Burnett, J.

**Fissidens taxifolius** Hedw. Commonest species of the genus in the state. Widely distributed.

SUBSTRATE: Bare clayey soil. pH5 to 7.
HABITAT: Most frequently in oak-hickory woods, but also found in thickets and old fields. Along stream banks, at the bases of trees and on newly disturbed clay banks. Elevation 150 to 1000 feet.
ASSOCIATES: Growing with *Dicranella heteromalla, Pohlia nutans* and species of *Eurhynchium*, *Hypnum* and *Cladonia.*
REPRODUCTION: Calyptra still present on capsules of plants collected in February. (25 specimens examined, 2 fruiting.)
COUNTIES: Bucks, Dauphin, Delaware, Lancaster, Lehigh, McKean, Montgomery, Montour, Northampton, Northumberland, Philadelphia, York. (12 counties). Published, not seen: Chester, James, PC.

(*Fissidens viridulus* (Web. & Mohr.) Wahlenb. No specimens seen. Reported in Grout (1936) 1:12 a sterile form collected on stones in stream at Strath Haven, Delaware County, Krout.)

## ORDER III. LEUCODONTALES

A. Cells in the distal portion of the leaf isodiametric . . . . . . . . . . . B.

A. Cells in the distal portion of the leaf longer than wide . . . . . . . . D.
B. Leaf ecostate, perichaetial leaf with cilia . . . . . . . III. *Hedwigaceae.*
B. Leaf costate, perichaetial leaf without cilia . . . . . . . . . . . . C.

C. Peristome always with linear-lanceolate teeth . . . . . . I. *Ptychomitriaceae.*

C. Peristome absent, or, if present, with triangular-lanceolate teeth II. *Orthotrichaceae.*
D. Gametophyte slender, often ½ to 4 feet long, aquatic . VIII. *Fontinalaceae.*
D. Gametophyte shorter, less than 6 inches in length, none strictly aquatic . E.

E. Gametophyte dendroid in habit (obscure in *Climacium Kindbergii*) . . . F.

E. Gametophyte not exhibiting a dendroid habit . . . . . . . . . . . G.
F. Branches pointing in one direction like those of a wind-blown tree; on vertical surfaces of moist, shaded rocks . . . . . . VI. *Porotrichaceae.*
F. Branches divergent in several directions; not growing on vertical surfaces of rocks . . . . . . . . . . . . . . . . . . . VII. *Climaciaceae.*

G. Gametophytes flattened until the leaves appear almost as if in two rows V. *Neckeraceae.*

G. Gametophyte not flattened . . . . . . . . . . . . IV. *Leucodontaceae.*

### I. PTYCHOMITRIACEAE

#### Ptychomitrium Fuern.

**Ptychomitrium incurvum** (Wahlenb.) Sull. Rare. On rock surfaces and old rock walls. Capsules mature, with calyptra present, in January.

Type locality: Lancaster County, Pennsylvania.
COUNTIES: Berks, Oley Furnace, Wilkins 59 (A); Bucks, Nockamixon, Kaiser 5/3/10; Northampton, Bethlehem, Wolle 7/73 and Weygat, Porter 11/27/07 (A); Philadelphia, Falls of the Pennypack, Krout 7/16/08 and Bustleton, James 9/60 and three other records (A). (4 counties). Published, not seen: Delaware, James, PC; Lancaster, Conewago, Small, PC.

### II. ORTHOTRICHACEAE

A. Gametophyte prostrate, with numerous erect, short lateral branches 4. *Drummondia.*

A. Gametophyte more or less erect . . . . . . . . . . . . . . . . . . B.
B. Gametophytes forming compact cushions on wet rocks . . . 3. *Amphidium.*
B. Gametophytes, if growing on rocks, not forming compact cushions . . . C.

C. Capsules immersed or emergent, calyptra smooth; leaves not crisped when dry . . . . . . . . . . . . . . . . . . . . . . . 1. *Orthotrichum.*

C. Capsules plainly exserted, calyptra hairy; leaves crisped (except in *U. americana*) . . . . . . . . . . . . . . . . . . . . . . . 2. *Ulota.*

#### 1. Orthotrichum Hedw.

A. Rock-inhabiting species; peristome single, teeth 16, erect or erect-spreading on dry capsules; stomata immersed . . . . . . . . . . . . . . . . . . B.

A. Tree-inhabiting species; peristome double, teeth usually united into 8 pairs, recurved or reflexed when dry . . . . . . . . . . . . . . . . . . C.

B. Capsules fully exserted, 16-striate . . . . . . . . . . . . *anomalum.*
B. Capsules immersed or emergent, 8 striate . . . . . . . . *strangulatum.*
C. Stomata superficial (i.e. with both guard cells on the surface) . . . . . . D.
C. Stomata immersed . . . . . . . . . . . . . . . . . . . . . . . . G.
D. Leaves obtuse, broad pointed, margins plane . . . . . . . . *obtusifolium.*
D. Leaves acute, margins revolute or involute . . . . . . . . . . . E.
E. Capsules nearly or quite exserted . . . . . . . . . . . . . . . *elegans.*
E. Capsules immersed to emergent . . . . . . . . . . . . . . . . . F.
F. Capsules smooth when dry, completely immersed . . . . . . . *striatum.*
F. Capsules strongly ribbed when dry, neck immersed . . . . . . *sordidum.*
G. Capsules strongly contracted below the mouth when dry and so strongly plicate that the red-brown folds are in contact on the outside when dry and empty . . . . . . . . . . . . . . . . . . . . . . . . *stellatum.*
G. Capsules very slightly or not at all contracted, much less strongly plicate, pale whitish or yellowish . . . . . . . . . . . . . . . . . . . . . H.
H. Leaves entire, blunt at extreme apex . . . . . . . . . . . *ohioense.*
H. Leaves (some at least) dentate with projecting cells, often apiculate . . I.
I. Leaves mostly acute at apex, not rounded; usually some with an apiculus of a single projecting cell; capsule plainly 8-plicate when dry . . . . . *pumilum.*
I. Leaves obtuse, rounded and some sharply denticulate at apex with several projecting cells; capsule smooth or faintly 8-plicate when dry . . . . *pusillium.*

**Orthotrichum anomalum** Hedw. Rare. On limestone rocks.

COUNTIES: Bucks, Narrowsville, James 11/67 (A); Delaware, Manoa, Krout 7/4/07; Lancaster, Porter 12/9/65 (A); Montgomery, Pottstown, Krout 7/6/10; Northampton, Easton, Porter 5/68 (A); Philadelphia, Wissahickon, James 5/59 (A).

**Orthotrichum elegans** Hook. & Grev. Very rare. Bark of trees.

COUNTIES: Bucks, Bedminster, Krout 8/30/06.
(*Orthotrichum Hallii* Sull. & Lesq. Excluded species. Range Rocky Mountains. Published records: Lancaster county, Porter 1862 TM.)

**Orthotrichum obtusifolium** Brid. Rare. On bark of trees, the following collections all on poplars.

COUNTIES: Monroe, Pocono Mountains, Britton 6/24/93 (A); Philadelphia, Pennypack Creek, James 2/64 (A). Published, not seen: Northampton, Bethlehem, Rau, PC.

**Orthotrichum ohioense** Sull. & Lesq. Rare. On bark of trees. Capsules mature in April.

COUNTIES: Chester, Laurel, Commons 59 (A); Lancaster, New Texas, Carter (A); McKean, Burnett 3021 (A). Published, not seen: Lehigh, Rau PC; Northampton, Bethlehem, Rau PC; Philadelphia, Wissahickon, James 5/59 TM.

**Orthotrichum pumilum** Dicks. Rare. Bark of deciduous trees. Elevation 100 to 400 feet.

COUNTIES: Delaware, Strath Haven, Krout 9/21/08; Lehigh, Dorney's Park, Krout 6/11/09; Northampton, Easton, Porter 11/1/67 (A); Philadelphia, Chestnut Hill, 6/5/60 (A). Published, not seen: Lancaster, Safe Harbor, Conewago and Tucquan, Small PC.

**Orthotrichum pusillum** Mitt. Rare. Bark of trees.

Type locality: Pennsylvania.
COUNTIES: Chester, West Grove, Krout 6/4/09; Philadelphia, Lowe 4/26/02, Wolle 7/73, Darby Road, 6/6/60 (A), Kingsessing and Wissahickon, James 5/62 (A). Published, not seen: Bucks, Kintnersville, Ruth, TM.

**Orthotrichum sordidum** Lesq. & James. Rare. On bark of trees.

No specimen seen. Published records: Lancaster, Conewago, Small PC; Monroe, Mount Pocono, Garber PC.

**Orthotrichum stellatum** Brid. Rare. On bark of trees.

COUNTIES: Huntingdon, Alexandria, Porter 8/13/59 (A); Lancaster, Safe Harbor, June 6/59 (A); Philadelphia, Wissahickon and Fairmont Park, James 6/61 (A). Published, not seen: Chester, James PC; Delaware, James PC; Lehigh, Rau PC; McKean, Burnett PC; Northampton, Bethlehem, Rau PC; Northumberland, James PC.

**Orthotrichum strangulatum** Schwaegr. Rare. On rocks.

COUNTIES: Bedford, Saxton, 4566; Bucks, Tohickon Creek, Gadsby 7/1/11; Center, State College, Wahl 7/29/47; Delaware, Darby Creek, Spencer 7/4/07; Lancaster, Porter (A). Published, not seen: Cambria, Cresson, James PC; Northampton, Easton, James PC.

**Orthotrichum striatum** Hedw. Rare. On trees.

COUNTIES: Monroe, Pocono Forks, James 11/68 (A). Published, not seen: Bucks, Narrowsville, James PC.

### 2. ULOTA Mohr.

A. Leaf not crisped, scarcely contorted . . . . . . . . . . . . . *americana.*
A. Leaf contorted or crisped . . . . . . . . . . . . . . . . . . . . . B.
  B. Capsule smooth except for the small, puckered mouth . . . . . . *Ludwigii.*
  B. Capsule strongly 8-ribbed . . . . . . . . . . . . . . . . . . *crispa.*

**Ulota americana** (Beauv.) Limpr. Fairly common.

SUBSTRATE: Rock surface. (Limestone and quartzite.)
HABITAT: Eastern hemlock and deciduous forests. Elevation 150 to 800 feet.
ASSOCIATES: *Dicranum fulvum.*
(15 specimens examined.)
Type locality: Pennsylvania (Muhlenberg).
COUNTIES: Berks, Bucks, Chester, Juniata, Lancaster, McKean, Monroe, Northampton, Philadelphia. (9 counties). Published, not seen: Cambria, Cresson, James PC; Center, Matternville, J; Delaware, Lindenberg, Krout 7/14/10 TM; Huntingdon, Porter PC; Lebanon, Penryn, Small PC; Lehigh, Rau PC; Pike, Rau PC; Somerset, Ursina J.

**Ulota crispa** (Hedw.) Brid. Fairly common.

SUBSTRATE: Bark of deciduous trees. (12 specimens examined.)
COUNTIES: Berks, Cambria, Clearfield, Elk, Lancaster, McKean, Northampton, Philadelphia, Sullivan. (9 counties). Published, not seen: Center, Bear Meadows, Porter PC; Chester, "Flora Cestrica" PC; Delaware, Smith, TM; Lebanon, Porter PC; Monroe, Tobyhanna, Garber and Pocono, James PC; Pike, Rau PC.

**Ulota Ludwigii** Brid. Rare. Bark of trees.

COUNTIES: McKean, Rutherford, Burnett 3/6/93 (A); Monroe, Pocono Forks, Porter 8/1/60 and James 10/69 (A). Published, not seen: Center, Bear Meadows, Porter PC; Chester, "Flora Cestrica" PC; Delaware, Smith PC; Lancaster, Conewago, Small PC.

### 3. AMPHIDIUM (Nees) Schimp.

A. Autoicous; leaf margins plane; perichaetial leaves entirely smooth, not papillose above . . . . . . . . . . . . . . . . . . . . . . . . *lapponicum.*
A. Dioicous; leaf margins more or less recurved; perichaetial leaves papillose near the apex . . . . . . . . . . . . . . . . . . . . . *Mougeotii.*

**Amphidium lapponicum** (Hedw.) Schimp. Rare. Wet rocks and crevices of rocks.
COUNTIES: Bucks, Narrowsville, Porter (A); Franklin, Mercersburg, Porter 8/52; Monroe, Buck Hill Falls, Britton 7/14/89 (NY) and Delaware Water Gap (NY); Northampton, Easton, Rau 1872 (NY), Bushkill Gap, Porter 11/10/65 (A) and Bangor, Porter 11/68 (A). (4 counties). Published, not seen: Carbon, Rau PC; Delaware, Smith TM; Huntingdon, Porter PC; Pike, Rau PC; Philadelphia, Wissahickon, James PC.

**Amphidium Mougeotii** (Bry. Eur.) Schimp. Rare. On damp shaded rock.
COUNTIES: Bucks, Narrowsville, Porter 11/28/67 (A); Monroe, Delaware Water Gap, Garber 11/6/68 (A); Philadelphia, Wissahickon, James 4/59 (A); Pike, Rau (NY). (4 counties).

### 4. Drummondia Hook.

**Drummondia prorepens** (Hedw.) Jennings. Rare. On bark of trees.
COUNTIES: Lancaster, Conewago, Small 1/1/92 (A), New Texas, Carter 12/93 (A) and Safe Harbor, James 6/18/59 (A); Lehigh, Rau (A); McKean, Quintuple, Burnett 456 (A); Northampton, Easton, Porter 1868 (A) and Weygat 11/67 (A). Published, not seen: Chester, James PC; Delaware, James PC; Philadelphia, James PC.

## III. HEDWIGIACEAE

### Hedwigia Hedw.

**Hedwigia ciliata** Hedw. Common. More frequent in the mountainous areas.
SUBSTRATE: On dry non-calcareous rocks. (Shale, serpentine, trap and conglomerate.)
HABITAT: Woodlands and in old fields. Shale bluffs, serpentine barrens, roadsides and south-facing slopes. Elevation 200 to 1900 feet.
ASSOCIATES: *Bartramia pomiformis* and species of *Hepaticae* and *Cladonia.*
REPRODUCTION: Capsules mature and shedding spores in April and May. (51 specimens, 11 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bucks, Center, Chester, Cumberland, Delaware, Fulton, Huntingdon, Juniata, Lancaster, Lehigh, McKean, Monroe, Montgomery, Northampton, Perry, Philadelphia, Schuylkill, Sullivan. (21 counties). Published, not seen: Dauphin, Peters Mountain, Small PC; Pike, Eich's Pond, Moldenke 3340.

## IV. LEUCODONTACEAE

A. Secondary stems little branched; calyptra smooth . . . . . . . *Leucodon.*
A. Secondary stems profusely branched; calyptra hairy . . . . . . . *Leptodon.*

### 1. Leucodon Schwaegr.

A. Seta shorter than the perichaetial leaves . . . . . . . . . . . . *brachypus.*
A. Seta longer than the perichaetial leaves . . . . . . . . . . . . . . B.
  B. Stem-leaf slenderly acuminate, strongly plicate . . . . . . . . . *sciuroides.*
  B. Stem-leaf abruptly short-acuminate, scarcely plicate . . . . . . *julaceus.*

**Leucodon brachypus** Brid. Rare. On trees.
COUNTIES: Carbon, Wolle; Lancaster, New Texas, Carter 12/93 (A); McKean, Langmade, Burnett 1276; Monroe, Pocono, Porter (A). Published, not seen: Cambria, Porter and James PC; Chester, Coventry, James PC; Pike, Rau PC.

**Leucodon julaceus** (Hedw.) Sull. Rare. On trees and rotten logs.
Type locality: Probably Pennsylvania.
COUNTIES: Beaver, Delaware, Lancaster, Monroe, Mercer, Montgomery, Philadel-

phia, Wayne. (8 counties). Published, not seen: Cambria, James PC; Chester, "Flora Cestrica" PC; McKean, Burnett PC; Northampton, Bethlehem, Rau PC.

**Leucodon sciuroides** (Hedw.) Schwaegr. Very rare. On rocks and trees.
COUNTIES: Delaware, Landenberg, Krout 7/14/10.

### 2. Leptodon Mohr.

**Leptodon trichomitrion** (Hedw.) Mohr. Rare. On trees and rocks in moist woods.
COUNTIES: Berks, Bernharts 5836; Lancaster, Porter 3/26/62 (A); Monroe, Bushkill Gap, Porter 11/16/68 (A) and Delaware Water Gap, James 11/68 (A). Published, not seen: Chester, "Flora Cestrica" PC; Delaware, Smith PC; McKean, Burnett PC; Northampton, Rau PC; Philadelphia, Fairmount Park and Byberry, James PC; Pike, Rau PC.

## V. NECKERACEAE

A. Leaf not cultriform or lobed . . . . . . . . . . . . . . . . . 1. *Neckera.*
A. Leaf cultriform or complicate-bilobed . . . . . . . . . . . . 2. *Homalia.*

### 1. Neckera Hedw.

**Neckera pennata** Hedw. Rare. On trunks of trees in cool moist woods.
COUNTIES: Lancaster, Porter (A) and New Texas, Carter 12/93 (A); Lehigh, Rau (A); Monroe, Pocono, Porter 8/23/59 (A); Northampton, Bergens Station, Wolle 8/72. (4 counties). Published, not seen: Cambria, Cresson, Porter PC; Chester, "Flora Cestrica" PC; Delaware, Smith TM; Franklin, Mercersburg, Porter PC; McKean, Burnett PC; Philadelphia, Fairmont Park PC; Pike, Rau PC.

### 2. Homalia (Brid.) Bry. Eur.

**Homalia Jamesii** Schimp. Very rare. On moist shaded cliffs and ledges.
COUNTIES: Lehigh, Rau (A); Pike, Wolle and Rau 8/73 (A).

## VI. POROTRICHACEAE

### Porotrichum Brid.

**Porotrichum alleghaniense** (C. Mull) Grout. Not common. Confined to the northern counties.
SUBSTRATE: Rocks and humus.
HABITAT: Eastern hemlock formation. In swamps and on stream banks. (12 specimens.)
COUNTIES: Bucks, Huntingdon, Lehigh, McKean, Monroe, Northampton, Wayne. (7 counties). Published, not seen: Berks, Friedensburg, Wilkens 1/15/28 TM; Cambria, Cresson, James PC; Lancaster, Martic Forge, Porter PC; Philadelphia, Wissahickon, James PC.

## VII. CLIMACIACEAE

### Climacium Web. & Mohr.

A. Capsules 3 to 4 times as long as broad; median leaf cells 7 to 10 times as long as broad . . . . . . . . . . . . . . . . . . . . . . . *dendroides.*
A. Capsules 5–6:1; median leaf cells not more than 7:1 . . . . . . . . . . B.
  B. Gametophytes distinctly tree-like in habit; median leaf cells 5–7:1 *americanum.*
  B. Gametophytes obscurely tree-like in habit, often nearly prostrate in dense tufts; median leaf cells 2–3:1 . . . . . . . . . . . . . . *Kindbergii.*

**Climacium americanum** Brid. Commonest species of the genus in Pennsylvania. In all the physiographic provinces.

SUBSTRATE: Soil, rotting-wood, soil and humus accumulated on wet ledges of silicious, crystalline, conglomerate and limestone rock. pH range from 4 to 8. Most samples above 7.

HABITAT: Prefers dense stands of mixed hardwoods, but also found under mixed stands of pine and hemlock with hardwoods. Less frequently occurring in old fields and grassy thickets. Usually at the base of slopes, under moist shaded ledges, along stream banks and in swampy areas. Elevation 150 to 800 feet.

ASSOCIATES: *Hypnum* spp., *Thuidium* spp., *Atrichum* spp., and *Cirriphyllum Boscii.*

REPRODUCTION: Capsules are mature in November. Spores are shed from this time through December and January. Empty capsules remain on some plants until July. (60 specimens examined, 10 fruiting.)

Type locality: Lancaster, Pa.

COUNTIES: Adams, Berks, Blair, Bradford, Bucks, Center, Chester, Delaware, Franklin, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Philadelphia, Schuylkill, Union, York. (19 counties). Published, not seen: McKean, Bradford, Burnett, PC.

**Climacium dendroides** (L.) Web. & Mohr. A northern species extending into Pennsylvania north of the glacial moraine.

SUBSTRATE: Soil.

HABITAT: Under hemlock-birch-maple forest cover. Stream banks, pond shore and edge of bogs. Elevation 1200 to 1448 feet.

ASSOCIATES: With *Mnium* spp., and *Fissidens* spp.

REPRODUCTION: All material examined in sterile condition. (8 specimens examined.)

COUNTIES: Bradford, Herrickville 3978; Monroe, Buck Hill Falls, Browne; Susquehanna, St. Joseph 3906; Tioga, Niles Valley, 4108, 4112, 4088, 4083; Wayne, Lakewood, Dix 9/13/46. (5 counties). Published, not seen: Chester, Darlington, PC; Dauphin, Harrisburg, Small PC. The following specimens cited in Miss Grace Tees's manuscript as *C. dendroides* prove to be *C. americanum*: Bucks, Center Bridge, Tees 102 (A); Delaware, Wayne, Bartram 4/28/08; Philadelphia, Pennypack, Krout 7/16/08.

**Climacium Kindbergii** (Ren. & Card.) Grout. Fairly common. More frequently found in the southern and southeastern counties.

SUBSTRATE: Soil, rotting wood and accumulated humus on rock surfaces. pH 4 to 7.

HABITAT: Mixed hardwoods and hardwood-hemlock forests. Swampy areas, stream banks, pond shores and moist areas at the bottom of slopes. Elevation 100 to 1500 feet.

ASSOCIATES: *Mnium* spp., and *Thuidium delicatulum.*

REPRODUCTION: Capsules mature in autumn. Empty capsules present in April. (14 specimens examined, 1 fruiting.)

COUNTIES: Adams, Berks, Center, Lebanon, Lehigh, Monroe, Philadelphia, Somerset, Susquehanna, York. (10 counties). Published, not seen: Bucks, Revere, Long 612 TM; Delaware, Llewelyn Mills, Kaiser 1/21/11 SMS; Lancaster, Mt. Hope and Penryn, Small PC; Luzerne, Lily Lake, Small PC; McKean, Bradford, Burnett PC; Montgomery, Zieglersville, Tees 527 TM.

## VIII. FONTINALACEAE

A. Leaf ecostate . . . . . . . . . . . . . . . . . . . . . 1. *Fontinalis.*
A. Leaf costate . . . . . . . . . . . . . . . . . . . . . 2. *Dichelyma.*

### 1. Fontinalis (L.) Myrin.

A. Older cauline leaves typically keeled or keeled-conduplicate, younger cauline leaves and branch leaves keeled, keeled-conduplicate, or concave *antipyretica* var. *gigantea.*

A. Neither cauline nor branch leaves keeled-conduplicate . . . . . . . . B.

B. Leaves dimorphic, cauline leaves and branch leaves similar with intergradation in shape and size more or less absent . . . . . . . . . . . C.

B. Leaves more or less uniform, cauline and branch leaves similar with intergradations in shape or size present (except *F. novae-angliae* var. *heterophylla.*) . . . . . . . . . . . . . . . . . . . . . . . . . . D

C. Cauline leaves more or less firm, narrowly lanceolate, 4–5.5 mm. long, about 1 mm. wide, usually about 1–1.5 times the length of the branch leaves *disticha.*

C. Cauline leaves flaccid, narrowly lanceolate to narrowly ovate-lanceolate, 3–8 mm. long, 0.5–2 mm. wide; usually 1.5–3.5 times the length of the branch leaves . . . . . . . . . . . . . . . . . . . . . . . . . . *Sullivanti*

D. Cauline leaves more or less concave or channelled, majority more or less firm . . . . . . . . . . . . . . . . . . . . . . . . . E.

D. Cauline leaves slightly concave or almost plane, majority more or less flaccid to very flaccid . . . . . . . . . . . . . . . . . . *Duriaei.*

E. Leaves narrowly-lanceolate or oblong-lanceolate, 2–4 mm. long, 0.5–1.25 mm. wide, 3–3.5:1; apices usually more or less acute; plants slender, upper perichaetial leaves usually narrow at the apex, acute or apiculate . . . *dalecarlica.*

E. Leaves slightly distant, usually ovate-lanceolate, 2.5–6 mm. long, 1–2.5 mm. wide, 1.75–4:1; apices usually denticulate, some more or less cucullate; upper perichaetial leaves with apices rounded or subapiculate . . . . *novae-angliae.*

**Fontinalis antipyretica** Hedw., var. **gigantea** Sull. Fairly common, chiefly confined to the northern mountainous counties. Abundant where found.

SUBSTRATE: Rocks in stream bed.

HABITAT: Cold rocky mountain brooks, under hardwood forests and hemlock-alder thickets. Elevations 450 to 2000 feet.

ASSOCIATES: One collection mixed with *Elodea.*

REPRODUCTION: All collections examined were sterile. (12 specimens examined.)

COUNTIES: Cambria, Ebensburg, James (A); Clinton, Rauchtown 4999; Lancaster, Bart township, Porter 1862 (A); Lehigh, Rau (A); McKean, Corydon, 4457; Monroe, Saylorsburg, Porter (A), Tobyhanna, Porter (A) and Kaiser 7/8/10; Northampton, Slate Valley and Martins Creek, Schaeffer; Sullivan, Lippincott (A). (8 counties.) (A specimen in the Academy of Natural Sciences Herbarium collected by Porter at Martic Forge, Lancaster county and labelled *antipyretica* has been determined as *F. novae-angliae* by Dr. W. H. Welch). Published, not seen: Blair, James PC; Delaware, Smith PC; Philadelphia, James PC; Pike, Rau PC.

(*Fontinalis biformis* Sull. Excluded species. Range is central Ohio and Indiana. Not known from the eastern states. (See Cardot in Grout's Vermont Mosses). Published records not authenticated by specimens: Lancaster, Small PC; McKean, Burnett PC; Pike, Rau PC.)

**Fontinalis dalecarlica** Bry. Eur. Not common. Widely distributed.

SUBSTRATE: Rocks and stones in brooks.

HABITAT: Shaded brooks and springs. Mixed hardwoods, hardwood and pine and hemlock forests. Elevation 500 to 2000 feet.

REPRODUCTION: Mature closed capsules present on collection made on November 11th. (19 specimens examined, 2 fruiting.)

COUNTIES: Berks, Hamburg, Wilkens (A); Bucks, Narrowsville, Porter (A); Center, Bear Meadow, Porter (A); Chester, Chester Valley, James (A); Columbia, 1 mi. w.

of Red Rock, 2839; Delaware, Heidelberg Township, Krout; Franklin, St. Thomas, 2693; Lycoming, Montgomery, 4381; Mifflin, Milroy, 4418, 4386; Monroe, Merwinsburg, Fogg, Delaware Water Gap, James and Porter (A), Tobyhanna, Porter (A), Buck Hill Falls, Browne 8/20/07; Pike, Milford, 5790; Schuylkill, Pine Grove, Krout; Sullivan, Eaglesmere, Githens 244, Ricketts Glen, Githens 236; Union, Keystone Camp, 4840. (14 counties). Published, not seen: Carbon, Rau PC; Lancaster, Martic Forge, Porter and Mt. Hope, Small PC; Lehigh, Rau PC; Philadelphia, James PC.

**Fontinalis disticha** Hook & Wils. Very rare. A southern species. Represented in Pennsylvania by the following collections: Monroe, East Branch Lake, Porter 8/1/67 (A); Schuylkill, Pine Grove, Stauffer (A). (2 counties) (Number 524 labelled *F. disticha* Aust. Musci Appalachiani, Supp. I determined as *F. Sullivanti* Lindb. by Dr. W. H. Welch. (A).)

**Fontinalis Duriaei** Schimp. Very rare. Represented in Pennsylvania by the following collections: Huntingdon, Porter (A) and Spruce Creek, James (A); Northampton, Bethlehem, Schweinitz (A). (2 counties.)

(*Fontinalis Lescurii* Sull. Excluded species. No authentic Pennsylvania specimens available of this species. A specimen labelled *F. Lescurii* collected at Tunkhannock, Monroe County by Porter on June 15, 1859 (A) has been determined as *F. Novae-angliae* by Dr. W. H. Welch. Another specimen collected in a shallow brook, Blue Mountains, North of Hamburg by Wilkens 5/13/28 (A) has been determined as *F. dalecarlica* Bry. Eur. by Dr. Welch. Published, not seen: Huntingdon, Porter PC; McKean, Burnett PC; Monroe, Mt. Pocono and Water Gap, James PC; Pike, Rau PC.)

**Fontinalis Novae-angliae** Sull. Most common species in Pennsylvania. Widely distributed over the state.

SUBSTRATE: Rocks and dead branches in streams and edge of lakes. pH 7.

HABITAT: Shallow water at edge of lakes and ponds, brooks and spring outlets. Under the shade of hemlock, hemlock-hardwood, and hardwood forests and thickets along streams in old fields. Elevation 75 to 2200 feet.

ASSOCIATES: One specimen heavily incrusted with growth of diatoms.

REPRODUCTION: All specimens examined were sterile. (17 specimens.)

COUNTIES: Adams, Arendtsville, 5791, 5799; Chester, Daylesford, 5798; Delaware, Collingsdale, Krout 7/27/07; Fayette, Markleysburg, 4784; Franklin, St. Thomas, 2692a; Lancaster, Martic Forge, Porter (A); Luzerne, Red Rock, 2881; Monroe, Tunkhannock, Porter (A); Philadelphia, Germantown, Porter (A); Somerset, Roxbury, 5192; Sullivan, Eaglesmere, Githens 242; Susquehanna, Gelatt, 3856; Warren, Russell 2692 and Youngsville 5792; Wayne, Waymart, 3834; York, Hallam, 5794. (15 counties). Published, not seen: Huntingdon, Spruce Creek, Porter PC; Northampton, Rau PC; Pike, Rau PC.

**Fontinalis Novae-angliae** Sull., var. **cymbifolia** (Aust.) Welch. One collection made in James Brook on top of Broad Mountain, 2 miles north of Nesquehoning, Carbon county, 2798. Elevation 1685 feet.

**Fontinalis Novae-angliae** Sull., var. **heterophylla** Card. Bradford, Burnett 5/13/96.

**Fontinalis Novae-angliae** Sull., var. **latifolia** Card. Monroe county, Pocono Forks, Porter 8/9/68 (A).

**Fontinalis Sullivanti** Lindb. A southern coastal plain species.

COUNTIES: Chester, Falls of French Creek, Krout 5/17/10; Sullivan, C. D. Lippincott (A). (2 counties). (Number 524 labelled *F. disticha* Austin in Musci Appalachiani, Supp. I. Rocky rivulets, mountains of N. J. and Pa. has been determined as *F. Sullivanti* by Dr. W. H. Welch. (A).)

### 2. DICHELYMA Myrin.

A. Costa long-excurrent . . . . . . . . . . . . . . . . . . . . *capillaceum.*
A. Costa subpercurrent to shortly excurrent . . . . . . . . . . . . *pallescens.*

**Dichelyma capillaceum** Bry. Eur. Rare. On dead wood and humus in swamps and rivulets. Hemlock ravines. (5 specimens.)

COUNTIES: Chester, Chester Valley, James 6/50 (A); Crawford, Rendalls Corners 5773; Lehigh, Rau (A); Monroe, Delaware Water Gap, Rau 11/1/74 (A). (4 counties). Published, not seen: Delaware, Smith TM.

**Dichelyma pallescens** Bry. Eur. Very rare.

COUNTIES: Monroe, Tobyhanna, James 10/69 (A). Published, not seen: McKean, Bradford, Burnett PC.

## ORDER V. HYPNOBRYALES

A. Sporophyte lateral on primary stem or branch . . . . . . . . . . . B.
A. Sporophyte terminal on main axis . . . . . . . . . . . . . . . . . . J.
B. Leaf papillose, but without projecting cell ends . . . . . . . . . . C.
B. Leaf smooth or papillose because of projecting cell ends, except in *Schwetschkeopsis* . . . . . . . . . . . . . . . . . . . . . . . . D.
C. Gametophyte usually julaceous, light to glaucous green . . . . I. *Theliaceae.*
C. Gametophyte seldom julaceous, bright green to very dark . . . II. *Leskeaceae.*
D. Capsule erect and symmetrical (*Hypnum imponens* may be sought here.) E.
D. Capsule seldom erect, usually curved . . . . . . . . . . . . . . F.
E. Leaf costate, or if ecostate, then papillose . . . . . . . . III. *Fabroniaceae.*
E. Leaf ecostate and smooth . . . . . . . . . . . . . . IV. *Entodontaceae.*
F. Leaf ecostate or nearly so . . . . . . . . . . . . . . . . . . . . G.
F. Leaf costate, often doubly so except in *Campylium hispidulum* . . . . H.
G. Gametophyte complanate-foliate except in *Plagiothecium striatellum*; leaves seldom secund . . . . . . . . . . . . . . . . . . VII. *Plagiotheciaceae.*
G. Gametophyte not complanate-foliate; leaves usually secund . VIII. *Hypnaceae.*
H. Capsules usually ovoid, short, thick and asymmetrical, little contracted below the mouth when dry . . . . . . . . . . . . . . . . . . . I.
H. Capsules usually longer, arcuate-cylindrical, somewhat contracted below the mouth when dry . . . . . . . . . . . . . . V. *Amblystegiaceae.*
I. Costa single and usually reaching beyond the middle of the leaf; paraphyllia none . . . . . . . . . . . . . . . . . . . . . . VI. *Brachytheciaceae.*
I. Costa double and usually not long; paraphyllia often abundant and large IX. *Hylocomiaceae.*
J. Leaf smooth . . . . . . . . . . . . . . . . . . . . . . . . . . K.
J. Leaf papillose . . . . . . . . . . . . . . . . . . . . . . . . . L.
K. Leaf-cells longer than wide . . . . . . . . . . . . . . . . X. *Bryaceae.*
K. Leaf-cells nearly isodiametric . . . . . . . . . . . . . . . XI. *Mniaceae.*
L. Endostome membrane divided above into 64 filiform, appendiculate cilia, forming a kind of delicate net-work . . . . . . . . . XIV. *Timmiaceae.*
L. Endostome not as above . . . . . . . . . . . . . . . . . . . . . . . M.
M. Capsule much longer than wide . . . . . . . . . . . XII. *Aulacomniaceae.*
M. Capsule subspherical, very short . . . . . . . . . . XIII. *Bartramiaceae.*

### I. THELIACEAE

A. Paraphyllia present . . . . . . . . . . . . . . . . . . . . . 1. *Thelia.*
A. Paraphyllia absent . . . . . . . . . . . . . . . . . . . . 2. *Myurella.*

### 1. Thelia Sull.

A. Papillae on dorsal surface of leaf not branched . . . . . . . . . . *hirtella.*
A. Papillae on dorsal surface of leaf branched . . . . . . . . . . . . B.
  B. Gametophyte growing on trees; leaf margin ciliate . . . . . . . *asprella*
  B. Gametophyte growing on sand or rocks; leaf margin seldom ciliate *Lescurii.*

**Thelia asprella** Sull. Not common. Chiefly in the mountainous counties.

SUBSTRATE: Bark of trees.
HABITAT: Eastern hemlock formation. On bark of oak and cedar in cool moist ravines and stream valleys. Elevation from 700 to 1500 feet. (12 specimens examined, 5 fruiting.)
ASSOCIATES: With lichens occasionally.
COUNTIES: Bucks, Carbon, Columbia, Lehigh, Monroe, Montgomery, Northampton, Pike, Schuylkill. (9 counties). Published, not seen: Chester, Chester Valley, James PC; Delaware, James PC; Lancaster, Conewago and Mount Hope, Small PC; McKean, Bradford, Burnett PC; Monroe, Tobyhanna Mills, James PC; York, Small PC.

**Thelia hirtella** (Hedw.) Sull. Rare. On bark of trees.

Type locality: Lancaster, Pa.
COUNTIES: Bucks, Plumsteadville, Garber and Solesbury, Fisher 12/96 (A); Lancaster, Conestoga, Porter 9/7/53 (A); Northampton, Easton, James 11/68 (A). (4 counties). Published, not seen: Delaware, Radnor, James PC; McKean, Gates Hollow, Burnett J; Philadelphia, Fairmount Park, James PC.

**Thelia Lescurii** Sull Rare.

SUBSTRATE: Soil and rocks.
HABITAT: Oak-hickory woods and stone walls around old fields. Elevation 550 to 700 feet.
REPRODUCTION: Capsules open and spores present in January.
COUNTIES: Berks, Wernersville, Williams 1/6/04 and Oley Furnace, Wilkens 60; Fulton, Warfordsburg 4750.

### 2. Myurella Bry. Eur.

**Myurella Careyana** Sull. Rare. On rock surfaces of cliffs.

COUNTIES: Lancaster, Porter 8/59 (A) and Cedar Hill, Porter 4/26/62 (A); Montgomery, Ringing Rocks Park, Krout 7/6/10; Northampton, Easton, Rau (A) and Bushkill Gap, Porter (A). Published, not seen: Bucks, Narrowsville, Porter PC; Carbon, Rau PC; Franklin, Mercersburg, Porter PC; Huntingdon, Alexandria, Porter PC; Lehigh, Rau PC; Monroe, Analomink Creek, James PC; Pike, Rau PC.

## II. LESKEACEAE

A. Robust plants (except *Anomodon tristis* and *A. rostratus*), without paraphyllia, leaves densely papillose and subopaque; capsules erect and symmetric; peristome with segments narrow and cilia rudimentary or wanting; archegonia on the branches . . . . . . . . . . . . . . . 5. *Anomodon.*
A. Plants small to robust; paraphyllia mostly present; capsules and peristome various; archegonia mostly on the stems . . . . . . . . . . . . . . B.
  B. Plants with abundant filiform paraphyllia, which are usually branched; capsules curved, peristomes perfect . . . . . . . . . . . . . . . C.
  B. Paraphyllia less abundant; capsules various; peristomes with cilia rudimentary or often lacking . . . . . . . . . . . . . . . . . . . D.
C. Paraphyllia felted along the stem and attached to the leaf base . . 2. *Helodium.*
C. Paraphyllia abundant, not felted and not attached to the leaf base . 1. *Thuidium.*

D. Leaves ovate-lanceolate, acuminate, spreading to squarrose when moist, with plane margins; peristome teeth blunt; inner peristome of a scarcely perceptible basal membrane . . . . . . . . . . . . . . . 4. *Lindbergia.*
D. Leaves ovate to acuminate, erect-spreading when moist; peristome teeth slender-pointed, segments linear in most species . . . . . . . . 3. *Leskea.*

## 1. Thuidium B.S.G.

A. Apical cell of branch leaves crowned with 2–4 papillae . . . . . . . . . B.
A. Apical cell of branch leaves with a single terminal papilla . . . . . . . . G.
B. Paraphyllia numerous, more or less branched . . . . . . . . . . . C.
B. Paraphyllia few, small, mostly linear-oblong, 2–6 cells long . . . . . F.
C. Stems closely once pinnate, branches subjulaceous when dry . . . . . . D.
C. Stems loosely pinnate, branches pinnate to bipinnate . . . . . . . . . . E.
D. Plants comparatively soft; leaf cells with 2–5 small papillae on each surface . . . . . . . . . . . . . . . . . . . . . . . . . . . *scitum.*
D. Plants rigid; leaf cells with a single papilla on each surface . . . *abietinum.*
E. Stem leaves spreading-recurved, margins plane, costa percurrent; perichaetial leaves not ciliate; apparently calcicolous . . . . . . . . . . . *recognitum.*
E. Stem leaves erect-spreading, margins recurved, costa vanishing below the apex; perichaetial leaves ciliate; plants very regularly bi-tripinnate. . *delicatulum.*
F. Plants very small, 1–2 cm. stems and branches filiform, branches papillose *pygmaeum.*
F. Plants small, 2–4 cm.; branches smooth . . . . . . . . . . *minutulum.*
G. Stem leaves roundish-ovate, abruptly acuminate to a broad oblong point; margins erose-serrate . . . . . . . . . . . . . . . . . . . . *virginianum.*
G. Stem leaves rather gradually long-acuminate; margins crenulate-serrate or entire . . . . . . . . . . . . . . . . . . . . . . . . *microphyllum.*

**Thuidium abietinum** (Brid.) Bry. Eur. Rare.
SUBSTRATE: On soil and conglomerate rock.
HABITAT: In ravines and old fields.
ASSOCIATES: Growing with *Hypnum* spp. and *Polytrichum commune.*
(6 specimens examined.)
COUNTIES: Berks, Krumsville, Schaeffer 11/28/47 and Stonersville 5885; Northampton, Weygat, Potter & James (A): (12 counties.)

**Thuidium delicatulum** (Hedw.) Mitt. Abundant. In all physiographic provinces.
SUBSTRATE: Soil, rotting wood, accumulated humus on rock surfaces. pH 4 to 5.
HABITAT: All forest types, preferring the dense stands. Very common along wooded streams, in dark moist ravines, hemlock bottoms and shaded road banks. An indicator of mesophytic conditions. At elevations between 150 and 2200 feet.
ASSOCIATES: Growing with *Hypnum* spp., *Polytrichum* spp., *Atrichum* spp., and *Cladonia* spp., in the mesophytic forests. Along stream banks and in hemlock bottoms with *Mnium* spp., and the hepatic *Tricocholea tomentella.*
REPRODUCTION: Young sporophytes averaging 2 mm. long were found in a specimen collected in September. Immature capsules were found in August and closed mature capsules in September. Open capsules shedding spores were collected in November. (172 specimens examined, 20 fruiting.)
COUNTIES: Adams, Bedford, Berks, Blair, Bradford, Bucks, Carbon, Center, Chester, Clearfield, Clinton, Columbia, Crawford, Cumberland, Dauphin Delaware, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mifflin, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Schuylkill, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango, Warren, York. (45 counties.)

**Thuidium microphyllum** (Hedw.) Best. Rare. More common further south.

SUBSTRATE: Soil, rotting wood and humus on rock surfaces.
REPRODUCTION: Young sporophytes 15 mm. long present on specimens collected May 16. Capsules open on material collected June 17. (4 specimens examined, 2 fruiting.)
COUNTIES: Delaware, Moylan, Spencer 5/30/06; Northampton, Slateford, Schaeffer 7/1/47; Philadelphia, Wissahickon, Krout 1906 (A) and Highlands, Haydock (A). (3 counties). Published, not seen: Berks, Leesport, Wilkens 10/22/27 TM; McKean, Bradford, Burnett J.

**Thuidium minutulum** (Hedw.) Bry. Eur. Rare. More common southward. On rotting logs and exposed roots. Capsules mature in November. (4 specimens, all fruiting.)

Type locality: Lancaster county, Muhlenberg.
COUNTIES: Blair, Burgoon Gap, Garber 8/1869 (A); Cambria, Allegheny Mountains, James 10/1861 (A); McKean, Bolivar Run, Burnett 2034 (A); Northampton, Easton, Porter 11/13/68 (A). (4 counties). Published, not seen: Carbon, Mauch Chunk, James PC; Chester, Chester Valley, James PC; Delaware, James PC; Huntingdon, Porter PC; Lancaster, Muhlenberg TM; Monroe, James PC and Levis Falls, Moldenke 3343; Philadelphia, Wissahickon PC. Following specimens cited as this species in Tees Mss. from Berks county, have been determined as *T. virginianum*: Blind Hartmans, Wilkens, Nov. 13, 1927 (A) and White Bear, Wilkens, Oct. 20, 1929 (A).

**Thuidium pygmaeum** Bry. Eur. Rare. Calcareous rocks. Capsules open in September and October. (3 specimens.)

COUNTIES: Northampton, Easton, Porter and James (A). Published, not seen: Lehigh, Rau PC; Philadelphia, James PC.

**Thuidium recognitum** (Hedw.) Lindb. Not common. Occurs in all physiographic provinces.

SUBSTRATE: Soil and rock surface in limestone regions.
HABITAT: Moist shaded woods. One collection on rock exposure in a limestone sink overgrown by *Juniperus virginiana*. Elevation 550 to 2000 feet.
REPRODUCTION: Immature capsules present in June, empty capsules in December. (8 specimens, 2 fruiting.)
COUNTIES: Bedford, Beans Cove Church 4733; Berks, Bernharts 5882; Franklin, Greencastle 5877 and Housum 4681; Lancaster, Rawlinsville, Carter 6/30/93 (A); McKean, Hazelhurst 5889; Northampton, Slateford, Schaeffer 8/19/47 and Easton, Porter 11/1868 (A): (6 counties). Published, not seen: Clinton, between Renovo and Haneyville, J; Monroe, Pocono, James, PC; Philadelphia, James, PC.

**Thuidium scitum** (Beauv.) Aust. Rare.

SUBSTRATE: Soil, fallen logs and bases of trees.
HABITAT: Hardwood forest.
ASSOCIATES: One collection mixed with *Thuidium delicatulum*.
REPRODUCTION: Capsules mature and open in late October. (8 specimens, 3 fruiting.)
COUNTIES: Blair, var. *aestivale*, Bald Eagle, James 1/30/59 (A); Lehigh, New Smithville, Schaeffer 11/28/47; McKean, Bradford, Burnett 7/5/96 and Gilbert Run, Burnett 2811, also var. *aestivale*, Burnett Brook, Burnett 2790; Northampton, var. *aestivale*, Bethlehem, Rau (A); Philadelphia, Wissahickon, James 5/65 (A); Pike, Elbow Swamp, Wolle 1873. (6 counties). Published, not seen: Chester, New Garden, James PC; Lancaster, Muhlenberg, TM. Specimen labelled *T. scitum* from Berks county, Gibraltar Hill, Wilkens 10/30/27 cited in the Tees Mss. determined as *T. virginianum*.

**Thuidium virginianum** (Brid.) Lindb. Fairly common. All provinces of the state in more open and drier woodlands.

SUBSTRATE: Soil and humus covered rocks. (Shale, sandstone and trap.) pH 4.
HABITAT: Under stands of pine, pine-oak and hemlock-hardwoods. South facing wooded slopes, roadsides, shale bluffs and sandstone ledges. Elevation 150 to 1000 feet.
ASSOCIATES: *Atrichum Macmillanii*, *Grimmia pilifera*, *Bartramia pomiformis*, *Hypnum* spp. and lichens of the genus *Cladonia*.
REPRODUCTION: Sporophytes 1 to 1.5 cm. long in April, capsules immature on material collected in May. Capsules open and empty in September and October. (14 specimens examined, 8 fruiting.)
COUNTIES: Adams, Berks, Bucks, Center, Dauphin, Huntingdon, Northampton, Philadelphia, Snyder, Sullivan. (10 counties). Published, not seen: Blair, Bald Eagle Valley, Porter PC; Cambria, Cresson, James PC; Delaware, Krout, 5/30/07 TM; Lancaster, Muhlenberg and New Texas, Small PC; Monroe, Buckhill Falls, PC.

### 2. HELODIUM (Sull.) Warnst.

**Helodium paludosum** (Sull.) Aust. Not rare. Widespread. Local.

SUBSTRATE: Soil and humus. pH 4 to 6.
HABITAT: Grassy ditches, marshy spots and wet areas, usually near the edge of hardwood forests. Elevation 100 to 500 feet.
ASSOCIATES: With *Aulacomnium palustre*.
REPRODUCTION: Capsules mature and closed in April. Open in May and June. (9 specimens examined, all fruiting.)
COUNTIES: Bucks, Chester, Delaware, Franklin, Lehigh, Montgomery, Northampton, Philadelphia. (8 counties). Published, not seen: Lancaster, Muhlenberg, TM and Dillerville Swamp, Porter PC; McKean, Bradford, Burnett, J (var. *helodioides* (Ren. & Card.) Grout.)

### 3. LESKEA Hedw.

A. Leaves papillose, costate; median cells usually isodiametric; peristomial teeth abruptly incurved from a bulging base when dry . . . . . . . . . . B.
A. Leaves smooth or nearly so, costate or ecostate; peristomial teeth erect when dry . . . . . . . . . . . . . . . . . . . . . . . . . . . *nervosa*
  B. Leaves ovate-lanceolate, acute to acuminate, more than twice as long as wide . . . . . . . . . . . . . . . . . . . . . . . . . . C.
  B. Leaves ovate, subacute to obtuse, less than twice as long as wide . . . D.
C. Capsule straight, operculum short-conic . . . . . . . . . . . . . *polycarpa*.
C. Capsule curved; operculum long-conic . . . . . . . . . . . . *arenicola*.
  D. Leaves symmetric, biplicate, margins often revolute . . . . . *gracilescens*.
  D. Leaves asymmetric, not plicate, margins plane . . . . . . . . *obscura*.

**Leskea arenicola** Best. Very rare. Bases of trees.
COUNTIES: Delaware, Chelsea, Krout 5/27/11 TM.

**Leskea gracilescens** Hedw. Common.

SUBSTRATE: Roots, rotting logs and bark of trees.
HABITAT: Alluvial woods, open hardwoods and juniper trees in old pasture.
ASSOCIATES: With *Mnium cuspidatum* and *Anomodon attenuatus*.
REPRODUCTION: Capsules mature and closed in May. Open and shedding spores in June and July. Empty capsules present until September. (20 specimens, 13 fruiting.)
Type locality: Pennsylvania.
COUNTIES: Bucks, Franklin, Fulton, Lancaster, Lehigh, Montour, Northampton. (7 counties). Published, not seen: Berks, Wernersville, Tees 269 TM; Montgomery, Elkins Park, Tees 296 and Arcola, Tees 519a TM; Philadelphia, Pennypack, Tees 299 TM.

**Leskea nervosa** (Schwaegr.) Myrin. Rare. On bark of trees.
COUNTIES: Delaware, Strath Haven, Krout 9/21/07; Lehigh, Fogelsville, Schaeffer 11/28/47; McKean, Bennett Brook Burnett 7/12/96.

**Leskea obscura** Hedw. Not common.

SUBSTRATE: On bases of trees and rotten wood and soil.
HABITAT: Hardwoods. Stream banks, ravines and soil deposited on a bridge. Elevation 100 to 640 feet.
REPRODUCTION: Capsules closed in June. Open in July, remaining on the plants until October. (11 specimens, 5 fruiting.)
Type locality: Pennsylvania.
COUNTIES: Bucks, Chester, Delaware, Lancaster, Lehigh, Montour, Northampton. (7 counties). Published, not seen: Blair, Tyrone, James PC; McKean, Burnett PC; Philadelphia, Wissahickon, James PC and Pennypack, Krout 5/30/07 TM.

**Leskea polycarpa** Hedw. Fairly common. Eastern half of the state.
SUBSTRATE: Bark of trees, rotten wood and rarely on stones.
HABITAT: Woodlands. On exposed roots, old stumps, bases of trees, prostrate trunks and stone walls.
REPRODUCTION: Sporophytes 1 cm. long in April. Mature and closed in June. Open and shedding spores in July. (14 specimens, 5 fruiting.)
COUNTIES: Berks, Delaware, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia. (7 counties). Published, not seen: Bucks, Ottsville, Long 603 & 604 TM; Chester, Valley Forge, Tees 367 TM.

### 4. LINDBERGIA Kindb.

**Lindbergia brachyptera** (Mitt.) Kindb., var. *Austinii* (Sull.) Grout. Very rare. On bark of trees and stones. Frequently on the bark of *Juniperus virginiana*.
COUNTIES: Lehigh, Rau (A); Northampton, Bethlehem, Rau (A). Published, not seen: Lancaster, Dillerville Swamp, Small PC; Monroe, Water Gap, Austin PC.

### 5. ANOMODON Hook. & Tayl.

A. Secondary stems and branches slender, julaceous when dry . . . . . . . . B.
A. Secondary stems and branches coarse, scarcely julaceous . . . . . . . . . C.
  B. Leaf acute, ending in a hair point . . . . . . . . . . . . . *rostratus.*
  B. Leaf lingulate, obtuse . . . . . . . . . . . . . . . . . . . . . *tristis.*
C. Secondary stems much branched, many branches attenuate to flagelliform; many of leaves apiculate and toothed at the apex . . . . . . . . *attenuatus.*
C. Secondary stems sparingly branched, no attenuate branches . . . . . . . D.
  D. Upper portion of leaves lingulate-lanceolate, tapering to the apex, often secund; usually growing on rock . . . . . . . . . . . . . *viticulosus.*
  D. Upper portion of leaves lingulate and of nearly equal breadth, not secund; plants nearly always growing on bark of trees, stumps or logs . . . . E.
E. Leaves not decurrent having large fimbriate-papillose auricles, often apiculate *Rugelii.*
E. Leaves somewhat irregularly appressed, decurrent, without auricles, not apiculate . . . . . . . . . . . . . . . . . . . . . . . . . . . *minor.*

**Anomodon attenuatus** (Hedw.) Huben. Common. Generally distributed over the state. Forms a thick carpet-like growth.

SUBSTRATE: Exposed rock surfaces, less frequently on bases of trees. Very frequent and vigorous on limestone and conglomerate, but also occurs on shale, sandstone and quartzite. pH 7 to 8.
HABITAT: Deciduous woods, occasionally under hemlock and juniper. Cliffs, ravines,

shale bluffs, talus slopes, serpentine barrens, stream banks and at the bases of trees up to one foot above the soil surface. Elevation 150 to 2567 feet.
ASSOCIATES: Overgrows *Grimmia pilifera* and is itself overgrown by *Anomodon rostratus*, *Thuidium delicatulum* and species of *Cladonia*. This and other species of *Anomodon* accumulate a very fine dark soil at the base of the carpet-like masses preparing the way for more mesic species of mosses.
REPRODUCTION: Capsules open and empty on material collected in December and January. (42 specimens examined, 3 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bucks, Center, Chester, Dauphin, Delaware, Franklin, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia, Somerset, Sullivan, York. (17 counties). Published, not seen: Huntingdon, Pennsylvania Furnace J; McKean, Bolivar Run, Burnett J.

**Anomodon minor** (Beauv.) Lindb. Not common. Widespread in the state.

SUBSTRATE: Bark of trees, occasionally on rocks. (Limestone and conglomerate.)
HABITAT: On bases of trees, around bases of boulders and foot of cliffs, in moist deciduous woods. Elevation 200 to 1600 feet.
REPRODUCTION: Spores ripe in late fall or winter. (13 specimens examined.)
Type locality: Eastern North America (Muhlenberg) probably Pennsylvania.
COUNTIES: Berks, Stonersville, 5983; Bucks, George School, Krout 5/7/10; Center, Phillipsburg, James (A); Franklin, Welsh Run, 4664; Lebanon, Rau (A); Lehigh, Fountain Hill, Wolle; McKean, Swiston Creek, Burnett 2864 (A); Monroe, Buck Hill Falls and Cresco, Browne; Northampton, Bath and Riverton, Schaeffer and Easton, Porter (A). (9 counties). Published, not seen: Cambria, James PC; Lancaster, Muhlenberg PC; Philadelphia, Byberry, James PC.

**Anomodon rostratus** (Hedw.) Schimp. Fairly common. Widespread.

SUBSTRATE: Rock surfaces. (Limestone, conglomerate and shale.) Bases of trees.
HABITAT: Open deciduous woods, pine-oak woods and old pastures overgrown by juniper. On boulders, in limestone quarries and sink-holes, shale bluffs, bases of trees and stream banks. Elevation 100 to 900 feet.
ASSOCIATES: Mixed with *Mnium* spp., overgrowing *Anomodon attenuatus* and in turn invaded by *Cladonia* spp.
REPRODUCTION: Capsules mature in September, open in October. (42 specimens examined, 4 fruiting.)
Type locality: Lancaster County, Pennsylvania.
COUNTIES: Bedford, Berks, Blair, Bradford, Bucks, Center, Chester, Franklin, Huntingdon, Lancaster, Lehigh, Monroe, Northampton, Philadelphia, York. (15 counties). Published, not seen: Delaware, Cresson TM and Wawa, Kaiser TM; McKean, Burnett PC.

**Anomodon Rugelii** (C. Mull.) Keissel. Rare. Bases of trees. Northern plateau region.

COUNTIES: McKean, Gates Hollow, Burnett 3003 (A); Monroe, Pocono Mountain, Porter 1869 (A); Pike, Rau (A). (3 counties). Published, not seen: Lancaster, Chiquesalunga Creek, Small PC.

**Anomodon triste** (Cesati) Sull. Rare.

SUBSTRATE: Soil, rock surfaces and bark.
HABITAT: Deciduous woods.
COUNTIES: Carbon, Onoko Glen, Wolle 6/73; Delaware, Newton township, Krout 7/4/08; Northampton, Bethlehem, Rau (A) and Easton, Porter 11/6/68 (A); Philadelphia, Manayunk, James 1860 (A) and Wissahickon, James (A). (4 counties). Published, not seen: Clearfield, James PC; Chester, James PC; Lancaster, Porter PC; McKean, Gates Hollow, Burnett J; Monroe, Analomink Creek, James PC.

**Anomodon viticulosus** (Hedw.) Hook. & Tayl. Rare. Rocky cliffs.

COUNTIES: Bucks, Narrowsville, James 11/1867 (A). Published, not seen: Franklin, Mercersburg, Porter PC; Lancaster, Tucquan, Small PC.

## III. FABRONIACEAE

A. Gametophyte extremely small; leaf slightly denticulate to ciliate-dentate (occasionally entire) . . . . . . . . . . . . . . . . . . . . . 1. *Fabronia.*
A. Gametophyte larger; leaf entire to slightly denticulate . . . . . . . . . B.
  B. Leaf costate . . . . . . . . . . . . . . . . . . . 2 *Anacamptodon.*
  B. Leaf ecostate . . . . . . . . . . . . . . . . . 3. *Schwetzchkeopsis.*

### 1. FABRONIA Raddi.

A. Leaf strongly serrate . . . . . . . . . . . . . . . . . . . . . *ciliaris.*
A. Leaf slightly denticlulate to entire . . . . . . . . . . . . . . . *Ravenelii.*

**Fabronia ciliaris** (Brid.) Brid. Very rare. On bark of trees.

COUNTIES: Philadelphia, Bustleton, 6/6/66 (A). Published, not seen: Northampton, Bethlehem, Wolle PC.

**Fabronia Ravenelii** Sull. Very rare. On bark of trees.

COUNTIES: Franklin, Mercersburg, Porter PC; Northampton, James PC.

### 2. ANACAMPTODON Brid.

**Anacamptodon splachnoides** (Froehl.) Brid. Rare.

SUBSTRATE: In moist cavities in decaying wood.
HABITAT: Eastern hemlock forest. Elevation 150 to 1480 feet.
COUNTIES: McKean, Bradford, Burnett 140; Montgomery, Ringing Rocks Park, Krout 7/23/10; Northampton, Bethlehem, Rau (A); Philadelphia, Wissahickon, James 5/56 (A); Tioga, Mansfield, 4047. (5 counties). Published, not seen: Delaware, Smith TM; Lancaster, Muhlenberg PC; Lehigh, Rau PC.

### 3. SCHWETSCHKEOPSIS Broth.

**Schwetschkeopsis denticulata** (Sull.) Broth. Rare. On bark of trees.

COUNTIES: McKean, Lewis Run, Burnett 1543 (A); Monroe, Analomink, James 11/68 (A); Northampton, Bethlehem, Rau 1874 (A); Philadelphia, Schuylkill, James 7/53 (A). Published, not seen: Cambria, Cresson, James PC; Chester, New Garden, Michener PC; Delaware, James PC; Lehigh, Rau PC.

## IV. ENTODONTACEAE

### ENTODON C. Mull.

A. Leaf gradually and narrowly acuminate; segments of the inner peristome adherent to the teeth of the outer . . . . . . . . . . . . . . . *brevisetus.*
A. Leaf acute to apiculate; segments of the inner peristome free . . . . . . B.
  B. Leaves scarcely complanate . . . . . . . . . . . . . . . . *seductrix.*
  B. Leaves strongly complanate . . . . . . . . . . . . . . . . . . . . C.
C. Plants robust; leafy stems and branches more than 1 mm. wide, peristome teeth not strongly striolate or papillose . . . . . . . . . . . *cladorrhizans.*
C. Plants slender; leafy stems and branches 1 mm. wide or less; peristome teeth striolate or papillose . . . . . . . . . . . . . . . . . . . . *compressus.*

**Entodon brevisetus** (Hook. & Wils.) Jaeger & Sauerb. Rare. On bases of trees and limestone rocks.

COUNTIES: Chester, Landenberg, Krout 7/14/10. Published, not seen: Chester, New Garden, Michener PC; Elk, Bennett's Branch, McMinn PC; McKean, Burnett PC; Philadelphia, Bingham's PC.

**Entodon cladorrhizans** (Hedw.) C. Mull. Fairly common. Widespread.

SUBSTRATE: On rotten wood, tree trunks and soil.
HABITAT: All forest types. Elevation 150 to 2000 feet. (13 specimens.)
ASSOCIATES: With *Atrichum undulatum.*
Type locality: Lancaster, Pennsylvania.
COUNTIES: Adams, Berks, Bradford, Cameron, Columbia, Monroe, Philadelphia, Sullivan, Susquehanna, Warren. (10 counties). Published, not seen: Chester, Coventry, James PC; Delaware, Smith TM; Lancaster, Mount Hope, Small PC and Muhlenberg TM; Lehigh, James PC; McKean, Burnett PC; Northampton, James PC; Philadelphia, Wissahickon, Krout 8/5/08 TM and Kaiser 3/2/11 TM.

**Entodon compressus** (Hedw.) C. Mull. Not common.

SUBSTRATE: On soil, rotting logs and bases of trees.
HABITAT: Woodlands, marshy places and old pastures. Elevation 150 to 1300 feet.
ASSOCIATES: *Amblystegium serpens.*
(5 specimens.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Bradford, Greene Landing 4000a; Chester, Coventry, James 12/50 (A); Northampton, Easton, Porter 10/9/71 (A); Philadelphia, Wissahickon, Krout 9/7/10 (A) and Schuylkill, James 12/67 (A).

**Entodon seductrix** (Hedw.) C. Mull. Common. Widespread.

SUBSTRATE: Decaying logs, soil, humus and rock surfaces. (Limestone and quartzite.)
HABITAT: All forest types and old fields. Wooded slopes, banks of streams, stone walls, serpentine barrens and old quarries. Elevation 80 to 1820 feet.
REPRODUCTION: Capsules mature and shedding spores from October to January. (30 specimens, 10 fruiting.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Adams, Berks, Bradford, Bucks, Center, Chester, Delaware, Elk, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia, York. (14 counties). Published, not seen: Huntingdon, J; McKean, Burnett PC.
(*Entodon Sullivantii* (C. Mull.) Lindb. Excluded species. No specimens seen. Published, not seen: Philadelphia, Schuylkill River, James PC)

## V. AMBLYSTEGIACEAE

A. Leaf-margin strongly differentiated . . . . . . . . . . . . 4. *Sciaromium.*
A. Leaf-margin not differentiated . . . . . . . . . . . . . . . . . . . B.
  B. Paraphyllia abundant and conspicuous . . . . . . . . . . 5. *Cratoneuron.*
  B. Paraphyllia not abundant or conspicuous . . . . . . . . . . . . . C.

C. Leaves slender, strongly costate and falcate-secund . . . . 10. *Drepanocladus.*

C. Leaves not both strongly costate and falcate-secund . . . . . . . . . D.
  D. Leaf obtuse or rounded at apex . . . . . . . . . . . . . . . . . E.
  D. Leaf acuminate and acute . . . . . . . . . . . . . . . . . . . F.

E. Costa subpercurrent; gametophyte not conspicuously pinnately branched 8. *Calliergon.*

E. Costa lacking or short and double; gametophyte large and pinnately branched 9. *Calliergonella.*
  F. Leaf-cells 2–5 times as long as wide . . . . . . . . . . . . . . G.
  F. Leaf-cells 5–15 times as long as wide . . . . . . . . . . . . . H.

G. Gametophyte amphibious; cell-walls not usually thick; costa thin 2. *Amblystegium.*

G. Gametophyte aquatic; cell-walls thick, costa thick and heavy 3. *Hygroamblystegium.*

H. Leaf shortly acuminate with obtuse apex . . . . . . . . 7. *Hygrohypnum.*
H. Leaf more slenderly acuminate with acute apex . . . . . . . . . . . I.
I. Leaves squarrose-spreading . . . . . . . . . . . . . . . . . . 6. *Campylium.*
I. Leaves erect-spreading or flaccid (see also *Campylium polygamum.*) . . . . . 1. *Leptodictyum.*

### 1. Leptodictyum (Schimp.) Warnst.

A. Leaf broadly ovate to ovate-lanceolate, shortly acuminate; gametophyte sometimes growing in wet places but not aquatic . . . . . . . . . *trichopodium.*
A. Leaf longer lanceolate, more slenderly acuminate; gametophyte usually aquatic *riparium.*

**Leptodictyum riparium** (Hedw.) Warnst. Rare. On rocks in water.

COUNTIES: Berks, Jacksonwald Pond, Wilkens 12/8/29 (A); Dauphin, Harrisburg, Porter 10/52 (A); Franklin, Mercersburg, Porter 1852 (A); Monroe, Tobyhanna, James 10/69 (A); Northampton, Bushkill, Porter 10/68 (A) and Pot Rock Pond, Porter 9/10/58 (A); Philadelphia, Wissahickon, James (A). (6 counties). Published, not seen: Bucks, Nockamixon, Kaiser TM and Oxford Valley, Tees 248 TM; Chester, James PC; Delaware, James PC; Lancaster, Lititz Spring, Porter PC.

**Leptodictyum trichopodium** (Schultz.) Warnst., var. *Kochii* (Bry. Eur.) Broth. Very rare. No specimens seen. Published records: Center, Scotia J; Delaware, Swarthmore, Cresson 5/03 SMS; Lehigh, Center Valley, Tees 554 TM; McKean, Bradford, Burnett PC.

### 2. Amblystegium Bry. Eur.

A. Costa percurrent or nearly so, or excurrent . . . . . . . . . . . . . B.
A. Costa ending well below the apex, usually not far above the middle . . . . C.
B. Very slender, densely tufted; leaves finely and sharply denticulate; median leaf cells 6–10:1 . . . . . . . . . . . . . . . . . . . . . *compactum.*
B. Larger, leaves entire or at most obsoletely denticulate; median cells 3–6:1 *varium.*
C. Median leaf cells reaching 10:1 or longer . . . . . . . . . *Juratzkanum.*
C. Median leaf cells less than 8:1 . . . . . . . . . . . . . . . . . . . *serpens.*

**Amblystegium compactum** (C Mull.) Aust. Rare. On rock surfaces along stream banks. With *Mnium orthorhynchum* and a *Hepaticae.* Elevation 1400 feet.

COUNTIES: McKean, Gates Hollow, Burnett 1712 (A); Tioga, Niles Valley 4099. Published, not seen: Credited to Pennsylvania by L. Cheney (Bot. Gaz. 24:265).

**Amblystegium Juratzkanum** Schimp. Not common.

SUBSTRATE: Soil, stones and rotting wood.
HABITAT: Old orchard pasture on spring box, overgrown land and culverts. Elevation 300 to 1450 feet.
REPRODUCTION: Capsules open and shedding spores in April. (6 specimens.)
COUNTIES: Adams, Berks, Chester, Montgomery, Northampton, Warren. (6 counties). Published, not seen: Delaware, Broomall, Fogg 5/19/23 TM; Philadelphia, Chamoneoux, Tees 139, TM.

**Amblystegium serpens** (Hedw.) Bry. Eur. Commonest species in the state. Widespread.

SUBSTRATE: Moist substrates of all kinds. Soil, bark, stones and rotting logs. pH 6 to 7.
HABITAT: Deciduous forests. Stream banks, ravines, wet roadside woods, pond shores and bases of trees. Elevation 100 to 1300 feet.

REPRODUCTION: Immature capsules in March, open and shedding spores in late April. (21 specimens, 10 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Chester, Cumberland, Delaware, Lancaster, Lehigh, Monroe, Northampton, Philadelphia, York. (13 counties). Published, not seen: Cambria, Lloydsville, J.

**Amblystegium varium** (Hedw.) Lindb. Fairly common. Confined to the "cool" area.

SUBSTRATE: Rocks, rotting wood and humus.
HABITAT: Principally eastern hemlock formation. Exposed tree roots, shaded roadsides, ravines, shores of ponds and spring boxes. Elevation 100 to 1700 feet.
REPRODUCTION: Capsules open and shedding spores in late April and early May. (17 specimens, 7 fruiting.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Adams, Berks, Chester, Delaware, Lehigh, McKean, Monroe, Northampton, Philadelphia, Sullivan, Tioga. (11 counties). Published, not seen: Bucks, Rau PC; Huntingdon, Spruce Creek, Porter PC; Lancaster, Muhlenberg TM and Lancaster, Tees 639 TM; Lebanon, Porter PC; Lehigh, Rau PC; Somerset, Ursina J; York, Porter PC.

**Amblystegium varium** (Hedw.) Lindb., var. **ovatum** Grout. Slender, julaceous or nearly so; stem leaves smaller, 1.2–1.5 mm. long, concave, round-ovate, abruptly and narrowly short acuminate.

COUNTIES: Philadelphia, Holmsburg 5903.

### 3. HYGROAMBLYSTEGIUM Loeske.

A. Costa excurrent . . . . . . . . . . . . . . . . . . . . . *noterophilum.*
A. Costa not excurrent . . . . . . . . . . . . . . . . . . . . . B.
  B. Stem leaves entire, cordate-ovate to oblong-lanceolate, apex rather blunt; all forms aquatic . . . . . . . . . . . . . . . . . . . . . . . C.
  B. Stem leaves narrower in outline, usually acute with a more slender acumen; growing in water or wet places . . . . . . . . . . . *irriguum.*
C. Stem leaves oblong-ovate to broadly oblong-lanceolate, 1–2 mm. in length, gradually and evenly narrowed to a rather blunt apex . . . . . . . *fluviatile.*
C. Stem leaves ovate to cordate-ovate, usually less than 1.2 mm. long, more abruptly narrowed to a distinct acumination . . . . . . . . . . *orthocladon.*

**Hygroamblystegium fluviatile** (Hedw.) Loeske. Fairly common. Widespread.

SUBSTRATE: On stones and soil in and along streams.
HABITAT: All forest types. Streams and stream banks in dark cool ravines and hollows. Elevation 100 to 760 feet.
ASSOCIATES: *Eurhynchium rusciforme.*
REPRODUCTION: Capsules open and shedding spores in May. (15 specimens, 5 fruiting.)
COUNTIES: Berks, Chester, Clinton, Lycoming, McKean, Monroe, Philadelphia, Schuylkill. (8 counties). Published, not seen: Pike, outlet of East Branch Pond, Rau PC.

**Hygroamblystegium fluviatile** (Hedw.) Loeske, var. **ovatum** Grout.

Type locality: Near West Chester, Chester county, Pennsylvania, F. Windle 5/15/04. Grout (1931) 3:74.

**Hygroamblystegium irriguum** (Wils.) Loeske. Rare.

SUBSTRATE: Soil and rocks at edge of water.
HABITAT: Wooded streams and ponds.
REPRODUCTION: Capsules mature and spores present in May. (7 specimens.)

COUNTIES: Adams, Knoxlyn 5845; Berks, Wernersville, Williams 5/9/08; Delaware, Williamson School, Lowe 6/3/99; Franklin, Orrstown 6007; Lehigh, Allentown, Pretz 13613 (A); Northampton, Bethlehem, Rau (A); Philadelphia, Wissahickon, Kaiser 5/16/10 and Shawmont, Krout 6/14/99. (7 counties). Published, not seen: Bedford, Hyndman J; Bucks, Point Pleasant, York 5/32, TM and Lumberville, Long 582, TM; Cambria, Cresson and Johnstown, James PC; Huntingdon, Porter PC; Lancaster, Muhlenberg, TM; Monroe, Water Gap, Wood, PC.

**Hygroamblystegium noterophilum** (Sull.) Warnst. Rare. In streams and springs containing lime.

Type locality: Franklin County, Pennsylvania.
COUNTIES: Franklin, Mercersburg, Porter (A); Lancaster, Lititz Spring, Porter 5/65 (A) and Musci Appal. Austin 385, Porter (A); Northampton, Monocacy, Rau 4/72 (A). (3 counties.)

**Hygroamblystegium orthocladon** (Beauv.) Grout. Common. Widespread.

SUBSTRATE: Rocks and sandy soil. pH 6 to 7.
HABITAT: Hardwood forests. Wet cliffs, streams and old dam breast. (18 specimens.)
COUNTIES: Berks, Bucks, Cambria, Chester, Delaware, Lancaster, McKean, Montgomery, Northampton, Philadelphia, York. (11 counties.)

### 4. Sciaromium Mitt.

**Sciaromium Lescurii** (Sull.) Broth. Rare. On wet rocks.

COUNTIES: Lancaster, Safe Harbor, Porter 7/57 (A); Lehigh (A); Northampton, Bushkill Gap, Porter 11/16/68 (A); York, Opposite Marietta, Porter 7/11/57 (A). (4 counties). Published, not seen: Carbon, Rau PC; Delaware, Springfield, Krout 9/08; Luzerne, Rau PC; Philadelphia, Wissahickon, James PC.

### 5. Cratoneuron (Sull.) Roth.

**Cratoneuron filicinum** (Hedw.) Roth. Rare. Streams and wet areas, preferably where limestone is present.

COUNTIES: Bucks, Nockamixon, Rau 7/74 (A); Huntingdon, Spruce Creek, Porter (A); Lancaster, Dillerville Swamp, Porter 2/57 (A). (3 counties). Published, not seen: Northampton, Monocacy, Rau PC.

### 6. Campylium (Sull.) Mitt.

A. Leaves strongly squarrose . . . . . . . . . . . . . . . . . . . . . . B.
A. Leaves not noticeably squarrose . . . . . . . . . . . . . . . . . . D.
    B. Leaves strongly costate . . . . . . . . . . . . . . . *chrysophyllum.*
    B. Leaves without costa or with costa short and double . . . . . . . . . C.
C. Plants very slender; alar cells not conspicuously enlarged or inflated *hispidulum.*
C. Plants stouter; alar cells conspicuously enlarged and inflated . . . . *stellatum.*
    D. Stem leaves cordate-ovate, abruptly slenderly acuminate; dioicous . *radicale.*
    D. Stem leaves broadly lanceolate, gradually narrowed to a very slender acumination; monoicous . . . . . . . . . . . . . . . . *polygamum.*

**Campylium chrysophyllum** (Brid.) Bryhn. Common. Widespread.

SUBSTRATE: Soil, logs and humus on rock surfaces.
HABITAT: All forest types and old fields. Shaded paths, stream banks, wet cliffs and lake shores. Elevation 100 to 2000 feet.
ASSOCIATES: *Eurhynchium serrulatum.*
REPRODUCTION: Capsules open and shedding spores in May. (17 specimens, 3 fruiting.)

COUNTIES: Adams, Bucks, Chester, Columbia, Lancaster, McKean, Monroe, Northampton, Philadelphia, Susquehanna, Tioga, York. (12 counties). Published, not seen: Carbon PC; Delaware, Brinton's Bridge, Kaiser 4/22/22 TM and Lima Tees 678 TM; Lehigh PC; Montgomery, Zieglersville, Tees 526 TM; Pike, PC.

**Campylium hispidulum** (Brid.) Mitt. Fairly common. Widespread.
SUBSTRATE: Soil, old logs and stone walls. pH 5 to 7.
HABITAT: Hardwood forests. Stream banks, road banks, wall of bridge, bases of trees and wooded slopes.
REPRODUCTION: Capsules mature in May. (12 specimens, 5 fruiting.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Bucks, Center, Chester, Delaware, Northampton, Philadelphia, York. (7 counties). Published, not seen: Cambria, James PC; Center, Scotia J; Lancaster, Porter and Small PC and Muhlenberg TM; Lehigh, Rau PC; McKean, Burnett PC; Monroe, Pocono, James PC; Montgomery, Pottstown, Kaiser 3/22/11 SMS.

**Campylium hispidulum** (Brid.) Mitt., var. **Sommerfeltii** (Myrin) Lindb.
COUNTIES: Bucks, Narrowsville, James 7/71 (A).

**Campylium polygamum** (Bry. Eur.) Bryhn. Rare.
SUBSTRATE: Humus on wet rocks.
HABITAT: Beech-maple woods on lake shore. Elevation 100 to 2000 feet.
COUNTIES: Cambria, Allegheny Mountains, James 6/58 (A); Philadelphia, Wissahickon, James 7/52 and 8/64 (A); Susquehanna, Gelatt 3871.

**Campylium radicale** (Beauv.) Grout. Rare.
COUNTIES: Lehigh, Black River, Rau (A); Northampton, Bethlehem, Rau 6/22/73 (A); Philadelphia, James 6/89 (A) and Wissahickon 6/1/59 (A). Published, not seen: Lancaster, Conewago, Small PC; McKean, Bradford, Burnett J; Pike, Rau PC.

**Campylium stellatum** (Hedw.) Lange & C. Jens. Rare.
COUNTIES: Lancaster, Dillerville, Porter 6/66 (A); Lehigh, Rau (A); Northampton, Bingens, Rau 5/74 (A). Published, not seen: Chester, "Flora Cestrica" PC; Delaware, Glenolden, Krout 4/03 TM; McKean, Burnett PC.

### 7. HYGROHYPNUM Lindb.

A. Alar cells large and conspicuous, clear, hyaline or colored, forming distinct decurrent auricles; outer layer of stem cells much enlarged . . . . . . . B.
A. Alar cells thick-walled, less distinctly inflated, granulose to subopaque, often colored; outer layer of stem cells not enlarged . . . . . . . . . *palustre.*
    B. Alar cells hyaline and thin-walled; costa usually reaching the middle of the leaf; dioicous . . . . . . . . . . . . . . . . . . *ochraceum.*
    B. Alar cells usually colored and thick-walled except the outer row or two, which are usually thin-walled and often hyaline; costa double, short and faint; monoicous . . . . . . . . . . . . . . . . . . . *eugyrium.*

**Hygrohypnum eugyrium** (Bry. Eur.) Loeske. Rare. "Cool" mountainous area.
SUBSTRATE: Rocks in stream.
HABITAT: Hemlock forest. Streams and spring outlets.
COUNTIES: Carbon, Onoko Glen, Wolle 6/74; Huntingdon, Porter (A); McKean, Bennett Brook, Burnett 7/97; Monroe, Delaware Water Gap, M. R. 7/60; Snyder, Troxelville 5481. Published, not seen: Luzerne, Rau PC.

**Hygrohypnum ochraceum** (Turn.) Loeske. Rare.
COUNTIES: Lehigh, Rau (A); Monroe, Pocono Forks, James 11/68 (A). Published, not seen: Cambria, Cresson, James PC; Carbon, Mauch Chunk, James PC; McKean, Burnett PC; Northampton, Bethlehem, Rau PC; Pike, Rau PC.

**Hygrohypnum palustre** (Hedw.) Loeske. Very rare.

COUNTIES: Huntingdon, Porter (A). Published, not seen: Carbon, Rau PC; McKean, Burnett PC.

### 8. Calliergon (Sull.) Kindb.

A. Costa extending to the middle or a little above . . . . . . . . . . . B.
A. Costa subpercurrent . . . . . . . . . . . . . . . . . . . . . . . . . C.
  B. Slender, yellowish-green to straw-color; stem leaves usually suberect and imbricated when dry, oblong to ovate-oblong . . . . . . . *stramineum.*
  B. More robust, brighter green; stem leaves spreading to erect-spreading, broadly cordate-ovate to suborbicular . . . . . . . . . . *Richardsoni.*
C. Slender, simple or sparingly branched; alar cells gradually enlarged . *cordifolium.*
C. Robust, profusely branched; alar cells abruptly enlarged . . . . . *giganteum.*

**Calliergon cordifolium** (Hedw.) Kindb. Rare. Swamps, northern part of the state.

COUNTIES: Lehigh, Rau (A); Monroe, Pocono Mountain, Porter 6/67 (A); McKean, Fosters Branch, Burnett 735 (A). Published, not seen: Bucks, Rau PC and Penn Valley, Krout 5/10/99 TM; Cambria, Lloydsville, J; Delaware, Smith TM; Lancaster, Dillerville, Small 7/25/94, Northampton, Rau PC; Pike, Wynne (1945).

**Calliergon giganteum** (Schimp.) Kindb. Very rare. Swamps.

COUNTIES: Lancaster, Dillerville, Porter (A).

**Calliergon Richardsoni** (Mitt.) Kindb. Rare.

Published, not seen: Lancaster, Dillerville Swamp, 7/25/94, Wynne (1945).

**Calliergon stramineum** (Brid.) Kindb. Very rare. Swamps.

COUNTIES: Monroe, Tunkhannock, Porter 7/21/60 (A).

### 9. Calliergonella Loeske

A. Alar cells abruptly inflated, thin-walled and usually hyaline, forming decurrent auricles . . . . . . . . . . . . . . . . . . . . . . . . *cuspidata.*
A. Alar cells somewhat enlarged but not thin-walled nor forming auricles . *Schreberi.*

**Calliergonella cuspidata** (Brid.) Loeske. Rare.

SUBSTRATE: Swamps and marshy ground.
COUNTIES: Lancaster, Dillerville, Porter (A); Northampton, Bingen Swamps, Rau 6/74 (A). Published, not seen: Lehigh, Rau PC; McKean, East Branch, Teina Swamp, Burnett J; Snyder, between Shamokin Dam and Richfield J.

**Calliergonella Schreberi** (Bry. Eur.) Grout. Fairly common. "Cool" mountainous area, chiefly.

SUBSTRATE: Soil and decaying logs.
HABITAT: Principally in eastern hemlock formation. Swamps, shaded slopes, road banks and ditches. Elevation 100 to 2100 feet.
ASSOCIATES: *Mnium affine*, *Leucobryum glaucum*, *Pohlia nutans*. Several times collected growing under *Lycopodium* spp. (21 specimens).
COUNTIES: Bedford, Berks, Bucks, Dauphin, Lancaster, Lebanon, Lehigh, Luzerne, Northampton, Philadelphia, Potter, Sullivan, Warren, Wayne. (14 counties). Published, not seen: Cameron, Hunt's Run, Burnett J; Carbon, Rau PC; Chester, James PC; Delaware, James PC; Elk, McMinn PC; Huntingdon, Porter PC; McKean, Burnett PC; Monroe, Britton PC and Barett Township, Moldenke 3362; Pike, Garber PC; Potter, Eulalie Township, Moldenke 16213; Somerset, Allegheny Mountains, Patterson J.

### 10. Drepanocladus (C. Mull.) Roth.

A. Leaves entire; alar cells usually greatly enlarged and inflated . . . . . . B.
A. Leaves, some or all plainly dentate . . . . . . . . . . . . . . . . . . C.
  B. Costa stout; enlarged auricular cells not reaching the costa, their cell walls usually somewhat thickened and colored when old . . . . . . *Sendtneri.*
  B. Costa more slender, enlarged and inflated auricular cells often reaching the costa, not thickened, rarely much colored . . . . . . . . . *aduncus.*
C. Leaves strongly plicate even when moist . . . . . . . . . . . *uncinatus.*
C. Leaves not plicate, alar cells more or less inflated . . . . . . . . . *fluitans.*

**Drepanocladus aduncus** (Hedw.) Warnst. Rare.

COUNTIES: Franklin, Mercersburg, Porter 1852 (A); Northampton, Bethlehem, Rau (A); York, opposite Marietta, Porter (A). Published, not seen: Bucks, Nockamixon, Kaiser SMS; Lancaster, Porter PC.

**Drepanocladus aduncus** (Hedw.) Warnst., var. **Kneiffi** (Bry. Eur.) Warnst.

COUNTIES: Monroe, Delaware Water Gap, Austin 10/71 (A). Published, not seen: Carbon, Wolle PC; Lancaster, Conewago, Small PC; Luzerne, Rau PC.

**Drepanocladus fluitans** (Hedw.) Warnst. Rare. Usually in flowing water.

COUNTIES: Chester, Williston Township, Windle 4/22/08; Delaware, Tinicum Island, Krout 7/3/09; Lancaster, Smithville Swamp, Small 10/31/91 (A); Lehigh, Rau (A); Luzerne, Hazelton, Wolle 7/75; Monroe, Tobyhanna, James 11/68 (A); Delaware Water Gap, Austin 10/71 (A) and Porter 1868 (A). (6 counties). Published, not seen: Carbon, Rau PC; Center, Bear Meadow, Porter PC; McKean, West Branch, Burnett J; Pike, Rau PC.

**Drepanocladus Sendtneri** (Schimp.) Warnst., var. **Wilsoni** (Schimp.) Monkem. Very rare.

COUNTIES: Monroe, Pocono Mountain, Porter (A).

**Drepanoclaudus uncinatus** (Hedw.) Warnst. Not common.

SUBSTRATE: Rotting logs above water level, but in moist situations.
HABITAT: Swamps and wet wooded hillside. Elevation 100 to 2000 feet.
COUNTIES: McKean, Corydon 4446 and Rew 5996; Monroe, Mount Pocono, Kaiser 7/9/10; Philadelphia, Manayunk, James 6/51 (A); Pike, Elbow Swamp, Rau 8/73 (A). (4 counties). Published, not seen: Cambria, James PC; Chester, Michener PC; Delaware, Smith PC; Huntingdon, Porter PC; Lancaster, Dillerville, Porter PC; Northampton, Bethlehem, Rau PC.

## VI. BRACHYTHECIACEAE

A. Leaf conspicuously papillose beneath by projecting cell-angles . . . 1. *Bryhnia.*
A. Leaf not conspicuously papillose beneath . . . . . . . . . . . . . B.
  B. Leaf large, concave, spoon-shaped, abruptly acuminate . . . 3. *Cirriphyllum.*
  B. Leaf seldom plicate or, if so, more gradually acuminate . . . . . . . . C.
C. Apical cells of branch leaves often shorter and broader than the rest; costa often ending in a spine beneath; operculum long-rostrate . . 2. *Eurhynchium.*
C. Apical cells of branch leaves not noticeably different; costa not ending in a spine beneath; operculum conic to conic-rostrate . . . . . . . . . . D.
  D. Gametophyte small: calyptra hairy; inner peristome adherent to outer; seta rough . . . . . . . . . . . . . . . . . . . . 6. *Homalotheciella.*
  D. Gametophyte larger; calyptra smooth; inner peristome separate from outer; seta smooth or rough . . . . . . . . . . . . . . . . E.

E. Erect symmetric and cylindrical capsules, lacking cilia in the peristome 4. *Chamberlainia.*

E. More or less cernuous and unsymmetric capsules; cilia well developed 5. *Brachythecium.*

### 1. BRYHNIA Kaurin.

A. Branch-leaf broad, shortly acuminate; apex twisted . . . . . *novae-angliae.*

A. Branch-leaf ovate-lanceolate, more slenderly acuminate; apex not twisted *graminicolor.*

**Bryhnia graminicolor** (Brid.) Grout. Fairly common. Widespread.
SUBSTRATE: Rocks, soil and rotting wood.
HABITAT: All forest types. Steep wooded slopes and shaded ravines. Elevation 100 to 1400 feet. (13 specimens).
Type locality: Pennsylvania, Muhlenberg.
COUNTIES: Berks, Bucks, Huntingdon, Lancaster, Northampton, Philadelphia, Tioga, York. (8 counties). Published, not seen: Delaware, Smith TM; Franklin, Mercersburg, Porter PC; Lehigh, Rau PC; McKean, Bradford, Burnett PC; Pike PC.

**Bryhnia novae-angliae** (Sull. & Lesq.) Grout. Fairly common. Widespread.
SUBSTRATE: Soil and decaying logs.
HABITAT: Hardwood forests. Moist woodlands, stream banks, log in spring, swampy area and on serpentine barrens. (13 specimens.)
COUNTIES: Berks, Chester, Delaware, Lancaster, Lehigh, Monroe, Northampton, Philadelphia, Sullivan. (9 counties). Published records not seen: McKean, Burnett PC; Montgomery, Pottstown, Kaiser 3/22/11 SMS; Pike, Rau PC; York, Porter PC.

### 2. EURHYNCHIUM Bry. Eur.

A. Apical cells of branch leaves oblong-rhomboidal to circular . . . . . . . B.

A. Apical cells of branch leaves not materially different from the median cells *serrulatum.*

  B. Seta rough . . . . . . . . . . . . . . . . . . . . . . . . *hians.*

  B. Seta smooth . . . . . . . . . . . . . . . . . . . . . . . . C.

C. Aquatic, on stones in streams . . . . . . . . . . . . . . . *rusciforme.*

C. Terrestrial, usually growing on soil . . . . . . . . . . . . . *strigosum.*

(*Eurhynchium diversifolium* (Schleich.) Bry. Eur. Excluded species. Range is western North America. Published record: Northampton, Bethlehem, Rau PC.)

**Eurhynchium hians** (Hedw.) Jaeger & Sauerb. Fairly common. Widespread.
SUBSTRATE: Soil.
HABITAT: All forest types. Moist areas in woods, shores of ponds and streams.
ASSOCIATES: *Climacium dendroides.* (7 specimens.)
Type locality: Lancaster, Pennsylvania.
COUNTIES: Bradford, Bucks, Lebanon, Monroe, Philadelphia, York. (6 counties). Published, not seen: Cambria, Cresson, Porter PC; Chester, Coventry, James PC; Delaware, Smith, PC; Elk, Bennett's Branch, McMinn PC; Franklin, Mercersburg, Porter PC; Lancaster, Porter PC and Muhlenberg TM; Lehigh, Rau PC; McKean, Burnett PC.

**Eurhynchium rusciforme** (Neck.) Milde. Fairly common. Widespread.
SUBSTRATE: Wet rocks and soil. pH6 to 7.
HABITAT: Eastern hemlock formation. Stream banks, wet cliffs and swamps. Elevation 150 to 1400 feet. (17 specimens.)
COUNTIES: Bradford, Bucks, Center, Clinton, Lehigh, McKean, Monroe, Montgomery,

Philadelphia, Tioga, York. (11 counties). Published, not seen: Cambria, Cresson, James PC; Chester, Coventry, James PC; Lancaster, Chickies, Porter and Mount Hope, Small PC; Northampton, Bethlehem, Rau PC.

**Eurhynchium serrulatum** (Hedw.) Kindb. Common. Widespread.

SUBSTRATE: Soil, rotting wood and humus.
HABITAT: All forest types and old fields. Wooded hillsides, stream banks, roadside ditches and banks, overgrown lanes and ravines. Elevation 10 to 2000 feet.
ASSOCIATES: *Dicranum* spp., *Mnium affine.*
REPRODUCTION: Capsules mature in September and October. (54 specimens, 16 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Center, Chester, Clinton, Delaware, Lancaster, McKean, Monroe, Montgomery, Northampton, Philadelphia, Potter, Schuylkill, Sullivan, York. (18 counties). Published, not seen: Cambria, Cresson, James PC; Lehigh, Rau PC; Pike, Rau PC.

**Eurhynchium strigosum** (Hoffm.) Bry. Eur., var. **praecox** (Hedw.) Husnot. Rare. In road cut on north facing bank, pH7. York county, Tildens 6019. Published, not seen: Lancaster, Muhlenberg PC.

**Eurhynchium strigosum** (Hoffm.) Bry. Eur., var. **robustum** Roll. Common. "Cool" mountainous area.

SUBSTRATE: Soil, decaying wood, humus and rock surfaces covered with litter.
HABITAT: Eastern hemlock formation. Stream banks, hillsides, bases of trees, ravines and stone walls. Elevation 100 to 1400 feet.
REPRODUCTION: Capsules mature and closed in September and October. (20 specimens.)
COUNTIES: Berks, Bucks, Clinton, Delaware, Huntingdon, Lehigh, McKean, Monroe, Northampton, Philadelphia, Potter, Tioga, York. (13 counties). Published, not seen: Chester, Coventry, James PC; Elk, McMinn PC; Lancaster, Muhlenberg TM.

### 3. CIRRIPHYLLUM Grout.

A. Leaf with a long, filiform acumination . . . . . . . . . . . . . *piliferum*
A. Leaf shortly acuminate . . . . . . . . . . . . . . . . . . . . . *Boscii.*

**Cirriphyllum Boscii** (Schwaegr.) Grout. Common. Widespread.

SUBSTRATE: Soil and rock surfaces. (Sometimes limestone.) pH4 to 7.5.
HABITAT: Deciduous forests. Stream and pond shores, old fields, thickets and serpentine barrens. Elevation 150 to 1300 feet.
ASSOCIATES: *Mnium affine*, *Hypnum* spp., and species of *Cladonia.* (43 specimens.)
COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Chester, Columbia, Delaware, Franklin, Lancaster, Lehigh, Montgomery, Northampton, Philadelphia, York. (15 counties). Published, not seen: Cambria, Porter PC; Huntingdon, Pennsylvania Furnace, J; Monroe, Mount Pocono, Britton PC.

**Cirriphyllum piliferum** (Hedw.) Grout. Rare.

SUBSTRATE: Soil.
COUNTIES: McKean, Langmade, Burnett 2869; Monroe, Delaware Water Gap, James 11/68 (A); Philadelphia, Wissahickon, James 2/52 (A). Published, not seen: Delaware, Smith TM; Elk, Benezette PC.

### 4. CHAMBERLAINIA Grout.

A. Plants as robust as *Brachythecium oxycladon*, and resembling it when sterile *acuminata.*
A. Plants more slender . . . . . . . . . . . . . . . . . . . . *crytophylla.*

**Chamberlainia acuminata** (Schwaegr.) Grout. Not common. Soil and rotting wood in shaded areas. (9 specimens.)

Type locality: Lancaster, Pennsylvania.
COUNTIES: Center, Chester, McKean, Northampton, Philadelphia, York. (6 counties). Published, not seen: Bucks, Kintnersville, True 6/31/31 TM; Clearfield, Phillipsburg, James PC; Franklin, Mercersburg, Porter PC; Lancaster, Conewago, Small PC and Muhlenberg TM; Lehigh, Center Valley, Tees 555 TM; Montgomery, Kulpsville, Tees 250 TM.

**Chamberlainia crytophylla** (Kindb.) Grout. Rare.
COUNTIES: McKean, Riverside Park, Burnett 2774 (A).

### 5. BRACHYTHECIUM Bry. Eur.

A. Costa percurrent or nearly so . . . . . . . . . . . . . . . . *populeum.*
A. Costa extending ½–⅔ the length of the leaf . . . . . . . . . . . . B.
    B. Seta smooth . . . . . . . . . . . . . . . . . . . . . . . . . C.
    B. Seta rough above, smooth below . . . . . . . . . . . . . . . . G.
C. Capsules suberect, 3–4:1 . . . . . . . . . . . . . . . . . . . . *oxycladon.*
C. Capsules strongly inclined and unsymmetric 2–3:1 . . . . . . . . . . D.
    D. Leaves not plicate or striate; stem leaves gradually narrowed from base to apex . . . . . . . . . . . . . . . . . . . . . . . . *acutum.*
    D. Leaves plicate or striate . . . . . . . . . . . . . . . . . . . . E.
E. Stem leaves lanceolate, 0.6 mm. broad at base gradually and evenly narrowed to a slender acumination . . . . . . . . . . . . . . . . . . . *flexicaule.*
E. Stem leaves ovate, at least 1 mm. broad at base, more abruptly narrowed to a slender acumination . . . . . . . . . . . . . . . . . . . . . . . F.
    F. Stem leaves ovate-lanceolate, 2–2.5 by 0.8–1.1 mm., median leaf cells 10:1 *salebrosum.*
    F. Stem leaves triangular-ovate, 1.2–0.8 mm., median cells 4–6:1 . . *digastrum.*
G. Leaves plicate, long-acuminate, branch leaves strongly serrate . . . . *campestre.*
G. Leaves not plicate, shorter-acuminate, branch leaves entire or serrate . *flagellare.*
    H. Secondary stems often dendroid, stem leaves ovate and very sharp-pointed with enlarged and inflated alar cells . . . . . . . . . . . . . . *rivulare.*
    H. Not dendroid; stem leaves slenderly acuminate . . . . . . . . . . I.
I. Slender, leaves somewhat secund, stem leaves lanceolate . . . . . *velutinum.*
I. Robust, leaves not secund, stem leaves ovate to triangular-ovate . . . . . J.
    J. Complanate-foliate; leaves cordate-triangular and strongly and widely decurrent; cilia of inner peristome appendiculate . . . . . . . . *Starkei.*
    J. Not complanate; leaves ovate and less strongly decurrent; cilia not appendiculate . . . . . . . . . . . . . . . . . . . . . *rutabulum.*

**Brachythecium acutum** (Mitt.) Sull. Rare. No specimens seen. Northern species.
Published, not seen: Lehigh, Rau PC; McKean, Burnett PC; Monroe, Water Gap, Austin PC; Montgomery, Ambler, Kaiser 11/18/16 SMS; Northampton, Rau PC.

**Brachythecium campestre** Bry. Eur. Rare. Northern species.
COUNTIES: Bucks, Morrisville, James 9/50 (A); Elk, Benezette, James 11/68 (A). Published, not seen: McKean, Bennett Brook and Quintuple, Burnett J; Monroe, Tobyhanna, Rau PC; Northampton, Bethlehem, Rau PC.

**Brachythecium digastrum** C. Mull. & Kindb. Very rare. Rocks on creek bank.
Capsules open and closed in April. Elevation 400 feet. pH6.
COUNTIES: Adams, Hampton 5992.

**Brachythecium flagellare** (Hedw.) Jennings. Common. Widespread.

SUBSTRATE: Rocks and soil along streams. Semi-aquatic. pH7.
HABITAT: Alluvial woods. Stream banks, pastures and moist wooded slopes. Elevation 100 to 1600 feet. (20 specimens.)
COUNTIES: Berks, Bucks, Center, Chester, Delaware, Lehigh, McKean, Monroe, Northampton, Philadelphia, Pike, Sullivan, Susquehanna. (13 counties). Published, not seen: Bedford, Hyndman J; Lancaster, Rock Hill and Tucquan, Small PC; Montgomery, Fraser's Bog, Wismer 1/29/33 TM.

**Brachythecium flexicaule** Ren. & Card. Rare. Northern species. On rotten stump at 1900 feet in hardwood forest. pH5. Capsule closed in September.

COUNTIES: McKean, Rew 5984. Published, not seen: Lancaster, Muhlenberg PC; McKean, Burnett PC.

**Brachythecium oxycladon** (Brid.) Jaeger & Sauerb. Common. Widespread.

SUBSTRATE: Soil and humus covered rocks.
HABITAT: All forest types. Dry rocks, grassy road banks, stream banks and serpentine barrens.
REPRODUCTION: Capsules mature and closed in October and November. (12 specimens, 4 fruiting.)
Type locality: Lancaster, Pennsylvania (Ludwig.)
COUNTIES: Bucks, Franklin, Lancaster, McKean, Monroe, Montgomery, Northampton, Philadelphia, Schuylkill, York. (10 counties). Published, not seen: Berks, Wernersville, Tees 270 TM; Delaware, Smith TM.

**Brachythecium populeum** (Hedw.) Bry. Eur., var. **ovatum**, Grout. Rare. On stone walls and boulders in open woodlands.

ASSOCIATES: *Bryum argenteum.*
COUNTIES: Berks, Stonersville 5990; Philadelphia, Wissahickon, Githens 494 (A) and Holmesburg, James 4/60 (A); York, Wrightsville, James 8/24/61. (3 counties.) Published, not seen: Delaware, Smith TM.

**Brachythecium rivulare** Bry. Eur. Fairly common. Widespread.

SUBSTRATE: Silt, rocks and rotting wood in stream beds or along the shore. pH 6–7.
HABITAT: Alluvial hardwoods. Ravines, wet cliffs, stream banks, falls and dam breast. Elevation 100 to 1448 feet.
ASSOCIATES: *Atrichum undulatum* and *Thuidium delicatulum.*
REPRODUCTION: Capsules mature in November. (18 specimens, 2 fruiting.)
COUNTIES: Adams, Bucks, Delaware, Lehigh. Luzerne, McKean, Monroe, Northampton, Philadelphia, Susquehanna, Wyoming, York. (12 counties). Published, not seen: Cambria, Cresson, James PC; Chester, Downingtown, Tees 149 & 159 TM; Lancaster, Mount Hope, Small PC; Montgomery, Arcola, Tees 517 TM.

**Brachythecium rutabulum** (Hedw.) Bry. Eur. Common. Northern species reaching its southern limits in Pennsylvania and New Jersey.

SUBSTRATE: Soil and stones in moist places. Less frequent on roots and rotting wood.
HABITAT: More frequent in the eastern hemlock formation, but occurs in oak-hickory woods. 150 to 2000 feet.
REPRODUCTION: Capsules mature and closed in October. Open in November and December. (23 specimens, 14 fruiting.)
COUNTIES: Berks, Bradford, Chester, Elk, Lehigh, Monroe, Montgomery, Northampton, Philadelphia, Susquehanna, Warren, York. (12 counties). Published, not seen: Bucks, James PC; Delaware, James PC; Franklin, Mercersburg, Porter PC; Lancaster, Porter PC and Bartsville, Jackson 2/16 SMS; Philadelphia, Rau PC.

**Brachythecium salebrosum** (Web. & Mohr.) Bry. Eur. Fairly common. Widespread.
SUBSTRATE: Soil and rotting wood.
HABITAT: All forest types. Stream banks, wooded slopes, top of decaying stumps and logs, lawns. Elevation 100 to 1700 feet.
ASSOCIATES: *Mnium punctatum, Anomodon attenuatus.*
REPRODUCTION: Capsules closed and mature in September and October. (12 specimens, 4 fruiting.)
COUNTIES: Adams, Chester, Lehigh, McKean, Monroe, Philadelphia, Potter, Tioga, Venango. (9 counties). Published, not seen: Bucks, Brownsburg, Tees 353 TM; Clinton, Renovo J; Delaware, Smith TM; Elk, McMinn PC; Lancaster, Porter PC and Muhlenberg TM; Northampton, Bethlehem, Rau PC; York, Porter PC.

**Brachythecium Starkei** (Brid.) Bry. Eur. Not common. "Cool" mountainous area.
SUBSTRATE: Soil.
HABITAT: Eastern hemlock formation. Swamps and wet road banks. Elevation 1500 to 1700 feet.
ASSOCIATES: *Rhodobryum roseum.*
REPRODUCTION: Capsules closed and mature in September.
COUNTIES: Elk, Benezette, McMinn 11/68 (A); Monroe, Tobyhanna, James 10/69 (A); Potter, Sweden Valley 4276; Warren, Sugar Grove 6004. (4 counties.) Published, not seen: Carbon, Rau PC; McKean, Burnett PC; Pike, Rau PC.

**Brachythecium velutinum** (Hedw.) Bry. Eur. Rare. Northern species.
COUNTIES: Susquehanna, St. Joseph 3917 & 3918; York, Porter (A). Published, not seen: Lancaster, Small PC; McKean, Burnett PC; Philadelphia, Wissahickon, Krout 9/7/10 TM.

### 6. HOMALOTHECIELLA Card.

**Homalotheciella subcapillata** (Hedw.) Card. Rare. Widespread.
SUBSTRATE: Tree trunks and rock surfaces.
COUNTIES: Delaware, Llewellyn, Krout 5/5/06; Lancaster, Cedar Hill, Porter 12/10/61 (A); Montgomery, Pottstown, Kaiser 3/22/11; Northampton, Hellertown, Wolle 11/73 and Easton, Porter 11/67 (A); Philadelphia, Bartram's Gardens, James 10/50 (A) and near Schuylkill, James 12/55 (A). (5 counties). Published, not seen: Chester, Warwick Furnace, James PC; Elk, McMinn PC.

## VII. PLAGIOTHECIACEAE

### PLAGIOTHECIUM Bry. Eur.

A. Mostly very slender plants, light yellowish green to whitish, glossy; leaves little or not at all decurrent; median leaf cells narrowly linear, alar little or not at all differentiated; capsules not plicate . . . . . . . . . . . . . B.

A. Usually larger, darker green; leaves decurrent; leaf cells wider; alar clearly differentiated; capsules often plicate . . . . . . . . . . . . . . . . H.
B. Leaves complanate . . . . . . . . . . . . . . . . . . . . . . . C.
B. Leaves not complanate, entire . . . . . . . . . . . . . . *pulchellum.*

C. Leaves entire, scarcely a trace of serration on any leaf; cortical cells of stem very large; plants of cold ravines, growing mostly in moist crevices of ledges *Mullerianum.*

C. Leaves more or less serrate . . . . . . . . . . . . . . . . . . . . . D.
D. Leaves strongly serrate in the upper half . . . . . . . . . . . . E.
D. Leaves serrulate at or near apex only . . . . . . . . . . . . . . G.

E. Plants very slender, usually growing on decayed wood or humus, sometimes on soil . . . . . . . . . . . . . . . . . . . . . . . . *turfaceum.*

E. Plants larger, growing on earth and stones . . . . . . . . . . . F.

F. Plants dark green, leaves distant, apex usually bluntish . . . . *geophilum.*
F. Plants lighter green, usually yellowish and glossy, leaves closer, not blunt *deplanatum.*

G. Plants light yellowish-green, costa very faint or none; growing chiefly in the lowlands from Long Island southward . . . . . . . . . . . . . *micans.*

G. Plants not yellowish, often dark green; costa evident, often reaching middle of leaf; growing in cool ravines and on mountains . . . . . . . . . *elegans.*
H. Leaves not complanate, squarrose-spreading; capsule strongly striate *striatellum.*
H. Leaves complanate . . . . . . . . . . . . . . . . . . . . . . I.

I. Leaves slenderly acuminate; capsules erect and symmetric; peristome without cilia . . . . . . . . . . . . . . . . . . . . . . . . . *laetum.*

I. Leaves acute to somewhat acuminate; capsules more or less inclined and unsymmetric; peristome perfect . . . . . . . . . . . . . . . . . . . . J.
J. Not complanate or only slightly so . . . . . . . . . . . *Roeseanum.*
J. Conspicuously complanate . . . . . . . . . . . . . . . . . . K.

K. Plants dingy or yellowish green; leaves shrunken when dry, dioicous; operculum rostrate . . . . . . . . . . . . . . . . . . . . . . *sylvaticum.*

K. Plants bright green; monoicous; operculum conic . . . . . . *denticulatum.*

**Plagiothecium denticulatum** (Hedw.) Bry. Eur. Commonest species. Widespread.
SUBSTRATE: On soil, humus, rotten wood and stones. pH4 to 5.
HABITAT: All forest types. Wooded hillsides, road banks, bases of trees and shrubs, swamps and serpentine barrens. Elevation 200 to 2000 feet.
ASSOCIATES: *Mnium cuspidatum*, *Polytrichum* spp., and *Hypnum imponens*.
REPRODUCTION: Capsules mature and closed in May. Open and shedding spores from June to September. Empty capsules remain on the plants until November. (31 specimens, 14 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Cambria, Clinton, Delaware, Huntingdon, Lancaster, Lebanon, Lehigh, McKean, Monroe, Montgomery, Northampton, Pike, Schuylkill. Somerset, Sullivan, Tioga, Warren, Wayne, York. (23 counties). Published, not seen: Chester, James PC; Clearfield, Potterdale J and Dubois, Moldenke 4412; Franklin, Porter PC; Philadelphia, Wissahickon, Tees 80 TM and James PC.

**Plagiothecium deplanatum** (Sull.) Grout. Fairly common. Widespread.
SUBSTRATE: Soil, humus and rocks.
HABITAT: Deciduous forests. Wooded hillsides, ravines, stream banks, rocks covered with humus and bases of trees.
ASSOCIATES: *Mnium cuspidatum*.
REPRODUCTION: Capsules present in August. (18 specimens, 2 fruiting.)
COUNTIES: Adams, Berks, Delaware, Northampton, York. (5 counties). Published, not seen: Chester, James PC; Delaware, James PC; McKean, Burnett PC.

**Plagiothecium elegans** (Hook.) Sull. Rare. Northern species chiefly in northern mountainous counties. On rock surfaces.
COUNTIES: Northampton, Wolle and Weygat, James 11/28/67 (A); Sullivan, Lippincott (A). Published, not seen: Carbon, Rau PC; Delaware, Strath Haven, Krout 8/20/06 TM; McKean, Burnett PC; Philadelphia, Wissahickon PC; Pike, Rau PC.

**Plagiothecium elegans** (Hook.) Sull., var. **Schimperi** (Jur. & Milde) Limpr. Rare. More robust than the species. Hemlock ravine at spring outlet on soil. Elevation 950 feet.
COUNTY: Franklin, St. Thomas 5913.

**Plagiothecium geophilum** (Aust.) Grout. Not common. Widespread.

SUBSTRATE: Rocks and soil.
HABITAT: Deciduous woods and meadow lined with willows.
COUNTIES: Delaware, North Springfield 5950; Philadelphia, Schuylkill, James 9/63 (A) and Musci Bor. Amer. Ed. 2, Sull. & Lesq. 437 (A); Wayne, Aldenville, 3851. (3 counties). Published, not seen: Cambria, Cresson, Porter PC; Lancaster, Tees 640 TM; Lehigh, Rau PC.

**Plagiothecium laetum** Bry. Eur. Rare. Mountainous area.

COUNTIES: Cambria, Allegheny Mountains, James 6158 (A) and Ebensburg, James 11/58 (A).

**Plagiothecium micans** (Sw.) Paris. Rare. More common south of Pennsylvania.

SUBSTRATE: Soil and decaying logs.
HABITAT: Woodlands. Banks of streams and bases of trees.
COUNTIES: Delaware, Strath Haven, Krout 6/14/10; Lehigh, Shimersville, Schaeffer B53 (A); Northampton, Riverton, Schaeffer 8/11/47; Philadelphia, Morris Arboretum 6026. (4 counties). Published, not seen: Center, Bear Meadow, Porter PC.

**Plagiothecium Muellerianum** Schimp. Rare. Northern species. On moist soil and rocks in cool ravines, especially in crevices of rocks.

COUNTIES: Lancaster, Martic Forge, Porter 5/62 (A). Published, not seen: Bucks, Brownsburg, Tees 345 TM; Carbon, Rau PC; Philadelphia, Wissahickon, James PC.

**Plagiothecium pulchellum** (Hedw.) Bry. Eur., var. **nitidulum** (Wahlenb.) Husnot. Rare.

COUNTIES: Elk, Benezette, McMinn 10/68 (A). Published, not seen: Bucks, Narrowsville, James PC.

**Plagiothecium Roeseanum** (Hampe.) Bry. Eur. Not common. Soil in hemlock ravines. With *Pohlia nutans*.

COUNTIES: Adams, Arendtsville 5821; Philadelphia, Wissahickon, James 10/62 (A) and Pennypack, James (A). Published, not seen: Delaware, Radnor, James PC; Lancaster, Marietta, Porter PC; McKean, Burnett PC; Monroe, Cresco, James PC; Northampton, Bethlehem, Rau PC and Easton, Porter PC.

**Plagiothecium striatellum** (Brid.) Lindb. Not common. Wet shaded places on rocks and soil.

COUNTIES: Lehigh, Rau (A); McKean, Marilla Brook, Burnett 3147 (A); Monroe, Buck Hill Falls, Niering; Philadelphia, Wissahickon, James 6/66 (A); Sullivan, Lippincott 6/12/95 (A). (5 counties). Published, not seen: Cambria, Ebensburg, James PC; Carbon, Rau PC; Chester, Chester Valley, James PC; Delaware, Springfield, Krout 10/5/08 TM; Monroe, Garber PC; Pike, Rau PC.

**Plagiothecium sylvaticum** (Brid.) Bry. Eur. Not common. Northern species. On wet rocks, soil and humus in cool, shaded places.

COUNTIES: Berks, Blanda, Wilkens 6/24/27 (A) and Carsonia, Wilkens 3/4/27 (A); Delaware, Radnor, James 6/55 (A); McKean, Toad Hollow, Burnett 1329 (A); Philadelphia, Wissahickon, James 10/56 (A); York, opposite Marietta, Porter 7/11/57 (A). (5 counties). Published, not seen: Bucks, Holland, Tees 113 TM; Carbon, Rau PC; Chester, Chester Valley, James PC; Franklin, Mercersburg, Porter PC; Lehigh, Rau PC; Northampton, Green PC; Pike, Rau PC.

**Plagiothecium turfaceum** (Lindb.) Lindb. Rare. On decaying wood and humus. A northern species.

COUNTIES: Berks, Bernharts 5841; Cambria, Allegheny Mountains, James 6/59 (A); Monroe, Tobyhanna, Tees 176 (A). (3 counties). Published, not seen: McKean, Burnett PC; Pike, Rau PC.

## VIII. HYPNACEAE

A. Stem-leaves secund, often falcate (*Heterophyllium may be found here*) . . B.
A. Stem-leaves not falcate, rarely secund . . . . . . . . . . . . . . . F.
  B. Alar-cells enlarged, usually hyaline . . . . . . . . . . . . . . . C.
  B. Alar-cells not enlarged, frequently small and quadrate . . . . . . . E.
C. Epidermis of capsule not collenchymatous . . . . . . . . . . . . . . D.
C. Epidermis of capsule collenchymatous . . . . . . . . . 4. *Sematophyllum.*
  D. Operculum long-rostrate . . . . . . . . . . . . . . . . 2. *Brotherella.*
  D. Operculum conical to short-rostrate . . . . . . . . . . . . 1. *Hypnum.*
E. Capsule erect, symmetric; segments of the inner peristome at least partially adherent to outer peristome teeth; cilia absent or rudimentary . . . 7. *Pylaisia.*
E. Capsules erect or more usually asymmetric; segments free; cilia usually well developed . . . . . . . . . . . . . . . . . . . . . . . . 1. *Hypnum.*
  F. Capsules erect, symmetric; peristome without cilia . . . . 8. *Platygyrium.*
  F. Capsules inclined to horizontal, usually curved; peristome with cilia . . G.
G. Alar-cells enlarged and hyaline . . . . . . . . . . . 3. *Heterophyllium.*
G. Alar-cells not enlarged, often small and quadrate . . . . . . . . . . . H.
  H. Gametophyte very minute; leaves 0.8 mm. or less in length 6. *Amblystegiella.*
  H. Gametophyte of medium size; leaves about 1 mm. in length 5. *Homomallium.*

### 1. HYPNUM Hedw.

A. Alar cells conspicuously enlarged, hyaline and thin-walled . . . . . . . B.
A. Alar cells not conspicuously enlarged, often small . . . . . . . . . . . C.
  B. Region of enlarged alar-cells abruptly delimited from remaining leaf-cells *Patientiae.*
  B. Region of enlarged alar-cells gradually intergrading with remaining leaf-cells . . . . . . . . . . . . . . . . . . . . . . . . . . *pratense.*
C. Leaf papillose beneath with sharply projecting cell-ends . . . . . *molluscum.*
C. Leaf not papillose . . . . . . . . . . . . . . . . . . . . . . . . D.
  D. Gametophyte yellowish-green; beautifully plumose-pinnate; leaf plicate, apex curved toward the next lower branch . . . . . . . . *crista-castrensis.*
  D. Gametophyte seldom yellowish-green; pinnately or irregularly branched; leaf seldom plicate, apex curved toward the substrate . . . . . . . E.
E. Capsule nearly erect and symmetric . . . . . . . . . . . . . . . . F.
E. Capsule curved, asymmetric, inclined or horizontal . . . . . . . . . . G.
  F. Gametophyte relatively large; capsule 3–4 mm. long . . . . . . . *imponens.*
  F. Gametophyte relatively small; capsule less than 2 mm. long . . . *pallescens.*
G. Quadrate alar cells very numerous . . . . . . . . . . . . . . . . . H.
G. Quadrate alar cells few or none . . . . . . . . . . . . . . . . . . I.
  H. Leaf usually entire, with a few slightly enlarged alar cells . . *cupressiforme.*
  H. Leaf serrate, with no enlarged alar-cells . . . . . . . . . . . . *reptile.*
I. Capsule when dry longitudinally plicate . . . . . . . . . . . . *curvifolium.*
I. Capsule when dry smooth or slightly wrinkled . . . . . . . . . . . *fertile.*

**Hypnum crista-castrensis** Hedw. Not common. Confined to the "cool" mountainous area.

SUBSTRATE: Soil and decaying logs.

HABITAT: Eastern hemlock formation. In swampy bottoms and along streams. Elevation 1000 to 1700 feet.
ASSOCIATES: With *Hylocomium* spp., *Hypnum* spp., and *Thuidium delicatulum*.
COUNTIES: Blair, Bradford, Elk, Lehigh, McKean, Monroe, Northampton, Pike, Potter, Tioga. (10 counties). Published, not seen: Cambria, Cresson, Porter PC; Carbon, Rau PC; Chester, New Garden, Michener PC; Clinton, Renovo J; Delaware, Smith PC; Lancaster, Martic Forge, Porter PC; Philadelphia, Wissahickon, James PC; Somerset, Allegheny Mountains, Patterson J.

**Hypnum cupressiforme** Hedw. Not common.

SUBSTRATE: Bark of trees.
HABITAT: Forests. Bases of trees.
COUNTIES: Chester, Coventry, James 12/20/50 (A) and Falls of French Creek, Kaiser 3/21/11 (var. filiforme.); McKean, Rutherford Rocks, Burnett 1944 (var. filiforme.) (A); Philadelphia, Falls of the Pennypack, Krout 8/29/08, W. bank of Schuylkill, James (A), Wissahickon, James 10/56 (A) and James 10/58 (A). (3 counties). Published, not seen: Cambria, Ebensburg, James PC; Lancaster, Mount Hope, Small PC and Beartown, Eby 4/00 SMS.

**Hypnum curvifolium** Hedw. Fairly common. "Cool" mountainous area.

SUBSTRATE: Soil, decaying logs and humus covered rocks.
HABITAT: All forest types and grassy area at edge of woods. Stream banks, roadsides, wooded slopes and bridge masonry. Elevation 220 to 1600 feet.
ASSOCIATES: *Atrichum* spp. (12 specimens.)
COUNTIES: Cumberland, Lancaster, McKean, Monroe, Northampton, Philadelphia, Potter, York. (8 counties). Published, not seen: Bucks, Rau PC; Cambria, Ebensburg, James PC; Carbon, Rau PC; Chester, Chester Valley, James PC; Delaware, James PC and West Bradford Township, Krout 9/19/10 TM; Pike, Rau PC; Somerset, Ursina J.

**Hypnum fertile** Sendt. Rare. On decaying wood. "Cool" area.

COUNTIES: Cambria, Allegheny Mountains, James 6/68 (A) and Chestnut Creek, James 6/58 (A); McKean, Bennett Brook, Burnett 8/8/97. Published, not seen: Chester, Elverson, Krout TM; Pike, Rau PC.

**Hypnum imponens** Hedw. Commonest species in the state. Widespread.

SUBSTRATE: Decaying logs, soil and humus covered rock surfaces. pH4 to 5.
HABITAT: All forest types. Wooded slopes, stream banks, ditches and culverts and shaded road banks. Elevation 150 to 2100 feet.
ASSOCIATES: With species of *Dicranum*, *Polytrichum*, *Hypnum*, *Mnium*, *Eurhynchium*, *Heterophyllium Haldanianum*, *Leucobryum glaucum* and *Cladonia*.
REPRODUCTION: Capsules mature in autumn. Closed in September, but open in November and December. (57 specimens, 13 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Carbon, Center, Chester, Clinton, Columbia, Cumberland, Dauphin, Delaware, Elk, Lancaster, Lehigh, McKean, Mercer, Monroe, Northampton, Philadelphia, Potter, Somerset, Sullivan Tioga, Warren, York. (26 counties). Published, not seen: Cambria, Cresson, Porter PC; Franklin, Porter PC; Montgomery, Fraser's Bog, Wismer TM; Pike, Rau PC.

**Hypnum molluscum** Hedw. Fairly common. Widespread.

SUBSTRATE: Soil and exposed roots.
HABITAT: Hardwoods. Wooded hillside, shaded roadbanks and serpentine barrens. Elevation 100 to 1450 feet.
COUNTIES: Lancaster, McKean, Montgomery, Northampton, Philadelphia, Warren. (6 counties). Published, not seen: Blair, Garber PC; Cambria, Cresson, Porter PC; Chester, New Garden, Michener; Delaware, Smith PC; Elk, McMinn PC; Lehigh, Rau PC; McKean, Burnett PC; Monroe, James PC.

**Hypnum pallescens** (Hedw.) Bry. Eur. Very rare. A northern species. On soil.
COUNTIES: Monroe, Pocono Mountain, Porter 8/59 (A). Published, not seen: Cambria, Cresson, Porter; Pike, Rau PC.

**Hypnum Patientiae** Lindb. Fairly common. "Cool" mountainous area.
SUBSTRATE: Soil, humus and rotting wood.
HABITAT: Principally in the hardwood forest. Hillsides, shaded banks of brooks, old fields and ravines. Elevation 80 to 1600 feet. (14 specimens.)
COUNTIES: Bucks, Columbia, Delaware, McKean, Montgomery, Potter, Sullivan, Tioga, Warren. (9 counties). Published, not seen: Berks, Mineral Springs Park, Wilkens 11/13/27 and Wernersville, Tees 271 TM; Philadelphia, Wissahickon, Kaiser TM.

**Hypnum Patientiae** Lindb., var. **elatum** Schimp.
COUNTIES: Bucks, Delaware.

**Hypnum pratense** Koch. Fairly common. Chiefly in the "cool" mountainous area.
SUBSTRATE: Soil, humus and wet rock surfaces.
HABITAT: Principally eastern hemlock forest. Hillsides, ravines, shaded banks of brooks, wet cliffs and roadsides. Elevation 600 to 1520 feet. (13 specimens.)
COUNTIES: Berks, Bradford, Cambria, Columbia, Cumberland, Lancaster, Lehigh, McKean, Monroe, Northampton, Tioga. (11 counties). Published, not seen: Chester, Downingtown, Tees 156 TM; Philadelphia, James PC.

**Hypnum reptile** Mx. Fairly common. Confined to the northern mountainous counties.
SUBSTRATE: Bark, rotting wood and rock surfaces.
HABITAT: Chiefly in the eastern hemlock forest. Elevation 750 to 2000 feet.
REPRODUCTION: Capsules closed in July. Open and shedding spores, August to September. (19 specimens, 10 fruiting.)
COUNTIES: Berks, Bradford, McKean, Monroe, Pike, Schuylkill, Sullivan, Susquehanna. (8 counties). Published, not seen: Delaware, Smith TM; Lancaster, Muhlenberg PC.

### 2. BROTHERELLA Loeske.

A. Gametophyte complanate-foliate; capsule asymmetric and inclined; cilia of peristome well developed . . . . . . . . . . . . . . . . . . . . . . . B.
A. Gametophyte little complanate; capsule erect and symmetric; cilia none or rudimentary . . . . . . . . . . . . . . . . . . . . . . . *tenuirostris.*
  B. Gametophyte glossy, yellowish-green; operculum one-half as long as the rest of the capsule . . . . . . . . . . . . . . . . . . . . . . *recurvans.*
  B. Gametophyte not very glossy, seldom yellowish; operculum nearly as long as the rest of the capsule . . . . . . . . . . . . . . . *delicatula.*

**Brotherella delicatula** (James) Fleisch. Very rare.
Published, not seen: McKean, Bradford, Burnett PC

**Brotherella recurvans** (Mx.) Fleisch. Common. "Cool" mountainous area.
SUBSTRATE: Soil, rotting logs and humus covered rocks.
HABITAT: Eastern hemlock formation. Stream banks, wooded hillsides, and swampy woods. Elevation 1400 to 1940 feet.
REPRODUCTION: Capsules mature but closed in September. Open in November. (18 specimens, 8 fruiting.)
COUNTIES: Berks, Bradford, Center, Clinton, Elk, Lehigh, McKean, Monroe, Northampton, Pike, Potter, Sullivan, Tioga. (13 counties). Published, not seen: Carbon, Rau PC; Chester, James PC; Delaware, James PC; Lancaster, Mount Hope, Small PC and Chickies, Porter PC; Philadelphia, James PC; Somerset, Keystone J.

**Brotherella tenuirostris** (Schimp.) Broth. Rare. "Cool" mountainous area.

SUBSTRATE: Bases of trees, rotting wood and humus.
HABITAT: Wooded stream banks.
COUNTIES: Berks, Mineral Springs Park, Wilkens 11/13/22 (A); Carbon, Stony Creek, Wolle 8/74 and Onoko Glen, Wolle and Rau 7/73 (A); Chester, N. of Daylesford 4529; Northampton, Bethlehem, Rau (A). (4 counties). Published, not seen: Monroe, Delaware Water Gap, Austin PC.

### 3. HETEROPHYLLIUM (Schimp.) Kindb.

**Heterophyllium Haldanianum** (Grev.) Kindb. Common. Widespread.

SUBSTRATE: Soil, rotting wood, humus covered rocks and exposed roots. pH4 to 6.
HABITAT: All forest types, old fields and thickets. Stream banks, hillsides, wood roads and swamps. Elevation 100 to 1700 feet.
ASSOCIATES: *Mnium cuspidatum* and *Tetraphis pellucida*.
REPRODUCTION: Capsules closed in September. Open and shedding spores in December. (40 specimens, 25 fruiting.)
COUNTIES: Adams, Bradford, Berks, Bucks, Clinton, Columbia, Cumberland, Delaware, Lancaster, Lehigh, McKean, Monroe, Montgomery, Philadelphia, Pike, Potter, Schuylkill, Susquehanna, Tioga, Warren, York. (21 counties.) Published, not seen: Cambria, Cresson, Porter PC and Ebensburg, James PC; Chester, Chester Valley, James PC; Elk, McMinn PC; Northampton, Bethlehem, Rau PC.

### 4. SEMATOPHYLLUM Mitt.

A. Gametophyte growing on trees or recently fallen logs; capsule nearly erect and symmetric . . . . . . . . . . . . . . . . . . . . . . . . *adnatum*
A. Gametophyte growing on rocks; capsule curved and asymmetric . . . . . B.
  B. Leaf 1.5 mm. or less in length . . . . . . . . . . . . . . *carolinianum*.
  B. Leaf 2 mm. or more in length . . . . . . . . . . . . . *marylandicum*.

**Sematophyllum adnatum** (Mx.) E. G. Britton. Rare. On bark of living trees.

COUNTIES: Chester, Daylesford, Stewart 3/30/46. Published, not seen: Delaware, Paper Mill, Krout 9/6/99 TM; Monroe, Buck Hill Falls, Britton PC; Philadelphia, Wissahickon, Krout 8/5/08 TM.

**Sematophyllum carolinianum** (C. Mull.) E. G. Britton. Uncommon.

SUBSTRATE: Rocks and soil.
COUNTIES: Lehigh, Rau (A); Northampton, Bushkill Gap, Porter 10/69 (A); Weygat, Porter 8/14/76 (A) and Easton, Garber (A); Philadelphia, Wissahickon, James 10/68 (var. *admixtum*) (A); Sullivan, Eaglesmere, Githens 222; York, Long Level, 1996. Published, not seen: Carbon, Rau PC.

**Sematophyllum marylandicum** (C. Mull.) E. G. Britton. Very rare. On stones and ledges in and near cold brooks.

COUNTIES: Carbon, Onoko Glen, Wolle 7/73.

### 5. HOMOMALLIUM (Schimp.) Loeske.

**Homomallium adnatum** (Hedw.) Broth. Common. Widespread.

SUBSTRATE: On bark and rock surfaces.
HABITAT: All forest types. On roots of willows and bark of trees, up to two feet above the ground, along stream banks. Elevation 100 to 1300 feet.
ASSOCIATES: *Mnium cuspidatum*.
Type locality: Lancaster, Pennsylvania.
COUNTIES: Berks, Bucks, Franklin, Juniata, Lancaster, Lehigh, Northampton, Philadelphia, Wayne, York. (10 counties). Published, not seen: Monroe, Bushkill Falls, Britton PC.

### 6. AMBLYSTEGIELLA Loeske.

A. Plants growing on the base of deciduous trees, leaves reaching 0.6 mm. or more in length . . . . . . . . . . . . . . . . . . . . . . . . *subtilis.*

A. Plants growing on stones, especially limestone; leaves usually less than 0.5 mm. in length . . . . . . . . . . . . . . . . . . . . . *confervoides.*

**Amblystegiella confervoides** (Brid.) Loeske. Rare. Soil on boulders. Beech-maple woods along stream banks.

COUNTIES: Tioga, Mansfield 4060. Published, not seen: Huntingdon, Pennsylvania Furnace J; Lancaster, Porter PC; Northampton, Easton, Porter PC and Bethlehem, Rau PC.

**Amblystegiella subtilis** (Hedw.) Loeske. Rare. On trees and logs along stream banks.

COUNTIES: Delaware, Lima, Krout 8/9/04; Lehigh, Fogelsville, Schaeffer 11/28/47. Published, not seen: Berks, Wyomissing, Wilkens 2/23/30 TM; Chester, Cornog, Kaiser 11/18/11 SMS; Lancaster, Muhlenberg TM and Bartsville, Jackson 12/16 SMS.

### 7. PYLAISIA Bry. Eur.

A. Segments of endostome free from the teeth . . . . . . . . . . *polyantha.*

A. Segments of endostome wholly or partially adherent to the teeth . . . . . B.

  B. Segments partially adherent; spores 18–24 microns . . . . . . . *Selwynii.*

  B. Segments wholly adherent; spores 24–70 microns . . . . . . . . *intricata.*

**Pylaisia intricata** (Hedw.) Bry. Eur. Not common. Eastern Pennsylvania.

SUBSTRATE: Bark of trees and old logs.
HABITAT: Moist woods.
Type locality: Lancaster, Pennsylvania.
COUNTIES: Lancaster, New Texas, Carter 12/93 (A); Lehigh, Rau (A); Northampton, Shimersville, Schaeffer B52, Weygat, James 1008 (A) and Easton, Porter 1868 (A); Philadelphia, Wissahickon, James 4/57 (A) and Bartram's Garden, James 5/51 (A); Pike, Elbow Swamp, Rau 1873 (A). (5 counties). Published, not seen: Carbon, Rau PC; Chester, Darlington, TM; Delaware, Glenolden, Krout 12/21/07 TM; McKean, Burnett PC.

**Pylaisia polyantha** Bry. Eur. Rare. No specimens seen.

Published records: McKean, Burnett PC.

**Pylaisia Selwynii** Kindb. Rare. Bases of trees.

COUNTIES: Lancaster, New Texas, Carter 2/94 (A) and Conewago, Small 1/1/92 (A). Published, not seen: Chester, Coventry, James PC; Clearfield, Phillipsburg, James PC; Delaware, James PC; Elk, McMinn PC; McKean, Burnett PC; Northampton, Bethlehem, Rau PC and Easton, Porter PC; Philadelphia, James PC.

### 8. PLATYGYRIUM Bry. Eur

**Platygyrium repens** (Brid.) Bry. Eur. Common. Widespread.

SUBSTRATE: Bark and rotting logs.
HABITAT: All forest types. Ravines, wooded slopes and mountain tops. Logs, stumps and up to 5 feet on living trees. Elevation 100 to 2567 feet.
ASSOCIATES: *Heterophyllium Haldanianum*, *Dicranella heteromalla* and various lichens.
REPRODUCTION: Capsules mature in September and remain closed in October. (22 specimens, 5 fruiting.)

COUNTIES: Bedford, Berks, Bucks, Chester, Columbia, Delaware, Lancaster, Lycoming, Monroe, Montour, Philadelphia, Somerset, Susquehanna, York. (14 counties). Published, not seen: McKean, Bradford, Burnett PC; Northampton, Rau PC.

## IX. HYLOCOMIACEAE

A. Paraphyllia lacking or rare . . . . . . . . . . . . . . . . . . . . B.
A. Paraphyllia abundant . . . . . . . . . . . . . . . . . 3. *Hylocomium.*
  B. Leaf secund and rugose . . . . . . . . . . . . . . . 1. *Rhytidium.*
  B. Leaf spreading to squarrose, often plicate but not rugose 2. *Rhytidiadelphus.*

### 1. RHYTIDIUM (Sull.) Kindb.

**Rhytidium rugosum** (Hedw.) Kindb. Rare. Northern species, confined to "cool" area.

SUBSTRATE: Soil and rock surface in high dry cliffs.
COUNTIES: Bradford, Towanda, Barbour 6; Franklin, Mercersburg, Porter (A); Lehigh, Rau (A); Northampton, Easton, Wolle and Porter 1868 (A). Published, not seen: Bucks, Nockamixon, Small PC; Huntingdon, Porter PC; Lancaster, Porter PC.

### 2. RHYTIDIADELPHUS (Lindb.) Warnst.

A. Leaf smooth beneath, slenderly acuminate . . . . . . . . . . . *squarrose.*
A. Leaf spinose-papillose beneath, shortly acuminate . . . . . . . . . *triquetrus.*

**Rhytidiadelphus squarrose** (Hedw.) Warnst. Rare. "Cool" mountainous area. On logs, soil and rocks in cool shady places.
COUNTIES: Northampton, Rau (A); Pike, Wolle 8/72. Published, not seen: Cambria, Cresson, Lesquereux PC.

**Rhytidiadelphus triquetrus** (Hedw.) Warnst. Not common. Northern species confined to eastern hemlock formation. On moist soil in shaded spots.
COUNTIES: Bucks, Lancaster, Lehigh, Lycoming, McKean, Monroe, Montgomery, Northampton, Sullivan. (9 counties). Published, not seen: Cambria, Porter PC; Carbon, Rau PC; Chester, James PC; Delaware, James PC; Elk, McMinn PC; Luzerne, Small PC; Philadelphia, Fairmount Park, James PC; Pike, Rau PC.

### 3. HYLOCOMIUM Bry. Eur.

A. Stems closely and regularly bi-tri-pinnate . . . . . . . . . . . *splendens.*
A. Stems branching irregularly, or irregularly pinnate . . . . . . . . . . B.
  B. Stem leaves decurrent and coarsely toothed at base . . . . . *umbratum.*
  B. Stem leaves rounded-cordate at base and finely toothed . . . . *brevirostre.*

**Hylocomium brevirostre** (Beauv.) Bry. Eur. Not common. A northern species found in the eastern hemlock formation, principally in the "cool" area of the state.
SUBSTRATE: On decaying logs and humus covered rock surfaces.
HABITAT: Eastern hemlock forest. Swampy areas. Elevation 150 to 1600 feet.
ASSOCIATES: *Hypnum crista-castrensis* and *Hylocomium splendens.* (10 specimens.)
COUNTIES: Elk, Lehigh, McKean, Monroe, Philadelphia, Pike, Sullivan. (7 counties). Published, not seen: Blair, Porter PC; Cambria, James PC; Delaware, Smith TM; Lancaster, Martic Forge, Porter PC and Tucquan Creek, Eby 5/00 SMS; Northampton, Rau PC.

**Hylocomium splendens** (Hedw.) Bry. Eur. Fairly common. Northern species occurring in eastern hemlock forest, chiefly the "cool" region of the state.
SUBSTRATE: Decaying logs and hummocks of humus in wet swampy areas.
HABITAT: Eastern hemlock forest. Elevation 300 to 1700 feet.

ASSOCIATES: *Hypnum crista-castrensis, Hylocomium brevirostre, Thuidium delicatulum, Sphagnum* spp. (8 specimens.)
COUNTIES: Bucks, Clinton, McKean, Monroe, Northampton, Potter, Sullivan. (7 counties). Published, not seen: Blair, Porter PC; Carbon, Rau PC; Elk, McMinn PC; Lancaster, Martic Forge, Porter PC and Tucquan Creek, Eby 6/92 SMS; Luzerne, Pond Hill, Small PC; Philadelphia, Wissahickon, James PC; Pike, Rau PC.

**Hylocomium umbratum** (Hedw.) Bry. Eur. Rare. A northern species, same range in Pennsylvania as the two preceding species. Old logs and humus in wet shaded areas.
COUNTIES: McKean, Marilla Brook, Burnett 4/21/97 (A); Philadelphia, Upper Wissahickon, Krout 8/5/08.

## X. BRYACEAE

A. Leaf linear-lanceolate . . . . . . . . . . . . . . . . . . . 1. *Leptobryum.*
A. Leaf ovate to lanceolate . . . . . . . . . . . . . . . . . . . . . B.
  B. Leaf-cells at least 4 times as long as wide . . . . . . . . . . . 2. *Pohlia.*
  B. Leaf-cells less than 4 times as long as wide . . . . . . . . . . . C.
C. Leaves in compact rosettes . . . . . . . . . . . . . . 4. *Rhodobryum.*
C. Leaves not in compact rosettes . . . . . . . . . . . . . . . 3. *Bryum.*

### 1. LEPTOBRYUM (Bry. Eur.) Schimp.

**Leptobryum pyriforme** (Hedw.) Schimp. Not common. On soil. Widespread, of cosmopolitan distribution.
COUNTIES: Cambria, McKean, Monroe, Northampton, Philadelphia. (5 counties). Published, not seen: Chester, New Garden, Michener PC; Lancaster, Muhlenberg PC and Porter PC.

### 2. POHLIA Hedw. (Webera Hedw.)

A. Gametophyte with a distinct metallic lustre . . . . . . . . . . . . *cruda.*
A. Gametophyte without such a lustre . . . . . . . . . . . . . . . . . B.
  B. Gametophyte of a whitish-green color, with somewhat the appearance of the genus, *Philonotis* . . . . . . . . . . . . . . . . *Wahlenbergii.*
  B. Gametophyte ordinary green color . . . . . . . . . . . . . . . C.
C. Capsule about twice as long as wide . . . . . . . . . . . . . . . . *nutans.*
C. Capsule often as wide as long . . . . . . . . . . . . . . . . . *pulchella.*

**Pohlia cruda** (Hedw.) Lindb. Rare. A northern species. On moist rocks and soil, in shaded situations.
COUNTIES: Lancaster, Conestoga, Porter 5/5/64 (A); Northampton, Easton, Porter 4/28/62 (A); Bushkill Gap, Wolle 6/74 and Bethlehem, Rau (A). Published, not seen: Bucks, Narrowsville, Porter PC; Lehigh, Rau PC.

**Pohlia nutans** (Hedw.) Lindb. Very common. Widespread.
SUBSTRATE: Soil, rocks and humus, rotting wood and cinders. pH4 to 6.
HABITAT: All forest types. Ravines, road banks, shale bluffs, mountain tops, bases of trees, crevices in rocks, and city streets. In sun and shade. Elevation 100 to 2200 feet.
ASSOCIATES: Usually with *Dicranella heteromalla, Ceratodon purpureus* and species of *Cladonia.* Also with many other species of mosses.
REPRODUCTION: Archegonia and antheridia mature in April. Young sporophytes appear in November and December. Capsules are mature and shedding spores by July and August. (80 specimens examined, 46 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Carbon, Chester, Clinton, Columbia, Delaware, Franklin, Fulton, Lackawanna, Lancaster, Lehigh, Lycoming, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Schuylkill, Snyder,

Somerset, Sullivan, Susquehanna, Tioga, Wayne, York. (30 counties). Published, not seen: Cambria, Cresson J; Center, Scotia and Tussey's Mountain, J; McKean, Burnett PC; Montour, Montour Mountain J.

**Pohlia pulchella** (Hedw.) Lindb. Not common. Widespread.

SUBSTRATE: Soil.
HABITAT: Wooded roadsides, clay banks and stream banks. Elevation 100 to 800 feet.
REPRODUCTION: Capsules mature in May and June. (10 specimens, 6 fruiting.)
COUNTIES: Adams, Carbon, Delaware, Huntingdon, Lehigh, Monroe, Northampton, Philadelphia. (8 counties). Published, not seen: Bucks, James PC; Chester, James PC; Lancaster, Muhlenberg PC and Bartsville, Jackson 11/16 SMS.

**Pohlia Wahlenbergii** (Web. & Mohr.) Andrews. Fairly common. Widespread.

SUBSTRATE: Soil.
HABITAT: Woodlands. Stream banks, edge of ponds, road banks and ditches and wet cliffs. (20 specimens.)
COUNTIES: Bucks, Chester, Columbia, Dauphin, Elk, Lancaster, Lehigh, McKean, Monroe, Montgomery, Montour, Northampton, Philadelphia. (13 counties). Published, not seen: Delaware, Smith TM.

### 3. BRYUM (L.) Hedw

A. Gametophyte usually whitish or silvery . . . . . . . . . . . *argenteum.*
A. Gametophyte some shade of green, brown or red . . . . . . . . . . B.
B. Costa long excurrent . . . . . . . . . . . . . . . . . . . . . C.
B. Costa short excurrent or percurrent . . . . . . . . . . . . . . . D.
C. Leaf-cells usually less than 1½ times as long as wide; leaf-border usually inconspicuous . . . . . . . . . . . . . . . . . . . . . . . *capillare.*
C. Leaf-cells usually at least 2 times as long as wide; leaf-border usually conspicuous proximally . . . . . . . . . . . . . . . . . . *caespiticium.*
D. Leaf-cells usually less than 1½ times as long as wide; border usually conspicuous . . . . . . . . . . . . . . . . . . . . . . *capillare.*
D. Leaf-cells usually twice as long as wide, border various . . . . . . E.
E. Capsule purple-red at maturity, rounded at base . . . . . . . . . *bicolor.*
E. Capsule not usually brilliant at maturity, tapering toward base . . . . . F.
F. Gametophyte dioicous . . . . . . . . . . . . . . . *pseudotriquetrum.*
F. Gametophyte synoicous . . . . . . . . . . . . . . . . . . *cuspidatum.*

**Bryum argenteum** (L.) Hedw. Common. Widespread.

SUBSTRATE: Soil, slag, mortar of walls and rock. (Conglomerate and limestone.) pH8.
HABITAT: Open woods and exposed situations. Stone work, boulders roadsides and sidewalks. Elevation 100 to 640 feet.
REPRODUCTION: Capsules closed and immature in October and November. Opening from December to February. (38 specimens, 11 fruiting.)
COUNTIES: Adams, Berks, Bucks, Delaware, Franklin, Lancaster, Lehigh, McKean, Monroe, Montgomery, Montour, Northampton, Philadelphia. (13 counties). Published, not seen: Chester, Darlington TM; Huntingdon, Union Furnace J.

**Bryum bicolor** Dicks. Rare. Widespread.

COUNTIES: Beaver, James (A); Northampton, Easton, James (A); Philadelphia, James (A); York, James (A).

**Bryum caespiticium** (L.) Hedw. Common. Widespread.

SUBSTRATE: Soil, ashes, cinders, slag and mortar. pH7 to 8.
HABITAT: Edge of woods, meadows and exposed situations. Base of cliffs, river shores, railroad embankments, dumps and walls. Elevation 100 to 1300 feet.

REPRODUCTION: Antheridia mature in April. Capsules mature and open in May and June. (25 specimens, 14 fruiting.)
COUNTIES: Adams, Berks, Bucks, Cambria, Chester, Delaware, Franklin, Lancaster, Lehigh, McKean, Monroe, Northampton, Philadelphia, Schuylkill, Wayne. (15 counties). Published, not seen: Center, Scotia J; Clinton, Lock Haven J; Huntingdon, Birmingham J; Montgomery, Melrose, Long 551 TM.

**Bryum capillare** (L.) Hedw. Fairly common. Widespread.
SUBSTRATE: Rocks and humus accumulation.
HABITAT: All forest types. On boulders and in ravines. Elevation 100 to 1300 feet.
COUNTIES: Bucks, Cambria, Chester, Dauphin, Lycoming, Monroe, Philadelphia. (7 counties). Published, not seen: Carbon, Mauch Chunk, James PC; Delaware, Smith TM; McKean, Burnett PC; Northampton, Porter PC; York, Wrightsville, Small PC.

**Bryum cuspidatum** (Bry. Eur.) Schimp. Fairly common. Widespread.
SUBSTRATE: Soil, cinders, alluvium and rock surface (limestone). pH7.
HABITAT: Hardwood forests. Shaded rocks, bridge masonry and railroad embankments. Elevation 150 to 1100 feet.
ASSOCIATES: *Funaria hygrometrica.*
REPRODUCTION: Anthericia and archegonia present in May. Capsules mature in June and July. (13 specimens, 9 fruiting.)
COUNTIES: Bedford, Bucks, Center, Clearfield, Franklin, Lancaster, Lycoming, Monroe, Northampton, Philadelphia, Somerset. (11 counties). Published, not seen: Cambria, James PC; Delaware, Glenolden, Krout 5/25/11 SMS; McKean, Bradford, Burnett J.

**Bryum pseudotriquetrum** (Hedw.) Schwaegr. Fairly common. Widespread.
SUBSTRATE: Wet soil and humus covered rocks.
HABITAT: All forest types. Stream banks, ravines, wet cliffs, and roadside ditches. Elevation 200 to 1520 feet.
REPRODUCTION: Antheridia and archegonia mature in early May. Capsules open and shedding spores from June to August. (21 specimens, 6 fruiting.)
COUNTIES: Bradford, Bucks, Cambria, Columbia, Delaware, Elk, Franklin, Lancaster, Lehigh, McKean, Monroe, Northampton, Venango, York. (14 counties). Published, not seen: Center, Scotia J.

### 4. RHODOBRYUM (Schimp.) Hampe

**Rhodobryum roseum** (Bry. Eur.) Limpr. Fairly common. All physiographic provinces in Pennsylvania.
SUBSTRATE: Soil, and rock surface. Preference for conglomerate and limestone. pH7–8.
HABITAT: Mixed hardwoods and hemlock-hardwoods along stream banks, on pond shores and in swampy areas. Elevation 50 to 2000 feet.
ASSOCIATES: Frequently overgrown by *Mnium affine* and *M. punctatum.*
REPRODUCTION: Archegonia open in October collections. Blooming period reported as September by Towle (1908). Sporophytes almost mature in September, but do not open and shed spores until March or April. (42 specimens examined, 8 fruiting.)
COUNTIES: Berks, Blair, Bradford, Bucks, Center, Chester, Clinton, Delaware, Franklin, Huntingdon, Lancaster, Lehigh, Luzerne, McKean, Monroe, Northampton, Philadelphia, Potter, Schuylkill, Sullivan. (20 counties). Published, not seen: Pike, Garber PC.

## XI. MNIACEAE

### Mnium Hedw.

- A. Leaves not bordered . . . . . . . . . . . . . . . . . . . . . . . B.
- A. Leaves bordered . . . . . . . . . . . . . . . . . . . . . . . . C.
  - B. Large plants, leaves entire or only slightly serrate; leaf cells twice as long as broad . . . . . . . . . . . . . . . . . . . . . . *cinclidioides.*
  - B. Small plants, leaves usually serrate; leaf cells isodiametric . . . . . *stellare.*
- C. Leaves entire . . . . . . . . . . . . . . . . . . . . . . . . D.
- C. Leaves serrate, single teeth . . . . . . . . . . . . . . . . . . . E.
- C. Leaves serrate, teeth in pairs . . . . . . . . . . . . . . . . . . I.
  - D. Small plants, leaves usually costate to apex . . . . . . . *punctatum.*
  - D. Large plants, leaf margins thickened, of 2–4 layers, rarely fruiting *punctatum* var. *elatum.*
- E. Leaves serrate to base or nearly so, capsules clustered . . . . . . . . F.
- E. Leaves serrate in the upper ½ or ⅔ only . . . . . . . . . . . . . H.
  - F. Teeth of margins very short, operculum strongly beaked . . . *longirostrum.*
  - F. Teeth of margins generally 2–5 cells; operculum mammillate or apiculate G.
- G. Dioiceous; many marginal teeth of more than 2 cells . . . . . . . . . *affine.*
- G. Synoiceous; marginal teeth shorter, few of more than 2 cells . . . . *medium.*
  - H. Capsules clustered, leaves little shriveled in drying, not stoloniferous *Drummondii.*
  - H. Capsules single, leaves strongly shriveled when dry, stoloniferous *cuspidatum.*
- I. Leaves long and narrow, costa vanishing below apex . . . . . . . *hornum.*
- I. Leaves wider, costa reaching apex in upper leaves at least . . . . . . . J.
  - J. Costa toothed dorsally, cells not collenchymatous . . . . *orthorhynchum.*
  - J. Costa not toothed dorsally, cells rounded and collenchymatous . . *serratum.*

**Mnium affine** Bland. Abundant. In all the physiographic provinces. Varieties *rugicum* and *ciliata* are included under the species. Examination of many specimens clearly show both types of leaf variations on the same plant.

SUBSTRATE: Clay and sandy soil, humus accumulated on rock surfaces and rotten wood. pH4 to 7. (One record of pH8.)

HABITAT: All forest types occurring within the state. More frequent in stream bottoms and the moister shadier habitats. Occasionally in drier situations on slopes and bluffs. From 100 to 2200 feet.

ASSOCIATES: Most frequently with species of *Thuidium*, *Hypnum*, and other species of *Mnium*. Less often with *Climacium* and *Dicranum*.

REPRODUCTION: Mature archegonia were found in plants collected in August. An October collection contained developing archegonia which were twice their mature length. In other October and November specimens the archegonia were open and many had become brown and shriveled. Mature antheridia also were found in August. By late September and October they were open and empty. The capsules mature by April and are shedding spores. Empty capsules remain attached to the plants from May to July. (136 specimens examined, 11 fruiting.)

COUNTIES: Adams, Bedford, Berks, Blair, Bradford, Bucks, Cambria, Carbon, Center, Chester, Clearfield, Columbia, Cumberland, Delaware, Elk, Franklin, Fulton, Juniata, Lancaster, Lawrence, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Mifflin, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango, Warren, York. (44 counties.)

**Mnium cinclidioides** (Blyth.) Huebener. Rare. Mountains of the northern part of the state. A northern species that occurs in glaciated areas.

SUBSTRATE: Decaying logs and humus.
HABITAT: Swampy woods and sphagnum bogs. Elevation 1600 feet.
ASSOCIATES: With *Mnium hornum.*
REPRODUCTION: Capsules green and closed but well formed on April 30, 1945, in Monroe county collection. (6 specimens.)
COUNTIES: Carbon, Hazelton, Wolle; Luzerne, Glen Summit Spring, Ruth (A); McKean, West Branch Swamp (A & NY); Monroe, Pocono Lake Preserve, Harper 1642 (A & P). (4 counties.)

**Mnium cuspidatum** Hedw. Abundant. In all physiographic provinces.

SUBSTRATE: Soil, rotting wood and humus on rock surfaces. pH4 to 8, most samples at 6 and 7.
HABITAT: All forest types of the state. In drier situations generally than *M. affine*, although it has been collected along stream banks and in swampy thickets. Elevation 50 to 2567 feet.
ASSOCIATES: Growing with other species of *Mnium* and species of *Hypnum*, *Atrichum* and *Plagiothecium.*
REPRODUCTION: Antheridia and archegonia present and mature in May and early June. Mature capsules are present in April and many are open and shedding spores. This continues into May, by June the capsules are empty and remain on the plants until August. Young sporophytes are sometimes visible as early as August, but the majority appear in September and October. In measuring the length of many specimens, a great variation in the rate of growth was observed. By March the setae average 2 cm. long. (205 specimens examined, 76 fruiting.)
COUNTIES: Adams, Bedford, Berks, Blair, Bradford, Bucks, Carbon, Center, Chester, Columbia, Cumberland, Dauphin, Delaware, Franklin, Huntingdon, Juniata, Lancaster, Lehigh, Luzerne, McKean, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Schuylkill, Somerset, Sullivan, Susquehanna, Tioga, Venango, Wayne, York. (37 counties.) Published, not seen: Clearfield, DuBois, Moldenke 4113. (A specimen marked *M. spinulosum* from Luzerne County, Glen Summit Springs, Ruth 6/3/05 upon examination proves to be *M. cuspidatum.*)

**Mnium Drummondii** Bry. Eur. Rare. More frequent in the northern tier of states. On soil. One record for Pennsylvania. Lycoming county, McMinn, April 1869. James Herbarium (A. & C.).

**Mnium hornum** Hedw. Fairly common in Coastal Plain, Piedmont, Ridge and Valley Provinces. A few collections were made west of the Allegheny Mountain front along tributaries of the east flowing rivers. Dr. O. E. Jennings has collected it in 12 counties along the Allegheny Plateau from the southern boundary of the state to the northern boundary.

SUBSTRATE: Soil, humus, rotting wood and rock surfaces.
HABITAT: Prefers the dense shade and moisture of hemlock ravines and rhododendron thickets. Occasionally in dense stands of hardwoods along stream valleys and lake shores. Elevation 150 to 2100 feet.
ASSOCIATES: *Atrichum crispum*, *Mnium cinclidioides*, *M. punctatum* and *Tetraphis pellucida.*
REPRODUCTION: Mature capsules present in June and July. (35 specimens examined, 5 fruiting.)
COUNTIES: Bedford, Carbon, Center, Chester, Clinton, Dauphin, Delaware, Lancaster, Lehigh, Lycoming, McKean, Mifflin, Monroe, Northampton, Philadelphia, Pike, Schuylkill, Sullivan, Union, York. (20 counties). Published, not seen: Cambria, PC; 12 counties along Allegheny Plateau, J.

**Mnium longirostrum** Brid. Rare. World wide in its distribution, but better represented in southern part of North America. Moist rocks, humus and soil in the woods.

COUNTIES: Bucks, Narrowsville, Porter & James (A & C); Lancaster, Welsh Mountains and West Branch of Octoraro Creek, Small (NY); Lebanon, Mt. Gretna 2650; McKean, Corydon 4445 and Quintuple, Burnett 901a (NY); Pike, Rau 7/72 (NY); York, Emigsville, 3434. (6 counties). Published, not seen: Cambria, James, PC; Lycoming, McMinn, PC.

**Mnium medium** Bry. Eur. Rare. A northern species.

SUBSTRATE: Soil and leaf mold.
HABITAT: Shaded ravines and stream banks.
COUNTIES: Berks, Jacksonwald, Wilkens 232; McKean, Marilla Brook, Gates Hollow, Quintuple, Lewis Run and West Branch Swamp, Burnett (NY); Monroe, James (A & C). (3 counties.)

(*Mnium lycopodioides* (Hook.) Schwaegr. A species of northern distribution. Reported from Pennsylvania but all specimens seen are referable to *M. orthorhynchum*.)

**Mnium orthorhynchum** Brid. Rare. Probably overlooked. Confined chiefly to mountainous districts.

SUBSTRATE: Rocks and soil. Shows preference for calcareous substrate.
HABITAT: In hemlock and mixed hemlock-hardwood forests in cool moist ravines. On rock faces and stream banks. Elevation 900 to 1400 feet.
REPRODUCTION: Capsules mature and beginning to open in May. (8 specimens seen, 4 fruiting.)
COUNTIES: Blair, James (A); Bucks, Narrowsville, Porter 5/23/68 (A); Monroe, Pocono, James (C. & A.); Susquehanna, Rushville, 3928; Tioga, Niles Valley 4098, 4081. (5 counties.)

**Mnium punctatum** Hedw. Common. All physiographic provinces where the proper habitat occurs.

SUBSTRATE: Moist humus and soil, wet rotting wood and moist rock surfaces. pH4 to 7.
HABITAT: In hemlock, mixed hemlock and hardwood forests and rhododendron thickets. Along stream banks and in swampy woods. Elevation 150 to 2000 feet.
ASSOCIATES: *Mnium affine*, *M. cuspidatum*, *Hypnum* spp., *Leucobryum glaucum*, *Sphagnum* spp., *Marchantia* spp., and *Pallavacinia* spp.
REPRODUCTION: Immature sporophytes found as early as September and become 2 cm. long by November. Capsules are mature and open in April and May. (52 specimens examined, 10 fruiting.)
COUNTIES: Berks, Blair, Bucks, Cameron, Center, Chester, Clinton, Cumberland, Franklin, Huntingdon, Lancaster, Lehigh, McKean, Mifflin, Monroe, Northampton, Perry, Philadelphia, Pike, Potter, Schuylkill, Snyder, Sullivan, Susquehanna, Tioga, Venango, Warren. (27 counties). Published, not seen: Elk, McMinn, PC; Pike, Eich's Pond, Moldenke 3337.

**Mnium punctatum** Hedw., var. **elatum** Schimp. Distinguished from the species by its larger size and the thicker margins to the leaf. Separation at times is an arbitrary matter. Same substrate and habitat preference as the species. Elevation 760 to 1700 feet.

REPRODUCTION: Capsules were present and open on a specimen collected in February. Empty antheridia were found on a plant collected in October. (14 specimens, 1 fruiting.)
COUNTIES: Berks, Lancaster, Lycoming, McKean, Monroe, Northampton, Potter, Schuylkill, Snyder, Sullivan, Union. (11 counties.)

**Mnium serratum** (Schrad.) Schw. Rare. Local in its distribution. Widely distributed in the northern part of the continent.

SUBSTRATE: Wet rocks and soil.
HABITAT: Wooded stream banks and dark ravines.

REPRODUCTION: Sporophytes 1 cm. long on a specimen collected in November. (10 specimens examined, 1 fruiting.)
COUNTIES: Blair, Bald Eagle Ridge, Porter (C. & A.); Bucks, Nockamixon, Rau 7/1/74 (NY); Lancaster, Martic Forge, James (C) & Porter (A); S. of Lancaster, Tees 653 (A); Monroe, Analomink Creek, James (C. & A.); Delaware Water Gap, Garber, 11/6/68 (A); Northampton, Martins Creek, Schaeffer; Philadelphia, Wissahickon. (6 counties). Published, not seen: McKean, Hawkins and Quintuple 8/2/95, Burnett, J.

**Mnium stellare** Hedw. Rare. Northern species extending south to Virginia. Principally in the Ridge and Valley and Mountain Provinces.

SUBSTRATE: Soil and rocks. pH 4.
HABITAT: Hardwood and hemlock forests. Stream banks, swampy woods and cool ravines. Elevation 100 to 900 feet.
ASSOCIATES: *Mnium affine* and *M. orthorhynchum.*
REPRODUCTION: Archegonia present, open and brown in color, October 12th. All other material examined was sterile. (15 specimens examined.)
COUNTIES: Berks, Friedensburg, Wilkens 358; Bucks, Rieglesville, Tees 381 (A), Narrowsville, James (C); Delaware, Strath-Haven, Krout 9/15/06; Fayette, Ohio Pyle, Browne (C); Juniata, Cross Keys, 3480; McKean, Burnett 9/9/94. (A); Monroe, Analomink Creek, James 11/63 (A); Northampton, Coffeetown and Martins Creek, Schaeffer, Lime Ridge, Rau 8/73 (A); Philadelphia, Wissahickon, James (C & A); Somerset, Sipesville, Pohl & Lisi; Susquehanna, Rushville, 3928a. (11 counties). Published, not seen: Chester, James, PC.

## XII. AULACOMNIACEAE

### AULACOMNIUM Schwaegr.

A. Leaf-apex broad, strongly serrate . . . . . . . . . . . . . *heterostichum.*
A. Leaf-apex acute, serrulate near the tip; propagula usually present . . . *palustre.*

**Aulacomnium heterostichum** (Hedw.) Bry. Eur. Fairly common. Occurs in all the physiographic provinces of the state.

SUBSTRATE: Soil and humus covered rock surfaces.
HABITAT: Preference for hardwood and hardwood-pine forests. Occasionally under hemlock-hardwood. Found growing near the bottom of wooded north-facing slopes, along stream banks, road banks and shaded moss covered rock ledges. Elevation 150 to 900 feet.
ASSOCIATES: Grows very frequently with *Bartramia pomiformis* as noted by Dr. W. C. Steere, Bryologist 36:14–15. Also with *Mnium*, *Thuidium* and *Cladonia.*
REPRODUCTION: Sporophytes 1 cm. long in November. Mature capsules found open and shedding spores in April. Empty capsules remain on the plants until September. (44 specimens examined, 21 fruiting.)
Type locality: Lancaster, Pennsylvania, Muhlenberg.
COUNTIES: Berks, Bucks, Delaware, Franklin, Fulton, Huntingdon, Lancaster, Lehigh, McKean, Monroe, Montgomery, Northampton, Perry, Philadelphia, Susquehanna. (15 counties). Published, not seen: Chester, James, PC; Lehigh, Rau, PC.

**Aulacomnium palustre** (Web. & Mohr.) Schwaegr. Uncommon. In all physiographic provinces of the state.

SUBSTRATE: In wet areas on humus, soil, rotting wood and rock surfaces. pH4.
HABITAT: Swampy woods and thickets, marshy old fields at base of grass and wooded creek banks. Elevation 50 to 1820 feet.
ASSOCIATES: In the shade of grass and cattails. Growing mixed with *Sphagnum* spp., *Leucobryum glaucum*, *Mnium affine*, *Polytrichum commune*, and *Helodium paludosus.*

REPRODUCTION: Propagula present in all material examined. Capsules rare, open in June. Young sporophytes 1 to 1.5 cm. long in March. (25 specimens examined, 4 fruiting.)
COUNTIES: Adams, Berks, Chester, Clearfield, Delaware, Elk, Franklin, Lebanon, Lehigh, Luzerne, McKean, Monroe, Northampton, Philadelphia, Sullivan. (15 counties). Published, not seen: Lancaster, Safe Harbor, PC; Snyder, Richfield, 7/17/08, J.

## XIII. BARTRAMIACEAE

A. Leaf lanceolate to linear-lanceolate . . . . . . . . . . . 1. *Bartramia.*
A. Leaf shorter, ovate-lanceolate . . . . . . . . . . . . . . 2. *Philonotis.*

### 1. BARTRAMIA Hedw.

A. Leaves linear, from a sheathing scarious base . . . . . . . . . *ithyphylla.*
A. Leaves linear, without a sheathing base . . . . . . . . . . . *pomiformis.*

**Bartramia ithyphylla** Brid. Rare. No recent records.
SUBSTRATE: Soil.
REPRODUCTION: Immature capsules in May. Capsules open in July material.
COUNTIES: Bucks, Narrowsville, James. July 1871 (A); Fayette, Knipe, May 1871, James Herb. (A).

**Bartramia pomiformis** (L.) Hedw. Rather common. Widespread.
SUBSTRATE: Soil, shaley talus slopes, rock surfaces (Shale and sandstone).
HABITAT: More commonly found in mixed hardwoods and hardwood-pine. Does occur under hemlock and mixed hemlock-hardwoods. Ravines, steep hillsides, roadbanks, north-facing slopes of shale bluffs and on serpentine barrens. Elevation 150 to 1400 feet.
ASSOCIATES: Very frequently with *Aulacomnium heterostichum.* Also *Thuidium delicatulum*, *Leucobryum glaucum* and *Plagiothecium* spp., *Buxbaumia aphylla* collected growing out of a clump of this moss.
REPRODUCTION: Mature antheridia and archegonia found present in June. Capsules are open and shedding spores in late April and early May. Old capsules persist on the plants until September. (48 specimens examined, 29 fruiting.)
COUNTIES: Berks, Bucks, Chester, Clinton, Columbia, Dauphin, Delaware, Franklin, Fulton, Huntingdon, Lancaster, Lehigh, Lycoming, McKean, Montgomery, Northampton, Perry, Philadelphia, Sullivan, Susquehanna, Tioga, York. (22 counties). Published, not seen: Elk, Dent's Run, 7/19/04 J.; Monroe, Porter, PC; Pike, Rau, PC.

### 2. PHILONOTIS Brid.

A. Perigonia gemmiform, often appearing lateral . . . . . . . . . . *longiseta.*
A. Perigonia discoid, terminal . . . . . . . . . . . . . . . . . . . . . . . B.
    B. Leaf-cells papillose only at upper end . . . . . . . . . . . . . C.
    B. Leaf-cells papillose at lower end, rarely at upper or both ends . . *fontana.*
C. Leaf-cells linear; leaves triangular-lanceolate to ovate-lanceolate . . *marchica.*
C. Leaf-cells oblong to oblong-linear, broader; leaves ovate-lanceolate *Muhlenbergii.*

(*Philonotis calcarea* (Bry. Eur.) Schimp. Excluded species. Not definitely known from North America. Published records: Huntingdon, Warrior's Ridge, Porter PC; Clinton, Renovo J.)

**Philonotis fontana** (Hedw.) Brid. Fairly common.
SUBSTRATE: Wet soil, logs and rocks.
HABITAT: Eastern hemlock forest. Around springs, ditches, dripping cliffs and falls. Elevation 100 to 2000 feet. (14 specimens.)

COUNTIES: Bucks, Delaware, Lycoming, McKean, Monroe, Northampton, Philadelphia, Susquehanna. (8 counties). Published, not seen: Center, Matternville Gap J; Chester, James PC; Clinton, Hyner Run J; Huntingdon, Huntingdon J; Lancaster, Muhlenberg TM.

**Philonotis fontana** (Hedw.) Brid., var. **falcata** Brid. Differs from the species in having all of the leaves falcate.

COUNTIES: Clearfield, Columbia, Susquehanna, Wayne. (4 counties). Published, not seen: Center, Matternville Gap, J.

**Philonotis longiseta** (Rich.) E. G. Britton. Rare. Eastern Pennsylvania.

COUNTIES: Bucks, Nockamixon, Wolle 1/74 (A); Lehigh, Rockdale, Wolle 1/74 (A); Monroe Delaware Water Gap, Schweinitz (A).

**Philonotis marchica** (Willd.) Brid. Very rare.

COUNTIES: Lawrence, Slippery Rock, Lesquereux 6/65 (A); Lehigh, Rau (A).

**Philonotis Muhlenbergii** (Schwaegr.) Brid. Not common. Ravines, wet springy and grassy places.

Type locality: Pennsylvania.
COUNTIES: Delaware, Tinicum Island, Krout 7/6/06; Northampton, Coffeetown, Schaeffer 4/26/47, Pot Rock in Delaware River, Easton, Porter 6/68 (A) and Bethlehem, Rau 5/74 (A); Philadelphia, James 4/57 (A). Published, not seen: Lancaster, Muhlenberg PC.

### XIV. TIMMIACEAE

#### TIMMIA Hedw.

**Timmia megapolitana** Hedw. Rare. Northern species.

COUNTIES: Lancaster, Porter (A); Northampton, Easton, Porter 1872 (A). Published, not seen: McKean, Burnett PC.

## ORDER VI. SPLACHNALES

A. Total length of gametophyte with attached sporophyte less than 1 mm. I. *Ephemeraceae.*
A. Gametophyte alone usually much more than 2 mm. high . . . . . . . . . B.
  B. Costa faint in the upper part of leaf; protonema persistent II. *Disceliaceae.*
  B. Costa strong, nearly percurrent to shortly excurrent . . . III. *Funariaceae.*

### I. EPHEMERACEAE

A. Capsules with rudimentary operculum; capsule-wall a single layer of cells in thickness . . . . . . . . . . . . . . . . . . . . . 1. *Nanomitrium.*
A. Capsules without operculum; capsule-wall two layers of cells in thickness 2. *Ephemerum.*

#### 1. NANOMITRIUM Lindb.

**Nanomitrium synoicum** (James) Lindb. Very rare.

Type locality: Camden, New Jersey and across the Delaware River near Philadelphia.
COUNTIES: Philadelphia, Moyamensing, James 5/68 (A) and below the Navy Yard, James 8/65 (A).

#### 2. EPHEMERUM Hampe.

A. Leaves ecostate . . . . . . . . . . . . . . . . . . . . . . . *serratum*
A. Leaves costate . . . . . . . . . . . . . . . . . . . . . . . B.

  B. Costa ending at apex or below, leaves serrate; stomata scattered over the whole capsule . . . . . . . . . . . . . . . . . . . . . *cohaerens.*
  B. Costa excurrent . . . . . . . . . . . . . . . . . . . . . . . . C.
C. Costa excurrent into a long spinulose awn-like acumination which constitutes the greater portion of the leaf above the capsule . . . . . . . *spinulosum.*
C. Leaves gradually long-acuminate, strongly serrate at apex . . . *crassinervium.*

**Ephemerum cohaerens** (Hedw.) Hampe. Rare. On moist clay and sandy soil. Old fields.

COUNTIES: Philadelphia, Moyamensing, James 4/66 (A). Published, not seen: Bucks, James PC; Lancaster PC; Northampton, Bethlehem, Wolle PC.

**Ephemerum crassinervium** (Schwaegr.) C. Mull. Rare. On moist soil, flood plains. Type locality: Probably Pennsylvania.

COUNTIES: Northampton, Easton, Porter, 11/7/68 (A); Philadelphia, Moyamensing, James 10/66 (A). Published, not seen: Chester, Darlington TM; Delaware, Smith, TM; Lehigh, Rau TM; Lancaster, Muhlenberg TM.

**Ephemerum serratum** (Hedw.) Hampe. Rare. On moist bare soil. Old fields.

COUNTIES: Bucks, James (A); Chester, Coventry, James 12/50 (A) and James 4/51 (A); Philadelphia, James, Musci Appal. Austin (A). Published, not seen: Lancaster, Muhlenberg TM.

**Ephemerum spinulosum** Schimp. No specimens seen.

Published records: Lehigh, Rau PC; Northampton, Bethlehem, Rau PC; Philadelphia, Moyamensing, James PC.

## II. DISCELIACEAE

### DISCELIUM Brid.

**Discelium nudum** (Dicks.) Brid. Rare. On bare clayey soil.

COUNTIES: Lehigh, Rau (A); Northampton, Bingen, Wolle 6/73, Bethlehem, Rau 3/94 and Bethlehem, Musci Appal. Austin (A).

## III. FUNARIACEAE

A. Capsule immersed . . . . . . . . . . . . . . . . . 1. *Aphanorrhegma.*
A. Capsule exserted . . . . . . . . . . . . . . . . . . . . . . . . B.
  B. Capsule symmetrical, urn-shaped . . . . . . . . . . 2. *Physcomitrium.*
  B. Capsule asymmetrical, elongated . . . . . . . . . . . . . 3. *Funaria.*

### 1. APHANORRHEGMA Sull.

A. Exothecial cells strongly collenchymatous, line of dehiscence clearly marked *serratum.*

A. Exothecial cells thin-walled, not collenchymatous; line of dehiscence not clearly marked as a rule . . . . . . . . . . . . . . . . . . . . *patens.*

**Aphanorrhegma patens** (Hedw.) Lindb. Rare. On damp clayey soil.

COUNTIES: Delaware, Strath-Haven, Krout 7/21/08. Published, not seen: Lancaster, Muhlenberg PC.

**Aphanorrhegma serratum** (Hook. & Wils.) Sull. Rare. On damp clayey soil. Serpentine barrens.

COUNTIES: Franklin, Mercersburg, Porter 8/52 (A); Lancaster, New Texas, Porter 2/94; Northampton, Bethlehem, Rau 1875 (A) and Easton, Porter 11/10/68 (A); Philadelphia, James 1860 (A). Published, not seen: Chester, James PC; Delaware, James PC; Lehigh, Rau PC; McKean, Burnett PC.

### 2. PHYSCOMITRIUM Brid.

A. Capsule immersed . . . . . . . . . . . . . . . . . . . . . *immersum.*
A. Capsule on long seta . . . . . . . . . . . . . . . . . . . *turbinatum.*

**Physcomitrium immersum** Sull. Not common. On damp soil, often along river banks.

COUNTIES: McKean, East Branch, Burnett 6/10/95 (A); Philadelphia, Moyamensing, James 10/68 (A) and banks of Delaware, Musci Appal. Austin (A). Published, not seen: Dauphin, Harrisburg, Small PC; Lancaster, Muhlenberg TM.

**Physcomitrium turbinatum** (Mx.) Brid. Very common. Widespread.

SUBSTRATE: Bare earth, cinders, rock surfaces and mortar. pH5 to 7.
HABITAT: Grassy open woods, gardens, and old fields. Stream banks, hillsides, lawns, flower borders, stone walls and pavements.
ASSOCIATES: *Ditrichum* spp., *Funaria hygrometrica*, *Trematodon* spp.
REPRODUCTION: Immature capsules appear in early March. Mature capsules, open and shedding spores in May and June. (44 specimens, 35 fruiting.)
COUNTIES: Adams, Berks, Bucks, Chester, Delaware, Franklin, Huntingdon, Lehigh, Montgomery, Northampton, Philadelphia, York. (12 counties). Published, not seen: Lancaster, Muhlenberg PC and Small PC; McKean, Bradford, Burnett PC; Somerset, Ursina J.

### 3. FUNARIA Hedw.

A. Leaves long acuminate, costa excurrent in some leaves of each plant . . . . B.
A. Leaves short acuminate, costa percurrent, sometimes very shortly excurrent *hygrometrica.*
  B. Capsules curved and unsymmetric but scarcely cernuous; annulus lacking *Muhlenbergii.*
  B. Capsules plainly cernuous, annulus large . . . . . . . . . . . *flavicans.*

**Funaria flavicans** Mx. Uncommon. More southern in general distribution. Widespread.

SUBSTRATE: Soil and cinders.
HABITAT: Open woods and waste places.
ASSOCIATES: *Funaria hygrometrica.*
COUNTIES: Adams, Arendtsville 5779; Delaware, Swarthmore, Wherry 4/16/46; Lehigh, Allentown, Pretz 13631 (A); Northampton, Weygat, James 4/65 (A); Philadelphia, Byberry, James (A), Pennypack, Krout 8/25/08. Published, not seen: Lancaster, Muhlenberg and Small, PC.

**Funaria hygrometrica** Hedw. Common. Widespread.

SUBSTRATE: Soil, ashes, cinders, rotting wood and humus covered rocks. pH6 to 8.
HABITAT: Woods, old fields and waste places. Gardens, roadsides, fields, dumps, stonewalls, city streets, curbings, and ditches. Elevation 100 to 1680 feet.
ASSOCIATES: *Funaria flavicans*, *Bryum* spp., *Trematodon longicollis*, and *Hypnum* spp.
REPRODUCTION: Young sporophytes 1 to 1.5 cm. long in March. Mature capsules open in late May and early June. (59 specimens, 33 fruiting.)
COUNTIES: Adams, Berks, Bucks, Chester, Delaware, Elk, Huntingdon, Lancaster, Lehigh, Luzerne, McKean, Monroe, Montgomery, Northampton, Philadelphia, Potter, Somerset, Sullivan, York. (19 counties). Published, not seen: Cambria, St. Lawrence J; Carbon, Rau PC.

**Funaria Muhlenbergii** Turn. Rare. No specimens seen.

Type locality: Pennsylvania, Muhlenberg.
Published records: Bucks, Narrowsville PC; Lancaster, Muhlenberg PC.

## ORDER VII, POLYTRICHALES

A. Terminal gemmae surrounded by a leafy cup present in the gametophytes; capsules with 4 peristome teeth . . . . . . . . . . I. *Tetraphidaceae.*
A. Gemmae not present; capsule with 16 or more teeth . . . . . . . . . . B.
  B. Leaves of gametophytes with lamellae; capsules on long setae, symmetric II. *Polytrichaceae.*
  B. Leaves of gametophyte without lamellae; capsules large not symmetric, immersed or on medium length setae . . . . . . . . . . . . . . C.
C. Annual mosses. Gametophyte rudimentary, capsules oblique on rough setae III. *Buxbaumiaceae.*
C. Perennial mosses. Gametophyte developed, capsules immersed in perichaetium . . . . . . . . . . . . . . . . . . . . . . . IV. *Diphysciaceae.*

### I. TETRAPHIDACEAE

#### Tetraphis Hedw.

**Tetraphis pellucida** Hedw. Fairly common. In all the physiographic provinces, wherever the proper habitat occurs.

SUBSTRATE: Almost exclusively on rotten wood and humus. It has been collected growing on soil and conglomerate rock. pH4.

HABITAT: Under dense growth of hardwoods and conifers, usually along stream banks, in cool damp ravines, rhododendron thickets or swamps. It has been found at the base of stumps, trees, old logs and boulders, frequently under some larger species of moss. At elevations from 150 to 1940 feet.

ASSOCIATES: Prefers to grow under larger mosses such as *Mnium hornum*, *Dicranella heteromalla*, *Dicranodontium denudatum*, *Thuidium delicatulum* and *Hypnum* spp.

REPRODUCTION: Commonly reproduces by brood bodies called gemmae. These have been found present in material collected from July to January. Mature capsules shedding spores were found in May and June. The empty capsules remain on the plants until October. Young sporophytes 1 cm. long were collected on September 8th. (27 specimens examined, 15 fruiting.)

COUNTIES: Bedford, Berks, Carbon, Delaware, Elk, Lehigh, McKean, Monroe, Northampton, Philadelphia, Potter, Sulivan, Union, Warren, York. (15 counties.) Certainly more widespread but overlooked because of its size and habits of growth. Published, not seen: Bucks, Brownsburg, Tees 344, TM; Center, Scotia, Jennings 9/22/09, J; Chester, James, PC; Franklin, Small, PC; Lancaster, Small, PC; Pike, Rau, PC and Moldenke 3339.

### II. POLYTRICHACEAE

A. Calyptra not densely hairy: capsules cylindrical . . . . . . . . 1. *Atrichum.*
A. Calyptra densely hairy: capsule angular or cylindrical . . . . . . . . . B.
  B. Capsule cylindrical: gametophytes small . . . . . . . . 2. *Pogonatum.*
  B. Capsule longitudinally ridged: large gametophytes . . . . 3. *Polytrichum.*

#### 1. Atrichum Beauv. (Catharinea Ehrh.)

A. Leaves ovate-elliptical or obovate: lamellae few and small or lacking . *crispum.*
A. Leaves lanceolate to ligulate: lamellae many and conspicuous . . . . . . B.
  B. Leaves papillose, costa and lamellae ¼ to ⅔ the width of the leaf at the middle . . . . . . . . . . . . . . . . . . . . . . . . *Macmillani.*
  B. Leaves not papillose . . . . . . . . . . . . . . . . . . . . C.
C. Costa and lamellae narrower than 1/5 of width of leaf at the middle *undulatum.*
C. Costa and lamellae ¼ to ⅔ the width of the leaf at the middle *angustatum.*

**Atrichum angustatum** (Brid.) Bry. Eur. The status of this species in North America is open to question. All material I have examined has proved to be *A. Macmillani.* Many specimens in herbaria are labelled *A. angustatum* but all have been worked over carefully and found to have papillae on the leaves. Dr. W. C. Steere has intimated to me that we have no true *A. angustatum* in this country. A thorough study of all available material is certainly essential to establish the true relationship of this species and *A. Macmillani.*

**Atrichum crispum** (James) Sull. Not common. More frequently found in the Coastal Plain and Piedmont, but occurs in the mountains and plateau region along the water courses.

SUBSTRATE: Soil. Sometimes on badly rotted wood. Within a pH range of 4 to 5.
HABITAT: In shade, principally in the hardwood forests, but occasionally under hemlock and pine. Usually considered a Coastal Plain species but found along the rivers and extending up into the mountains along their tributaries. Collected at elevations ranging from 50 to 1940 feet.
ASSOCIATES: Found growing with *Mnium affine*, *Pohlia nutans*, *Anthoceros* spp. and *Sphagnum* spp.
REPRODUCTION: Mature antheridia found in April. Immature sporophytes occur in material collected in September. Mature capsules are found in November. Empty capsules are still present in April. (34 specimens examined, 6 fruiting.)
COUNTIES: Berks, Bucks, Cambria, Chester, Clearfield, Clinton, Columbia, Dauphin, Delaware, Elk, Lancaster, Lycoming, McKean, Monroe, Montgomery, Northumberland, Philadelphia, York. (18 counties.)

**Atrichum Macmillani** (Holz) Frye. Common. More common than formerly supposed as many specimens in the Herbaria labelled as *A. angustatum* (Brid.) Bry. Eur. prove to be papillose upon examination.

SUBSTRATE: On a wide variety of soils. Occasionally on rock surface. The pH range is from 4 to 7, principally from 4 to 5.
HABITAT: In the drier portions of the mixed hardwood forests, but also under pine and hemlock. Collected from wooded hillsides, roadsides, sometimes in old fields and pastures. Less frequently along water courses. At elevations from 100 to 2200 feet.
ASSOCIATES: With *Thuidium delicatulum*, *Hypnum* spp., *Cladonia* spp. principally, but grows with a wide variety of mosses and lichens.
REPRODUCTION: Sporophytes first appear in July. Mature closed capsules were found late October through December. The capsules were open and spores were found in the January specimens. (129 specimens examined, 86 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Carbon, Center, Chester, Clinton, Columbia, Cumberland, Dauphin, Delaware, Franklin, Fulton Huntingdon Juniata, Lancaster, Lebanon, Lehigh, Lycoming, McKean, Mifflin, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Potter, Somerset, Sullivan, Susquehanna, Tioga, Warren, Wayne, York. (37 counties). Published, not seen: Bedford, Wills Mountain, near Hyndman, 10/9/04, J.

**Atrichum undulatum** (Hedw.) Beauv. Fairly common. Occurs in all the physiographic provinces of the State.

SUBSTRATE: On sandy and clayey soil. Rarer on rotten wood and exposed rock surfaces.
HABITAT: All types of woodland within the State. Found in the more moist situations such as lowlands along streams, swampy thickets, cool shaded ravines, drainage ditches along roads and marshy old fields and pastures. Collected at elevations from 100 to 2000 feet.
ASSOCIATES: Commonly with species of *Hypnum* and *Mnium*.
REPRODUCTION: The sporophytes are first visible in August. By September they are from 2 to 2.5 cm. long. Open capsules shedding spores were collected in January.

Spores were still present in capsules collected as late as the 25th of April. Empty capsules remain on the plants until September. (97 specimens examined, 20 in fruiting condition.)
COUNTIES: Adams, Berks, Bucks, Carbon, Chester, Columbia, Dauphin, Elk, Fayette, Franklin, Huntingdon, Juniata, Lancaster, Lehigh, McKean, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Sullivan, Susquehanna, Tioga, Venango, Warren, Wayne, Westmoreland, York. (32 counties). Published, not seen: Clinton, Hyner, 7/15/08 J.; Delaware, Smith, TM.

**Atrichum undulatum** (Hedw.) Beauv., var. **Selwynii** (Aust.) Frye. Distinguished from the species by the length of the lamellae, which are 6–13 cells high. Found on the same type of substrate and in identical habitats as the species. Elevations 550 to 1900 feet.

COUNTIES: Blair, Arch Spring, Proctor 4/19/47; Bradford, Ulster, 3994; Montour, White Hall 5026 and Exchange 5105; Tioga, Mansfield, 4066. (4 counties.)

### 2. POGONATUM Beauv.

A. Stems branching: plants dark green: capsules smooth, curved . . . . *alpinum.*
A. Stems simple: leaves few: protonema persistent, forming a green felt mass upon which the plants grow . . . . . . . . . . . . . . . . . . . . . . B.
  B Leaves lanceolate-subulate, serrate . . . . . . . . . . . *pensilvanicum.*
  B. Leaves lingulate, blunt, entire . . . . . . . . . . . . . *brachyphyllum.*

**Pogonatum alpinum** (Hedw.) Rohl. Rare. Occurs only on the Pocono plateau.
SUBSTRATE: Soil and rocks.
HABITAT: Woods and shady places. At higher elevations.
REPRODUCTION: Capsules mature and open in specimens collected in July and September. (7 specimens seen, 3 fruiting.)
COUNTIES: Monroe only, as follows: Canadensis, Porter and James (A); Buckhill Falls, Porter 9/10/69 (NY); Small & Britton 7/13–15/89 (NY); headwaters of Broadhead Creek, Porter 9/10/69 (A & NY). Published, not seen: Chester County in Chester Valley, James, PC.

**Pogonatum brachyphyllum** (Rich.) Beauv. Rare. Primarily a southern Coastal Plain species.
SUBSTRATE: Soil.
HABITAT: Bare soil in waste places and pine woods.
REPRODUCTION: Capsules found open in April.
COUNTIES: Chester, West Chester, F. Windle 4/3/06. (NY). Published, not seen: Fayette County, Connellsville, Moldenke 3563, det. by Lewis.

**Pogonatum pensilvanicum** (Hedw.) Paris. Common. Occurs in all the physiographic province of the state.
SUBSTRATE: Eroded clayey soil, gravelly and sandy soil less frequently. pH 4 to 6.
HABITAT: Mixed hardwood forests generally. Occurring usually on eroded road banks or recently deposited alluvium along streams. The densest stand seen was on alluvial clay deposited on the banks of a small stream 1¼ miles southwest of Exchange in Montour County. Elevations from 50 to 2100 feet.
ASSOCIATES: The protonema of this moss forms a rather dense tough cover over the soil, so that masses of it can be collected without crumbling of the clods. An important species in the succession on recently disturbed clayey soil. Its protonema may be the first cover on eroded banks, where it will be followed by *Dicranella heteromalla*, *Marchantia* spp. and *Atrichum Macmillani.* In other instances the lichen *Baeomyces roseus* had been the first to initiate growth, followed by *Pogonatum* and its associates with species of *Cladonia.*

REPRODUCTION: The earliest appearance of sporophytes in collected material was in July, when they averaged 5 to 10 mm. in length. In August some had reached the length of 2 cm. and by September the setae was 3 cm. long. Mature closed capsules were present in November and December. Most of the capsules had opened by January. A few spores were still present in March. Shriveled capsules remained on the plants until May. (78 specimens examined, 55 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Carbon, Center, Clinton, Cumberland, Delaware, Elk, Franklin, Fulton, Huntingdon, Juniata Lancaster, Lehigh, McKean, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Potter, Schuylkill, Sullivan, Susquehanna, Tioga, Union, Warren, York. (33 counties). Published, not seen: Chester, James, PC.

### 3. POLYTRICHUM Hedw.

A. Leaf margins more or less toothed . . . . . . . . . . . . . . . . . . B.
A. Leaf margins entire . . . . . . . . . . . . . . . . . . . . . . . . E.
  B Marginal cells of lamellae like others in size and thickness of wall; lamellae entire . . . . . . . . . . . . . . . . . . . . . . . . . C.
  B. Marginal cells of lamellae unlike others in size and thickness of wall . . . D.
C. Cells of middle of leaf sheath at ⅔ distance from margin to costa 5.5–9 times as long as wide; at ¾ up the leaf the unistratose margin 2–3 cells wide; epidermal cells of the capsule with or without surface thin spots . . *formosum.*
C. Cells of middle of leaf sheath at ⅔ distance from margin to costa 1.5–4 times as long as wide; at ¾ up the leaf the unistratose margin 4–9 cells wide; epidermal cells of the capsule without surface thin spots . . . . . . *gracile.*
  D. Marginal cells of lamellae flattopped, not notched or only near leaf margin and base slightly so, capsule elongate . . . . . . . . . *ohioense.*
  D. Marginal cells of lamellae notched in cross section; capsule cuboidal *commune.*
E. Marginal cells of lamellae pear-shaped in cross section, awn short and reddish . . . . . . . . . . . . . . . . . . . . . . . . . . *juniperinum.*
E. Marginal cells of lamellae pear-shaped in cross section, awn long and hyaline *piliferum.*

**Polytrichum commune** Hedw. Common, not as abundant as *P. ohioense.* In all the physiographic provinces. Growing in extensive mats.
SUBSTRATE: On all types of acid soil, pioneering on cinders, ash dumps and rocky surfaces. Sometimes covering rotten wood and humus in advance stages of decay. Within a pH range from 4 to 6, but the majority of samples at 4.
HABITAT: Growing in the moister areas of oak, mixed oak-pine and hardwood-hemlock forests. It also invades old fields, thickets, sand-pits, road banks and old railroad beds. It has been collected in alluvial woods along streams and the wooded shores of lakes. At elevations from 50 to 2200 feet.
ASSOCIATES: Found mixed with *Sphagnum* spp., *Hypnum* spp., *Leucobryum glaucum*, *Dicranum scoparium* and a variety of other mosses. Also with *Cladonia* spp.
REPRODUCTION: Antheridia and archegonia are mature in April. Young sporophytes 5 mm. long were found in November. Mature capsules still covered by the calyptra were collected in June, but by July the capsules were open and shedding spores. Specimens collected in September were found to have a few spores remaining in their capsules. (116 specimens examined, 24 fruiting.)
COUNTIES: Adams, Berks, Bradford, Bucks, Cambria, Dauphin, Delaware, Elk, Fayette, Franklin, Huntingdon, Lancaster, Lebanon, Lehigh, Luzerne, Lycoming, McKean, Monroe, Montgomery, Montour, Northampton, Philadelphia, Pike, Potter, Snyder, Somerset, Sullivan, Susquehanna, Tioga, Union, Venango Warren, Wayne, York. (41 counties). Published, not seen: Cameron, Miller, 7/19/04. J.

**Polytrichum commune** Hedw. var. **perigoniale** (Mx.) Bry. Eur. Rarer than the species and differing from it in the length of the perichaetial leaves, which are long and thin. In similar but drier situations. From 50 to 2000 feet.

COUNTIES: Bedford, Bradford, Bucks, Cambria, Carbon, Columbia, Cumberland, Delaware, Elk, Jefferson, Luzerne, Monroe, Northampton, Perry, Susquehanna, Wayne, York. (17 counties.)

**Polytrichum formosum** Hedw. Rare. A species of northern affinities. On soil and humus in the mountains. (4 specimens.)

COUNTIES: Carbon, Frenchtown and Stony Creek, Rau (NY); McKean, Hazelhurst, 5388; Northampton, Monocacy, Rau (NY). (3 counties.)

**Polytrichum gracile** Smith. Rare. A northern species and difficult to separate from the preceding species. Growing on moist soil and rock surfaces in hardwood forests. (3 specimens.)

COUNTIES: Monroe, Tobyhanna and Naomi Pines, Britton (NY); Philadelphia, Porter (NY). (2 counties.)

**Polytrichum juniperinum** Hedw. Common. Growing in thick mats. Occurs in all the physiographic provinces.

SUBSTRATE: Soil and rock surfaces. pH4 to 5.
HABITAT: Generally distributed in hardwood, pine-hardwood and pine-forests and old fields. This species occurs in the more sunny situations along lanes and wood roads, in sand-pits, on shale bluffs, mountain tops and bare rocky ledges. At elevations from 50 to 2160 feet.
ASSOCIATES: Growing with other species of *Polytrichum*, *Leucobryum glaucum*, *Dicranum scoparium*, *Hypnum* spp. and *Cladonia* spp.
REPRODUCTION: Antheridia were present and well developed in April. Young sporophytes 5 mm. long were found in September. At this time plants with young sporophytes just appearing and plants with empty capsules were found in the same clump. The capsules mature and shed their spores in June and July. (71 specimens examined, 18 fruiting.)
COUNTIES: Adams, Bedford, Berks, Bradford, Bucks, Cambria, Center, Chester, Columbia, Cumberland, Delaware, Franklin, Fulton, Huntingdon, Lackawanna, Lancaster, Lebanon, Luzerne, Lycoming, McKean, Monroe, Montgomery, Montour, Northampton, Perry, Philadelphia, Pike, Potter, Susquehanna, Tioga, Warren, Wayne, York. (33 counties). Published, not seen: Clearfield, between Clearfield and Pottersdale, 7/13/08 J.; Clinton, near Loch Haven, 7/15/08 J.; Lehigh, Rau, PC.

**Polytrichum juniperinum** Hedw. var. **alpestre** Bry. Eur. Separated from the species by the presence of numerous matted drity-white rhizoids extending up among the leaves. Many specimens of the species collected show a tendency toward this condition and are difficult to place. Collected on rather wet soil, rich in humus and in sunny situations at elevations of 1400 and 2000 feet. The young sporophytes were 5 mm. long on a specimen collected on the 8th of August. (2 specimens, identification verified by Dr. W. C. Steere.)

COUNTIES: McKean, Hazelhurst, 2554; Perry, New Germantown Hemlocks, 3550.

**Polytrichum ohioense** Ren. & Card. The commonest species of the genus in the State. Found in all the physiographic provinces.

SUBSTRATE: Soil. Also found on old logs, humus and humus accumulated on rock surfaces. pH4.
HABITAT: Usually growing in hardwood forests, but found also under pine and hemlock. It is abundant on wooded hillsides, in thickets, along trails and wood roads, on shale cliffs and serpentine barrens. It grows in huge mats with other mosses, quite often at the base of trees or sandstone boulders. Elevations from 50 to 2320 feet.

ASSOCIATES: Found growing with other species of *Polytrichum*, *Atrichum Macmillani*, *Leucobryum glaucum*, *Dicranella heteromalla*, *Dicranum scoparium*, *Hypnum imponens*, *Thuidium delicatulum* and *Cladonia* spp.
REPRODUCTION: Mature antheridia were present in April. Young sporophyte plants 5 mm. long were first visible in August. Growth appears to be slow since specimens collected in November had sporophytes averaging 8 to 10 mm. in length. By April the sporophytes were found to have reached the length of 4 or 5 cm. and in June were 7 cm. long, mature and still covered by calyptra. Spores were being shed in July and by late August the capsules were empty. Old capsules remained attached to the plants until November. (138 specimens examined, 72 fruiting.)
COUNTIES: Adams, Bedford, Berks, Blair, Bucks, Cambria, Center, Chester, Clearfield, Clinton, Columbia, Cumberland, Dauphin, Delaware, Elk, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Lehigh, Lycoming, McKean, Mifflin, Monroe, Montgomery, Northampton, Northumberland, Perry, Philadelphia, Pike, Potter, Schuylkill, Snyder, Somerset, Sullivan, Union, Warren, Wayne, York. (41 counties.)

**Polytrichum piliferum** Hedw. Not common. Ridge and Valley province, Allegheny Mountains and Plateau.

SUBSTRATE: Stony and sandy soil and rock outcroppings. Generally on shale and sandstone rocks. pH4.
HABITAT: Scrub forest types, such as the oak-pine-cedar community found on shale bluffs and the scrubby mixed hardwood forests of the mountain tops. Usually found on the drier stony, south-facing slopes, mountain summits and dry wooded road banks. From 50 to 2000 feet.
ASSOCIATES: On the shale bluffs in the southwestern part of the State it grows associated with the lichen *Cetraria islandica* and *Cladonia rangiferina* and the mosses *Leucobryum glaucum*, *Dicranella heteromalla* and *Atrichum Macmillani.* This group is characteristic of every bluff occurring in Braillier shale. In the second-growth oak forests of the mountain tops and slopes it is associated with the above named species of mosses, plus *Dicranum scoparium.* Other species of *Cladonia* replace the two species of lichens named above.
REPRODUCTION: Antheridia were present on plants collected in April. New sporophytes had grown to a length of 5 mm. in an October collection. Sporophytes are rare in this species. (20 specimens examined, 1 fruiting.) Type locality: Lancaster, Muhlenberg.
COUNTIES: Bedford, Hopewell 5151, New Bueno Vista 5339, Chaneysville 5289; Clinton, Carroll 4903; Dauphin, Halifax 5478a; Delaware, Ridley Quarry, Krout; Fulton, Warfordsburg 4770; Indiana, Saltzburg, Burnett 491 (NY); Lehigh, Mosserville, Schaeffer 11/28/47; Lycoming, Collomsville 4858; McKean, Bennett Brook & Bolivar, Burnett (A); Monroe, Delaware Water Gap, Knipe (A); Northampton, Slateford, Schaeffer; Philadelphia, Germantown, James (A); Schuylkill, Hecla, Wagner 32; Somerset, Sand Patch, Pohl & Lisi. (14 counties). Published, not seen: Chester, James, PC; Lancaster, Porter and Muhlenberg, PC.

## III. BUXBAUMIACEAE

### BUXBAUMIA (Hall.) Hedw.

**Buxbaumia aphylla** Hedw. Not common. Majority of collections in the Piedmont and Ridge and Valley Provinces. A few records from the Allegheny Mountains and Plateau.

SUBSTRATE: Clayey soil and sandy loam. A few records on rotten wood and humus.
HABITAT: Open hardwood forests, at the roots of shrubs, on road banks and on wooded slopes. Seems to prefer north facing slopes. At elevations from 150 to 800 feet.
ASSOCIATES: Growing with *Dicranella heteromalla*, *Atrichum Macmillani*, *Bartramia pomiformis*, and species of *Cladonia*.

REPRODUCTION: Capsules mature and closed in November. April collections open and spores still present. (14 specimens.)
COUNTIES: Berks, Vinemont, Wilkens 21; Franklin, Mt. Alto, Edwards 4/20/35; Huntingdon, Three Springs, 5520a; Lehigh, Mountainville, Rau 5/29/72 (NY); Monroe, Delaware Water Gap, Knipe 1874 (C), Porter 11/68 (NY), Garber 11/8/68 (NY), Mt. Pocono, Porter 5/24/00 (NY); Northampton, Easton, Stultz, 5/15/95 (P. & NY), Bethlehem, Wolle 3/28/74; Philadelphia, Wissahickon, James 4/8/64 (C); Schuylkill, Hometown, Wagner 54. (8 counties). Published, not seen: Cameron, Burnett, PC; Chester, South Hills, Everhart and West Chester, F. Windle Bryologist III; Delaware, Crum Creek, Bryologist IV and Cresson 4/27/03, Bryologist VII; Lancaster, Muhlenberg, TM.

## IV. DIPHYSCIACEAE

### DIPHYSCIUM Mohr.

**Diphyscium foliosum** (Hedw.) Mohr. Not common. Scattered on soil, usually among other mosses. Piedmont, Ridge and Valley and Allegheny Mountain Provinces.
SUBSTRATE: Soil, usually sterile sandy soil. Occasionally on dry sandstone or shale rocks where humus has accumulated. pH4–5.
HABITAT: In shade of hardwood forests, usually oak-hickory. Frequently along old wood roads and foot paths. At elevations from 100 to 2200 feet.
ASSOCIATES: *Dicranella heteromalla* and species of *Cladonia.*
REPRODUCTION: Immature capsule on material collected as early as May 10th. Earliest date for open capsules producing spores, June 30th. Peak of spore release in July and August with some capsules still containing spores until November 30th. Shrunken capsules persistent until the following April. (40 specimens, 31 fruiting.)
COUNTIES: Berks, Bucks, Carbon, Chester, Dauphin, Delaware, Fayette, Lancaster, Lebanon, Lehigh, McKean, Monroe, Montgomery, Northampton, Philadelphia, Schuylkill, Somerset, Wayne, Westmoreland, York. (20 counties). Published, not seen: Center, Tussey's Mountain, J.

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# NORTH QUEENSLAND MOSSES COLLECTED BY L. J. BRASS

EDWIN B. BARTRAM

*Bushkill, Pike Co., Penna.*

The mosses listed below are the result of the activities of Dr. L. J. Brass in connection with the 1948 Archbold Cape York Expedition.[1] The list gives a very comprehensive idea of the moss flora of the Cape York Peninsula and likewise is an interesting and significant supplement to the information tabulated a few years ago by Mr. H. N. Dixon.[2]

The series includes six new species: *Fissidens terrae-reginae, Fissidens subkurandae, Campylopus Brassii, Dicranoloma spiniforme, Leucoloma circinatulum* and *Ectropothecium riparioides* supplemented by the following nine species not previously recorded from Australia as far as I know: *Bryobrothera crenulata, Himantocladium plumula, Calyptothecium caudatum, Thuidium Meyenianum, Warburgiella cupressinoides, Taxithelium instratum, Taxithelium petrophilum, Isopterygium minutirameum* and *Ectropothecium sandwichense.*

The affinities of these new records and new species are principally with the tropical regions to the north indicating that the moss flora of the Cape York Peninsula has a stronger and more logical bond with these areas than with continental Australia.

Unless otherwise noted the collector is Dr. L. J. Brass. One series including the types of all the new species is in my herbarium. Further distributions will no doubt be made to the Farlow Herbarium, the University of Michigan and elsewhere.

## FISSIDENTACEAE

**Fissidens** (Crispidium) **terrae-reginae** Bartr. sp. nov.

Caules gregarii, usque ad 3 mm. alti, lutescenti-virides. Folia conferta, sicca valde circinato-contorta, ad 2 mm. longa, lineari-lanceolata, anguste acuminata; lamina dorsalis ad basin costae enata; marginibus ubique elimbatis, minutissime crenulatis; cellulae minutissime, 5–7 μ, irregulariter hexagonae, minute papillosae. Fructus terminalis, seta 3–4 mm. longa, theca parva, inclinata.

Mossman River Gorge, on granite rock in rain forest, alt. 150 m., Mar. 16, 1948, No. 18183. Upper Parrot Creek, Annan River, moist rocks on bank of a stream in rain forest, alt. 350 m., Sep. 5, 1948, No. 20037.

This species is very near *F. sylvaticus* Griff. but seems to be distinct in the narrower, more sharply pointed leaves with the lower leaf cells of the duplicate blades often rectangular and to 25 μ long by 10 μ wide.

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[1] Collections of the 1948 Archbold Cape York Expedition, American Museum of Natural History, Mr. Leonard J. Brass, Leader. Distributed by the Arnold Arboretum, Harvard University.

[2] Additions to the Mosses of North Queensland. — Proc. Royal Soc. Queensland 53 $^2$: 23–40. 1941.

**Fissidens** (Aloma) **subkurandae** Bartr. sp. nov.

Plantae gregariae, humillimae, virides. Caulis ad 4 mm. longus, laxe foliosus, folia usque ad 12 juga, sicca leniter homomalla, circa 1 mm. longa, oblongo-lanceolata, acuminata; marginibus minutissime crenulatis, ubique elimbatis; lamina dorsalis ad basin costae enata; cellulae pellucidae, irregulariter hexagonae, laeves, diam. 10–15$\mu$. Fructus terminalis; seta 2–2.5 mm. longa; theca erecta.

Leo Creek, Upper Nesbit River: clay mortar of an old stonework forge in rain forest, alt. 420 m., Aug. 18, 1948, No. 19928.

*F. kurandae* Broth. & Watts is obviously closely related to the above species but, to judge from the description, is a more robust, corticolous plan with longer stems and more bluntly pointed leaves. In *F. subkurandae* the leaves are rather sharply acuminate and not at all "obtiuscula apiculata."

## DICRANACEAE

**Dicranella pycnoglossa** (Broth.) Par.

Mossman River Gorge: wet shaded bank of river, alt. 100 m., Mar. 16, 1948, No. 18194. Shiptons Flat: shady road bank in savanna-forest, alt. 300 m., Sep. 5, 1948, No. 20022. Upper Parrot Creek, Annan River; clayey road in rain forest, alt. 350 m., No. 20034; moist rocks on bank of a stream in rain forest, No. 20036, 20038.

**Campylopus introflexus** (Hedw.) Brid.

Mt. Finnegan: cushioned on rocks on summit, alt. 1140 m., No. 20138.

**Campylopus Wattsii** Broth.

Upper Parrot Creek, Annan River: covering an exposed rock outcrop in rain forest, alt. 500 m., No. 20312.

**Campylopus Brassii** Bartr. sp. nov.

Dioicus, sat robustus, caespitosus, caespitibus densis, lutescentibus. Caulis erectus, dense foliosus, rubrotomentosus; folia sicca imbricata, humida erecto-patentia, rigida, 4–4.5 mm. longa, e basi oblonga sensim subulato-acuminata, caniculato-concava; marginibus erectis, superne serratis; costa cum apice evanida, dorso lamellato, lamellis serratis; cellulis superioribus rhombeis, basilaribus majoribus, ad margines angustis, alaribus numerosis, fuscis. Seta flavida, arcuata; theca oblongo-ovalis, 2 mm. longa; calyptra fimbriata.

Mt. Finnegan: on open ground in high mountain scrub, alt. 1000 m., Sep. 7, 1948, No. 20106.

This species will be distinguished from *C. Wattsii* Broth. by the yellow color, the shorter, rigid leaves and the conspicuous dark brown alar cells not or scarcely auriculate.

**Campylopus umbellatus** (W. Arn.) Bartr.

Cody Creek, 13 miles WSW of Somerset: on moist sandy soil in black teatree scrub, Apr. 28, 1948, No. 18530 (stunted form). Summit of Mt. Tozer, Tozer Range: seepage-moist places on exposed granite rock faces, July 7, 1948, alt. 540 m., No. 19496.

**Holomitrium Muelleri** Hpe.

Lamb's Head, Lamb Range: sunny rocks in rain forest, alt. 3000–3500 ft., Mar. 28, 1948, leg. Austin Vievers, No. 18226. Upper Parrot Creek, Annan River: upper branches of a tall tree in rain forest, alt. 400 m., Sep. 17, 1948, No. 20281. Mt. Finnegan: on corky bark of Casuarina trees in savanna-forest, alt. 800 m., Sep. 21, 1948, No. 20360.

**Holomitrium perichaetiale** (Hook.) Brid.

Mt. Finnegan: small cushions in tops of trees of stunted high mountain forest, alt. 1060 m., Sep. 21, 1948, No. 20333.

**Dicranoloma Menziesii** (H. f. & W.) Par.

Lamb's Head, Lamb Range: sunny rocks in rain forest, alt. 3500 ft., Mar. 28, 1948, leg. Austin Vievers, No. 18228. Mt. Bellenden-Ker: summit of south peak, on shaded rocks in low forest, alt. 5000 ft., Apr. 6, 1948, No. 18282.

**Dicranoloma serratum** (Broth.) Par.

Mt. Finnegan: abundant on rocks and lower trunks of trees in high mountain forest, alt. 1040 m., Sep. 7, 1948, No. 20083.

**Dicranoloma austro-scoparium** (C. M.) Par.

Mt. Finnegan: on branches of an undergrowth tree in rain forest, alt., 850 m., Sep. 6, 1948, No. 20057; stems of trees in high stunted mountain forest, alt. 1060 m., Sep. 21, 1948, No. 20336.

**Dicranoloma spiniforme** Bartr. sp. nov.

Caules ad 12 cm. longi, flexuosi, irregulariter ramosi. Folia late patentia, caulina et ramulina superiora valde falcato-secunda, 8–10 mm. longa, e basi ovata, concava sensim setaceo-acuminata; marginibus longe infra apicem spinoso-serratis; costa excurrente, dorso lamellato, lamellis serratis; cellulis linearibus, porosis, alaribus numerosis, magnis, oblongo-rectangularibus, fusco-aureis. Fructus ignotus.

Mt. Finnegan: abundant on undergrowth in high mountain forest, alt. 1100 m., Sep. 7, 1948, No. 20090.

Possibly near *D. Blumii* (Nees) Par. but the leaves shorter, sharply spinose-serrate at least half way down and often nearly to the top of the leaf base.

**Leucoloma subintegrum** Broth.

Leo Creek, Upper Nesbit River: lower trunk of a tree in rain forest, alt. 500 m., Aug. 18, 1948, No. 19912. Mt. Finnegan: rotting wood in high mountain forest, alt. 1040 m., Sep. 7, 1948, No. 20096a; on bark of a rotting log in rain forest, alt. 850 m., Sep. 8, 1948, No. 20151a.

**Leucoloma** (Syncratodictyum) **circinatulum** Bartr. sp. nov.

Dioucum; humile, caespitosum, caespitibus densis, late extensis, superne viridibus, intus fuscescentibus. Caulis usque ad 1 cm. altus, plus minusve ramosus; folia conferta, flexuoso-patentia, superiora congesta, circinato-contorta, ad 3 mm. longa, e basi oblonga sensim subulata; marginibus erectis, superne papiloso-crenulatis, limbata, limbo hyalino, basi latiusculo, superne sensim angustiore, supra medium folii evanido;

costa infra summum apicem evanida; cellulis superioribus minutis, dense papillosis, obscuris, diam. 7–8 μ, basilaribus rectangularibus, laevibus, alaribus numerosis, magnis, rectangularibus, fusco-aureis. Caetera ignota.

Leo Creek, Upper Nesbit River: wet rocks in bed of creek, alt. 420 m., Aug. 17, 1948, No. 19888.

Differs from *L. perviride* Broth. of the Philippines in the crowded comal leaves with circinate points. The upper leaf margins are crenulate with papillae but not serrulate as in the Philippine plants.

**Dicnemoloma Sieberianum** (Hornsch.) Ren.

Lamb's Head, Lamb Range: sunny rocks in rain forest, alt. 3000–3500 ft., Mar. 28, 1948, leg. Austin Vievers, No. 18226a.

## DICNEMONACEAE

**Eucamptodon Mulleri** Hpe. & C. M.

Mt. Bellenden-Ker: summit of south peak, on bark of low trees, alt. 5000 ft., Apr. 6, 1948, No. 18279. Mt. Finnegan: on living and dead branchlets in high mountain scrub, alt. 1000 m., Sep. 7, 1948, No. 20108; dead twigs in shrubberies of summit, alt. 1140 m., Sep. 7, 1948, No. 20140; branches of low trees in high mountain scrub, alt. 910 m., Sep. 21, 1948, No. 20356.

## LEUCOBRYACEAE

**Leucobryum sanctum** (Brid.) Hampe

Mossman River Gorge: logs and tree trunks, alt. 100 m., Mar. 17, 1948, No. 18190 in part, 18196. Junction Creek, Russell River: on logs, alt. 50 m., Apr. 2, 1948, No. 18263 in part, 18264, 18265, 18268 in part. Leo Creek, Upper Nesbit River: moist rocks and rotten wood, alt. 420 m., Aug. 17, 1948, No. 19893, 19894a, 19895. Mt. Finnegan: granite rocks and wet banks, alt. 1040 m., Sep. 7, 1948, No. 20084, 20086. Upper Parrot Creek, Annan River: moist stream bank in rain forest, alt. 400 m., No. 20278.

**Leucobryum candidum** (Brid.) H. f. & W.

Mt. Bellenden-Ker: summit of south peak, on trees of low forest, alt. 5000 ft., Apr. 6, 1948, No. 18284. Tozer Range, ½ mile east of Mt. Tozer: lower trunks of trees in rain forest, alt. 425 m., July 1, 1948, No. 19404a; rotten wood in rain forest, alt. 425 m., No. 19472. Mt. Finnegan: west slopes, on rocks in savanna forest, Sep. 3, 1948, alt. 600 m., No. 20007, a peculiar form with the comal leaves often blunt, broadly margined and congested in a solid, cuspidate tip.

**Leucobryum candidum** forma **brachyphylla**

Cody Creek, 13 miles WSW of Somerset: on moist sandy soil in black teatree scrub, alt. 10 m., Apr. 28, 1948, No. 18531. Leo Creek, Upper Nesbit River: on rocks and rotten logs in rain forest, alt. 420 m., Aug. 17, 1948, No. 19898, 19938.

**Leucobryum candidum** var. **pentastichum** (Doz. & Molk.) Dix.

Lamb's Head, Lamb Range: sunny rocks in rain forest, alt. 3000–3500 ft., Mar. 26, 1948, leg. Austin Vievers, No. 18231, 18229.

**Leucobryum ballinense** Broth.

Speewah, upper Clohesy River: rotting logs in rain forest, alt. 1500 ft., Mar. 27, 1948, No. 18210 in part. Newcastle Bay, 2½ miles S. of Somerset: on logs and bark, alt. 20 m., May 7, 1948, No. 18656, 18658, 18764. Tozer Range, north end: on bark, alt. 300 m., June 29, 1948, No. 19371. Tozer's Gap, Tozer Range: logs and bases of trees in rain forest, alt. 100 m., June 30, 1948, No. 19383, 19385. Tozer Range ½ mile east of Mt. Tozer: trunks of living trees in rain forest, alt. 425 m., July 1, 1948, No. 19392. Shipton's Flat: on drift logs and charcoal, alt. 275 m., Sep. 4, 1948, No. 20020, 20169. Mt. Finnegan: on rotting logs, alt. 850 m., Sep. 6, 1948, No. 20055.

*Leucobryum ballinense* Broth. is not a convincing species. The author distinguishes it from *L. brachyphyllum* by the more slenderly acuminate leaves but I believe it will eventually have to be included in the synonymy of the protean *L. candidum* (Brid.) Hpe.

**Leucobryum Bowringii** Mitt. var. **sericeum** (Broth.) Dix.

Mossman River Gorge: on logs and shaded rocks, alt. 100 m., Mar. 17, 1948, No. 18185, in part, 18191. Mt. Finnegan: rocks on bank of stream in high mountain forest, alt. 1040 m., Sep. 7, 1948, No. 20081. Shipton's Flat: on moist shady banks of stream, alt. 275 m., Sep. 10, 1948, No. 20168.

**Leucophanes candidum** (Hornsch.) Lindb.

Mossman River Gorge: forming big bright green cushions on trees overhanging river, alt. 100 m., Mar. 17, 1948, No. 18189.

**Leucophanes australe** Broth.

Iron River: high on a rain forest tree, alt. 20 m., June 12, 1948, No. 19160 in part.

**Octoblepharum albidum** Hedw.

Lockerbie, 10 miles WSW of Somerset: dry lateritic rocks on edge of rain forest, alt. 50 m., May 4, 1948, No. 18644. Newcastle Bay, 2½ miles S. of Somerset: lower trunks of trees and logs in scrub of coastal sand dunes, May 7, 1948, No. 18657. Iron Range: high on rain-forest tree, alt. 20 m., June 12, 1948, No. 19160 in part.

## CALYMPERACEAE

**Syrrhopodon croceus** Mitt.

Tozer Range, ½ mile east of Mt. Tozer: lower trunks of trees in rain forest, alt. 425 m., July 1, 1948, No. 19404. Tozer Range, north end: bark of tree on edge of brushy forest, alt. 300 m., June 29, 1948, No.

19372. Leo Creek, Upper Nesbit River: lower trunk of a tree in main forest, alt. 420 m., Aug. 17, 1948, No. 19892.

**Thyridium fasciculatum** (Hook. & Grev.) Mitt.

Iron Range: on lower trunks of trees in rain forest, alt. 20 m., June 13, 1948, No. 19205. Tozer's Gap, Tozer Range: lower trunks of trees in rain forest, alt. 60 m., July 5, 1948, No. 19456. Leo Creek, Upper Nesbit River: on twigs in rain forest undergrowth, alt. 500 m., Aug. 18, 1948, No. 19913.

**Thyridium undulatulum** (Broth.) Fleisch.

Lockerbie, 10 miles WSW of Somerset: bark of *Wormia alata* in gallery woods, alt. 30 m., Apr. 30, 1948, No. 18541; in green patches on bark of savanna-forest trees adjacent to rain forest, alt. 50 m., May 4, 1948, No. 18645. Tozer Range, north end: bark of tree in bushy forest, alt. 300 m., June 29, 1948, No. 19370. Tozer's Gap, Tozer Range: on dead wood in rain-forested gully, alt. 100 m., June 30, 1948, No. 19382; trunk of living tree in rain forest, alt. 100 m., July 4, 1948, No. 19440. Tozer Range, ½ mile east of Mt. Tozer: high branches of a tree in rain forest, alt. 425 m., July 6, 1948, No. 19473. Leo Creek, Upper Nesbit River: trunk of a palm in rain forest, alt. 420 m., Aug. 20, 1948, No. 19956, 19872.

**Calymperes tenerum** C. M.

Newcastle Bay, 2½ miles S of Somerset: dead bark of trees in scrub of coastal sand dunes, May 7, 1948, No. 18670. Tozer Gap, Tozer Range: bark of living tree in rain forest, alt. 60 m., July 5, 1948, No. 19453.

## POTTIACEAE

**Hyophila involuta** (Hook.) Jaeg.

Mossman River Gorge: on wet rocks in river, alt. 100 m., Mar. 17, 1948, No. 18192.

## BRYACEAE

**Bryum pachytheca** C. M.

Hannibal Island, Shelburne Bay: terrestrial in brushy rain forest, alt. c. 1 m., Apr. 19, 1948, No. 18345. Tozer Gap, Tozer Range: on ground where logs have been burned in savanna-forest, alt. 120 m., July 3, 1948, No. 19429, 19524. Brown's Creek, Pascoe River: bare sandy patches in floodbed of creek, alt. 60 m., July 16, 1948, No. 19617.

**Bryum subpachypoma** Hpe.

Mossman River Gorge: on rocks in rain forest stream, bright green small tufts, alt. 150 m., Mar. 16, 1948, No. 18171; on granite rocks in rain forest, alt. 150 m., Mar. 16, 1948, No. 18175; wet banks of river, alt. 150 m., Mar. 17, 1948, No. 18197.

The distinctions between this species and *B. nitens* Hook. are negligible and I have little doubt but that they are one and the same thing.

## RHIZOGONIACEAE

**Rhizogonium spiniforme** (Hedw.) Bruch

Mossman River Gorge: on log in rain forest, alt. 100 ft., Mar. 17, 1948, No. 18185 in part, 18187, 18190 in part. Speewah, upper Clohesy River: on log in rain forest, alt. 1500 ft., Mar. 27, 1948, No. 18210. Junction Creek, Russell River, on logs in rain forest, alt. 20 m., Apr. 2, 1948, No. 18253, 18263 in part, 18268 in part. Leo Creek, Upper Nesbit River: on log in rain forest, alt. 420 m., Aug. 17, 1948, No. 19890, 19891, 19908, 19927. Tozer Range, ½ mile east of Mt. Tozer: base of dead tree in rain forest, alt. 425 m., July 1, 1948, No. 19391, 19470. Mt. Finnegan: on rocks (granite) in high mountain scrub, alt. 1100 m., Sep. 7, 1948, No. 20087.

**Bryobrothera crenulata** (Broth. & Par.) Ther.

Mt. Finnegan: on living branchlets of undergrowth in high mountain forest, alt. 1100 m., Sep. 7, 1948, No. 20091.

In studying these plants I was impressed with their resemblance to *Calomnion Dixoni* Bartr. of Fiji. Upon making comparisons they prove to be identical in every respect so *C. Dixoni* must be reduced to synonymy. Instead of being a New Caledonian endemic the species now includes Queensland and Fiji in its geographical range. My Fijian material is all sterile but in habit, appearance and structural detail it is an exact counterpart of No. 110 of Theriot's New Caledonian Exsiccati.

## ORTHOTRICHACEAE

**Macromitrium Scottiae** C. M.

Mt. Bellenden-Ker, summit of south peak: on dead wood of low trees, alt. 5000 ft., Apr. 6, 1948, No. 18280. Mt. Finnegan: on dead branchlets of trees in high mountain scrub, alt. 1100 m., Sep. 7, 1948, No. 20085.

**Macromitrium funiforme** Dix.

Mt. Bellenden-Ker, summit of south peak: on trees of low forest, alt. 5000 ft., Apr. 6, 1948, No. 18283. Mt. Finnegan: on dead branchlets in high mountain scrub, alt. 1000 m., Sep. 7, 1948, No. 20107.

**Macromitrium Daemelii** C. M.

Mt. Finnegan: covering dead branches of trees in stunted high mountain forest, alt. 1060 m., Sep. 21, 1948, No. 20334a.

**Macromitrium dimorphum** C. M.

Mt. Bellenden-Ker, summit of south peak: on trunks of low trees, alt. 5000 ft., Apr. 6, 1948, No. 18281a. Mt. Finnegan: on dead wood and dead branches in shrubberies of summit and high mountain forest, alt. 910–1140 m., Sep. 1948, No. 20136, 20139, 20334, 20358.

**Schlotheimia Brownii** Brid.

Mt. Bellenden-Ker, summit of south peak: on trunks of low trees, alt. 5000 ft., Apr. 6, 1948, No. 18281b; trunks of trees in stunted high mountain forest, alt. 910 m., Sep. 21, 1948, No. 20357.

### RHACOPILACEAE

**Rhacopilum convolutaceum** C. M.

Leo Creek, Upper Nesbit River: carpeting rocks on side of a bluff in rain forest, alt. 420 m., Aug. 17, 1948, No. 19896.

### PTEROBRYACEAE

**Mulleriobryum Whiteleggei** (Broth.) Fleisch.

Mossman River Gorge: on undergrowth and tree trunks in rain forest, alt. 150 m., Mar. 16, 1948, No. 18172, 18179. Upper Parrot Creek, Annan River: on rocks in bed of stream in rain forest, alt. 400 m., Sep. 17, 1948, No. 20276.

### METEORIACEAE

**Aerobryopsis longissima** (Doz. & Molk.) Fleisch.

Mossman River Gorge: on bark of *Agathis* sp. in rain forest, alt. 150 m., Mar. 17, 1948, No. 18198. Leo Creek, Upper Nesbit River: on trees on open bank of stream in rain forest, alt. 420 m., Aug. 17, 1948, No. 19887; dry twigs in rain forest undergrowth, alt. 500 m., Aug. 18, 1948, No. 19914. Mt. Finnegan: epiphytic in shrubberies of summit, alt. 1140 m., Sep. 7, 1948, No. 20143. Upper Parrot Creek, Annan River: lower trunks of trees in dryish rain forest, alt. 500 m., Sep. 19, 1948, No. 20313.

### NECKERACEAE

**Himantocladium plumula** (Nees) Fleisch.

Iron Range: lower tree trunks in rain forest, alt. 50 m., June 13, 1948, No. 19258.

**Calyptothecium recurvulum** (C. M.) Broth.

Mossman River Gorge: lower trunks of trees in rain forest, alt. 150 m., Mar. 16, 1948, No. 18176.

**Calyptothecium acutum** (Mitt.) Broth.

Mossman River Gorge: hanging from granite rocks in rain forest, alt. 150 m., Mar. 17, 1948, No. 18199.

### HOOKERIACEAE

**Callicostella Kaernbachii** Broth.

Wet rocks in rain forest stream, alt. 25 m., Apr. 2, 1948, No. 18255a.

### HYPOPTERYGIACEAE

**Hypopterygium Daymanianum** Broth. & Geh.

Mt. Finnegan: on trunks of trees in high mountain forest, alt. 1100 m., No. 20093.

**Hypopterygium Mulleri** Hpe.

Mossman River Gorge: shady rocks in rain forest, Mar. 17, 1948, No. 18195. Leo Creek, Upper Nesbit River: carpeting wet rocks in rain forest, alt. 420 m., Aug. 17, 1948, No. 19906.

## LESKEACEAE

**Thuidium furfurosum** (H. f. & W.) Jaeg.

Mossman River Gorge: carpeting rocks in rain forest, alt. 150 m., Mar. 16, 1948, No. 18166.

**Thuidium Meyenianum** (Hpe.) Bry. Jav.

Rocks and trunks of trees in rain forest, alt. 150 m., Mar. 16, 1948, No. 18169, 18181, 18182. Iron Range: carpeting rocks and logs in a moist rainforest ravine, alt. 40 m., June 16, 1948, No. 19214. Tozer gap, Tozer Range: lower trunks of trees in rain forest, alt. 60 m., July 5, 1948, No. 19445.

**Thuidium plumulosiforme** (Hpe.) Jaeg.

Mossman River Gorge: on underbrush in rain forest, alt. 150 m., Mar. 16, 1948, No. 18174. Upper Parrot Creek, Annan River: on stones in rain forest, alt. 400 m., Sep. 15, 1948, No. 20256.

## ENTODONTACEAE

**Trachyphyllum inflexum** (Harv.) Gepp.

Lockerbie, 10 miles WSW of Somerset: dry lateritic rocks on edge of rain forest, alt. 50 m., May 4, 1948, No. 18643. Archer River, Wenlock-Coen Road: on dead tree trunks in thin rain forest on banks of river, alt. 125 m., July 31, 1948, No. 19769.

The type collection of *T. papuanum* Broth. came from Thursday Island but as it is very questionably distinct from *T. inflexum* I believe these collections represent the first records for the Australian mainland.

## SEMATOPHYLLACEAE

**Acanthocladium extenuatum** (Brid.) Mitt.

On rotting bark in rain forest, alt. 800 m., Sep. 8, 1948, No. 20154.

**Warburgiella cupressinoides** C. M.

Mt. Bellenden-Ker, summit of south peak: on bark of *Leptospermum wooroonooran,* alt. 5000 ft., Apr. 6, 1948, No. 18281. Mt. Finnegan: carpeting a rotten log in rain forest, alt. 850 m., Sep. 6, 1948, No. 20056.

Previously known only from the Philippines and New Caledonia.

**Sematophyllum caespitosum** (Hedw.) Mitt.

Mossman River Gorge: on wet rocks on river bank, alt. 100 m., Mar. 17, 1948, No. 18193. Speewah, upper Clohesy River: on rocks in rain forest stream, alt. 1500 ft., Mar. 26, 1948, No. 18206. Junction Creek, Russell River: on rocks in rain forest stream, alt. 30 m., Apr. 2, 1948, No. 18248, 18256. Iron Range: living bark of trees in floodplain rain forest, alt. 20 m., June 6, 1948, No. 19050. Leo Creek, Upper Nesbit River: on base of tree in rain forest, alt. 420 m., Aug. 15, 1948, No. 19858; rocks on bank of creek in rain forest, Aug. 17, 1948, No. 19897. Upper Parrot Creek, Annan River: on bark of a creek-bank tree in rain forest, alt. 400 m., Sep. 17, 1948, No. 20280.

**Sematophyllum saproxylophilum** (C. M.) Fleisch.

Leo Creek, Upper Nesbit River: dead trunk of a tree in rain forest, alt. 420 m., Aug. 16, 1948, No. 19873. Mt. Finnegan: on bark of a rotting log in rain forest, alt. 850 m., Sep. 8, 1948, No. 20152. Shipton's Flat: rotten wood in creek-bank rain forest, alt. 275 m., Sep. 4, 1948, No. 20021.

**Acroporium erythropodium** (Hpe.) Broth.

Lamb's Head, Lamb Range: sunny rocks in rain forest, alt. 3000–3500 ft., Mar. 28, 1948, No. 18230. Mt. Finnegan: on living branches of trees in high mountain forest, alt. 1100 m., Sep. 7, 1948, No. 20092, 20137, 20332, 20335 in part.

**Trichosteleum hamatum** (Doz. & Molk.) Jaeg.

Tozer Gap, Tozer Range: on dead logs in a rain forested gully, alt. 100 m., June 30, 1948, No. 19384. Leo Creek, Upper Nesbit River: dead trunk of tree in rain forest, alt. 420 m., Aug. 16, 1948, No. 19873a. Mt. Finnegan: covering trunks of trees in high mountain forest, alt. 1040 m., Sep. 7, 1948, No. 20082. Upper Parrot Creek, Annan River: on wet decayed wood in a rain forest stream, alt. 400 m., Sep. 17, 1948, No. 20277. Junction Creek, Russell River: on rotting logs in rain forest, alt. 30 m., Apr. 2, 1948, No. 18252 in part.

**Acanthorrhynchium papillatum** (Harv.) Fleisch.

Leo Creek, Upper Nesbit River: rotten wood, wet rocks and tree trunks in rain forest, alt. 420 m., Aug. 17, 1948, No. 19894, 19894a in part, 19889, 19908a, 19909 in part, 19955. Upper Parrot Creek, Annan River: moist bank of a stream in rain forest, alt. 400 m., Sep. 17, 1948, No. 20279.

This wide ranging species is not uncommon in the Cape York Peninsula to judge from these collections and it seems strange that it has been recorded only once before. It frequently grows in association with *Leucobryum sanctum* both here and elsewhere through the range.

**Taxithelium instratum** (Brid.) Broth.

Mossman River Gorge: on log in rain forest, alt. 100 m., Mar. 17, 1948, No. 18186a.

A frequent Indo-Malaysian species but not previously known south of New Guinea.

**Taxithelium petrophilum** Williams

Tozer Gap, Tozer Range: covering stones in flood channel of a stream in rain forest, alt. 60 m., July 5, 1948, No. 19457.

The rupestrine habit, strongly complanate and sharply pointed leaves, the absence of enlarged alar cells and shorter setae are characters in the aggregate which clearly separate these plants from *T. instratum*. After reexamining the Philippine material I believe the reduction of *T. petrophilum* (*petrophila*) to a synonym of *T. instratum* was a mistake. The Queensland collection is similar in every particular to the Philippine type but is in much better condition so that the distinctions are more sharply defined.

**Taxithelium selenithecium** (C. M.) Par.

Mossman River Gorge: lower trunk of a tree in rain forest, alt. 150 m., Mar. 16, 1948, No. 18170. Lockerbie, 10 miles WSW of Somerset: covering a stone in rain forest, alt. 50 m., May 4, 1948, No. 18646. Iron Range: on dead bark of trees in floodplain rain forest, alt. 20 m., June 6, 1948, No. 19061. Tozer Gap, Tozer Range: wet rocks in bed of stream in rain forest, July 5, 1948, No. 19454. Coen: in wet shade in rocky bed of Coen River, alt. 200 m., Aug. 3, 1948, No. 19795.

**Taxithelium novae-valesiae** (Broth.) Broth.

Mt. Finnegan, west slopes: on bark of a rotting log in rain forest, alt. 850 m., Sep. 8, 1948, No. 20151. Mt. Finnegan: rotting wood in high mountain forest, alt. 1040 m., Sep. 7, 1948, No. 20096; small cushions in tops of trees of stunted high mountain forest, alt. 1060 m., Sep. 8, 1948, No. 20153 in part. Junction Creek, Russell River: on dead wood in rain forest, alt. 50 m., Apr. 2, 1948, No. 18266. Mossman River Gorge: decaying bark in rain forest, alt. 150 m., Mar. 16, 1948, No. 18180. Leo Creek, Upper Nesbit River: on living bark in rain forest undergrowth, alt. 420 m., Aug. 30, 1948, No. 19953.

## HYPNACEAE

**Isopterygium minutirameum** (C. M.) Jaeg. var. **brevifolia** Fleisch. — (*Hypnum austro-pusillum* C. M., Linn. 1871–73, p. 159)

Junction Creek, Russell River: on rotting logs in rain forest, alt. 30 m., Apr. 2, 1948, No. 18252 in part. Tozer Range, ½ mile east of Mt. Tozer: covering a dead stick in rain forest, alt. 425 m., July 1, 1948, No. 19405. Shipton's Flat: moist granite rock on bank of stream, alt. 275 m., Sep. 10, 1948, No. 20170. Upper Parrot Creek, Annan River: on rotten log in rain forest, alt. 400 m., Sep. 19, 1948, No. 20321.

**Ectropothecium sandwichense** (Hook. & W. Arn.) Mitt.

Mossman River Gorge: on a log in rain forest, alt. 100 m., Mar. 17, 1948, No. 18186. Speewah, upper Clohesy River: rotting log in rain forest, alt. 150 m., Mar 26, 1948, No. 18205. Junction Creek, Russell River: wet rocks in rain forest stream, alt. 25 m., Apr. 2, 1948, No. 18255. Iron Range: decayed wood on rain forest floor, alt. 20 m., June 15, 1948, No. 19204. Leo Creek, Upper Nesbit River: moist rocks of creek banks in rain forest, alt. 420 m., Aug. 17, 1948, No. 19904. Upper Parrot Creek, Annan River: on an old log in rain forest, alt. 500 m., Sep. 15, 1948, No. 20255.

This species probably has a wider distribution than the published records indicate and may eventually acquire a considerable synonymy.

**Ectropothecium Moritzii** (C. M.) Jaeg.

Leo Creek, Upper Nesbit River: carpeting wet rocks on creek bank in rain forest, alt. 420 m., Aug. 17, 1948, No. 19905; on a seepage-wet rock in rain forest, alt. 420 m., Aug. 17, 1948, No. 19907.

**Ectropothecium riparioides** Bartr. sp. nov.

Dioicum; gracile, caespitosum, caestipitibus laxis, depressis, viridibus. Caulis elongatus, flexuosus, ad 10 cm. longus, pinnatim-ramosus, ramis ad 1 cm. longis, complanate foliosis. Folia patentia, haud falcata, 0.8 mm. longa, ovato-lanceolata, acuminata, ecostata, superne minute denticulata; cellulis linearibus, laevissimis, alaribus paucis, subquadratis. Caetera ignota.

Junction Creek, Russell River: on shallowly submerged rocks in stream in rain forest, alt. 30 m., Apr. 2, 1948, No. 18251.

Possibly near *E. serrifolium* Broth. & Watts but entirely different in habit and quite distinct in the subentire leaves with smooth cells.

**Trachythecium verrucosum** (Hpe.) Fleisch.

Mossman River Gorge: lower trunks of trees in rain forest, alt. 150 m., Mar. 16, 1948, No. 18167, 18178.

### *Addendum*

Through the friendly cooperation of Mr. J. H. Willis I have received the mosses listed below which were collected by Dr. Brass and included with the Hepatics sent to the Melbourne Botanic Gardens for study. These are important additions to the moss flora of North Queensland and neither of the species appeared in the original series of moss collections. I am grateful to Mr. Willis for making them available and am happy to be able to include them in the list of mosses collected by Dr. Brass during the course of the expedition.

### LEMBOPHYLLACEAE

**Camptochaete brisbanica** (C. M.) Broth. & Watts.

Mt. Finnegan, west slopes (Cedar Bay S. of Cooktown), abundant on branches of woody undergrowth in rain forest, alt. 850 m., Sep. 8, 1948, No. 20058. Mt. Finnegan, dead twigs in rain forest, alt. c. 800 m., Sep. 8, 1948, No. 20155.

The only record of this species I can locate is in "The Mosses of North Queensland" (Proc. Linn. Soc. of N. S. Wales, Vol. 43, pt. 3, p. 561, 1918). Mr. Wallis tells me that he has compared these collections with material in the National Herbarium, Victoria, determined by Rev. W. W. Watts and finds that they match beautifully.

### HOOKERIACEAE

**Eriopus Brassii** Bartr. sp. nov.

Dioicum ut videtur. Caulis circa 1 cm. longus, simplex vel parce ramosus, laxe foliosus, parce radiculosus. Folia patentia, complanata, ad 2.5 mm. longa, 1.5 mm. lata, e basi angustata late ovata, apice rotundato-obtusa, tenuiter apiculata, ecostata, ubique limbata, limbo hyalino e cellulis 2–3 seriatis superne remote denticulatis instructo; cellulae superiores ovali-hexagonae, ca. 37 μ longae, 20 μ latae, parietibus firmis, basilares laxiores. Caetera ignota.

Mt. Finnegan, trunk of tree in high mountain forest, alt. ca. 1040 m., Sep. 7, 1948, No. 20097.

Unfortunately the plants I have seen are entirely sterile so that the sporophyte characters which are of high diagnostic value in this genus are lacking. The narrowly bordered leaves and the slender apiculus clearly differentiate this species from *E. apiculatus* (H. f. & W.) Mitt. and the denticulate leaf margins preclude any confusion with *E. Brownii* Dix. of New Zealand. The species of this widely distributed and remarkable genus are in need of a careful revisional study but meanwhile it would seem that the Mt. Finnegan plants are deserving of a definite specific status.

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# IDENTIFICATION OF YEASTS FROM COMMERCIAL CUCUMBER FERMENTATIONS IN NORTHERN BRINING AREAS[1]

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Cucumbers for pickling represent an important agricultural commodity — ranking fourth in acreage and sixth in value of all horticultural crops for processing. The annual crop of pickling cucumbers is about 10 million bushels; of this amount, approximately 8 to 8.5 million bushels are brine-cured and the balance goes to fresh-pack or pasteurized products. About one-fourth of the crop is brined in the Southeastern States; and Indiana, Michigan, and Wisconsin brine approximately one-half.

For the past several years this Bureau, in cooperation with the Department of Horticulture of the North Carolina Agricultural Experiment Station, has been investigating the microbiological changes occurring during the fermentation of cucumbers brined under southern conditions. More recently part of this cooperative work has centered around that portion of the fermentation caused by yeast activity. Particular emphasis has been placed on the identity of the individual species comprising the total yeast population. We are interested in obtaining basic information of this type for the major cucumber pickling areas of the country in an effort to improve existing brining procedures and minimize losses caused by (1) enzymatic softening of salt-stock, and (2) the formation of bloaters (hollow salt-stock). Most yeasts of cucumber brine origin possess two important qualities that would be required of any microbial group associated with the two important types of economic loss mentioned above. These qualities are high tolerance to salt and high tolerance to acid.

In a recent report (Etchells and Bell, 1950 *a*), 1,444 yeast isolates associated with the gaseous fermentation of cucumbers under conditions typical of southern brining areas (e.g. North Carolina) were classified. During the period when isolations were made, the brine strength of the fermentations was within the range of 10 to 18 percent by weight. It was found that the isolates could be reduced to the following six genera in the order of frequency of isolation: *Torulopsis*, 721 isolates; *Brettanomyces*, 588; *Zygosaccharomyces*, 59; *Hansenula*, 49; *Torulaspora*, 6; *Kloeckera*,

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[1] This study was carried out under a cooperative project with the Department of Horticulture of the North Carolina Agricultural Experiment Station. Published with the approval of the Director, North Carolina Agricultural Experiment Station as Paper No. 383 of the Journal Series.

1; and 20 cultures not fully classified. Bloater formation in the vats of salt-stock cucumbers examined was attributed to the gaseous yeast fermentation. The proportion of bloaters found in seven vats of large-sized cucumbers ranged from 23 to 54 percent.

Although the above study definitely established that certain yeast species were related to bloater formation under southern fermentation conditions, no incrimination of these species has been demonstrated to date (Etchells and Bell, 1951) in connection with the type of enzymatic softening of cucumber salt-stock described by Bell, Etchells, and Jones (1950). However, several yeast species (all from sources other than cucumber brines) have been reported (Luh and Phaff, 1948; Hall and Teunisson, 1948; Etchells and Bell, 1951) as being capable of producing a pectin-splitting enzyme similar to the one responsible for softening of salt-stock (Bell, Etchells, and Jones). Such yeasts, growing in commercial cucumber brines, could contribute materially to the softening type of spoilage. Continued isolation and identification of yeasts from cucumber fermentations in the major brining areas of the country may reveal species capable of glycosidic hydrolysis of pectin.

Previous studies on the yeasts responsible for the gaseous fermentation of cucumbers have been limited to conditions typical of southern states. The present investigation was undertaken (1) to establish whether yeast activity represents a part of the cucumber fermentation under conditions typical of northern brining areas represented by the states of Indiana, Michigan and Wisconsin, and (2) if so, to determine the nature and sequence of the principal yeast species present.

## EXPERIMENTAL PROCEDURE

During a 3-year period (1948–50) 155 brine samples were collected from 21 commercial cucumber brining stations, operated by eight pickle companies in Indiana, Michigan, and Wisconsin. The location of brining stations visited in each state, and the number of brining seasons each station was visited, are given in table 1. During the 1948 and 1949 seasons, the brines were collected during the first week in November and represented the middle to late periods of fermentation; during the 1950 season, the samples were taken during September, 4th to 9th, and covered the early period of fermentation. The brine temperatures of the fermentations sampled during the 1950 season were as follows: Indiana brines, 19 to 20°C; Michigan and Wisconsin brines, 15.5 to 20°C. Brine temperatures were not taken during the 1948 and 1949 sampling periods. A total of 452 yeast isolates were obtained during the investigation and information as to their source is presented in table 2. A general picture with respect to total yeast populations, rate of increase in brine strength, and chemical changes with respect to brine acidity and pH, is presented in figure 1. The curves represent mean values for all brines collected during the 3-year period.

TABLE 1. LOCATION OF NORTHERN CUCUMBER BRINING STATIONS FROM WHICH BRINE SAMPLES WERE COLLECTED DURING 1948, 1949, AND 1950.

| State | Brining Station | | General Location of Station in Each State | Brining Seasons During Which Station Was Visited | |
|---|---|---|---|---|---|
| | *code* | *no.* | | *no.* | *yrs.* |
| Indiana | NJ | | North West | 3 | 1948–50 |
| | KR | | North West | 3 | 1948–50 |
| | KO | | North West | 1 | 1948 |
| State Total | | 3 | | | |
| Michigan | LT | | South Central | 3 | 1948–50 |
| | LA | | South Central | 3 | 1948–50 |
| | CL | | Central | 2 | 1949–50 |
| | BA | | South West | 1 | 1948 |
| | RD | | South Central | 1 | 1948 |
| | SG | | East Central | 1 | 1950 |
| | NL | | Central | 1 | 1950 |
| | SN | | East Central | 1 | 1950 |
| | CS | | West Central | 1 | 1950 |
| | LV | | West Central | 1 | 1950 |
| | CC | | East Central | 1 | 1950 |
| State Total | | 11 | | | |
| Wisconsin | BR | | Central | 2 | 1948; 50 |
| | WY | | Central | 2 | 1948; 50 |
| | PL | | South East | 2 | 1948; 50 |
| | WA | | Central | 2 | 1948; 50 |
| | OX | | Central | 1 | 1948 |
| | GB | | East Central | 1 | 1950 |
| | WU | | Central | 1 | 1950 |
| | NK | | Central | 1 | 1950 |
| State Total | | 8 | | | |
| Total | | 22 | | | |

Of the 155 individual vats sampled, about one-third were under outside conditions and the remainder were sheltered from the weather and direct sunlight. Vats so protected afford excellent conditions for good growth of yeast species responsible for film formation on the brine surface (Etchells and Bell, 1950 *b*). More important is the fact that contamination of subsurface brine samples with species of film yeasts can become a problem unless care is taken with the sampling procedure (Etchells and Jones, 1946; Etchells and Bell, 1950 *a*). In the present study, less than 3 percent of the 452 isolates were classified as film yeasts which originated from surface growth on sheltered vat brines. The 12 film yeast isolates (7 *Candida* and 5 *Debaryomyces*) came from seven brines; five were collected during the 1949 season; and two from 1950.

The brine samples were collected, plated, and counted according to methods previously described by Etchells (1941) and revised by Etchells and Jones (1946), and Etchells and Bell (1950 *a*). All brines were plated on acidified glucose agar containing 6 to 8 percent salt by weight and the plates from the high dilutions set aside for picking representative colonies. These colonies were identified and the proportion of each species present was assigned a value which gave an estimate of their numbers in the brine sample. The methods and classification systems employed for the 452 isolates were essentially those outlined by the Dutch workers; Stelling-Dekker (1931), Lodder (1934), Diddens and Lodder (1942), and Custers (1940). Bedford's (1942) classification system was used for the genus *Hansenula*. For confirming the ability of isolates of certain genera (e.g. *Hansenula* and *Brettanomyces*) to utilize nitrate, the assimilation test of Wickerham (1946, 1951) was particularly useful. Certain other modifications and additions were made in connection with the taxonomic tests employed by the Dutch group. These have been fully described by Etchells and Bell (1950 *a*, *b*).

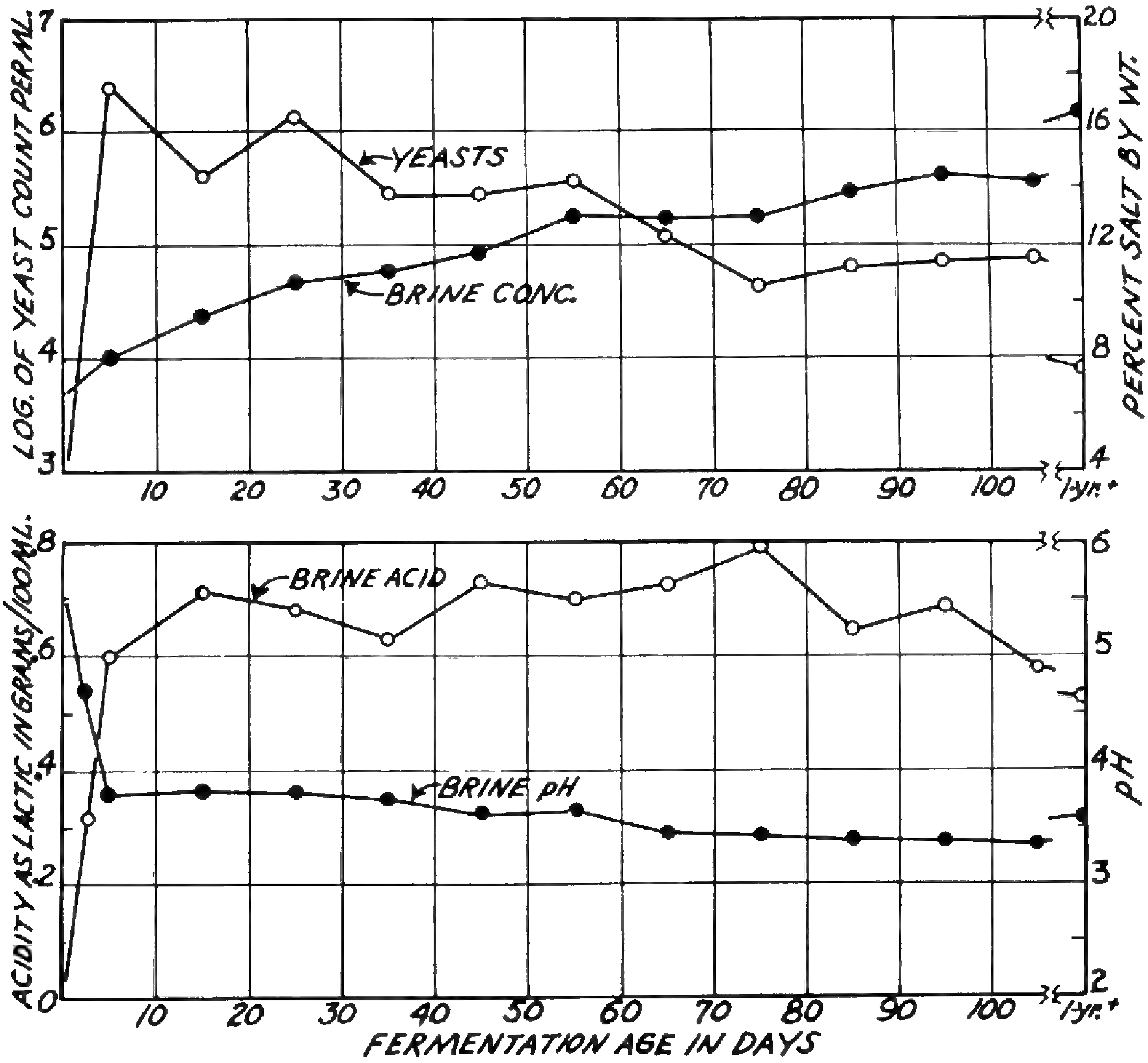

**Figure 1.** Total yeast populations, increase in brine concentration, brine acidity and pH of northern cucumber fermentations.

TABLE 2. ORIGIN OF 452 YEAST ISOLATES FROM 155 CUCUMBER BRINES OBTAINED FROM 22 BRINING STATIONS LOCATED IN INDIANA, MICHIGAN, AND WISCONSIN (1948–50 BRINING SEASONS).

| State and Brining Season | Brining Stations Visited[1] | Brine Samples Obtained | Chemical Examination of Brines | | | Fermentation Period Covered by Samplings[2] | Yeast Isolates Obtained |
|---|---|---|---|---|---|---|---|
| | | | Salt Conc. by Wt. | Acidity as Lactic | pH | | |
| | *number* | *number* | *percent* | *percent* | | *days* | *number* |
| Indiana | | | | | | | |
| 1948 | 3 | 11 | 13–17 | 0.46–.88 | 4.1–3.4 | 54–97 | 31 |
| 1949 | 2 | 21 | 13–15 | .34–.78 | 3.6–3.2 | 66–105 | 56 |
| 1950 | 2 | 16 | 4–12 | .27–.85 | 3.9–3.7 | 4–55 | 59 |
| | 7 | 48 | | | | | 146 |
| Michigan | | | | | | | |
| 1948 | 4 | 20 | 11–18 | 0.38–.88 | 4.2–3.1 | 39–94 | 57 |
| 1949 | 3 | 16 | 14–17 | .52–.83 | 3.7–3.3 | 70–98 | 33 |
| 1950 | 9 | 32 | 7–12 | .31–.92 | 4.8–3.6 | 2–44 | 97 |
| | 16 | 68 | | | | | 187 |
| Wisconsin | | | | | | | |
| 1948 | 5 | 21 | 11–14 | 0.62–1.16 | 3.6–3.2 | 48–100 | 58 |
| 1949 | 0 | 0 | .... | .... | .... | .... | 0 |
| 1950 | 7 | 18 | 8–13 | .41–.98 | 4.1–3.6 | 13–38 | 61 |
| | 12 | 39 | | | | | 119 |
| Overall | 35 | 155 | 4–18 | 0.27–1.16 | 4.8–3.1 | 2–105 | 452 |

[1] Refers to total number visits to 22 individual brining stations operated by 8 pickle plants and located as follows: Indiana, 3 stations; Michigan, 11; and Wisconsin, 8.

[2] Brine samples were obtained from several vats in Indiana and Michigan during 1948 and 1949 after 12–14 months' storage.

## RESULTS

The 452 isolates obtained during the 3-year study were reduced to eight generic groups as follows: I. *Brettanomyces*, 132 isolates (29.2%); II. *Torulopsis*, 103 (22.8%); III. *Torulaspora*, 68 (15.0%); IV. *Hansenula*, 59 (13.1%); V. *Saccharomyces*, s.g. *Zygosaccharomyces*, 46 (10.2%); VI. *Saccharomyces*, s.g. *Saccharomyces* s.s., 22 (4.9%); VII. *Candida*, 7 (1.5%); VIII. *Debaryomyces*, 5 (1.1%); and an unclassified group of 10 isolates. Species separation under each generic group is summarized in table 3. Information is also presented on species distribution for each brining season with respect to: (1) Number of isolates found; (2) number of vat brines where found; and (3) number of brining stations where found.

### Predominating Genera

Group I, Genus *Brettanomyces* Kuff. et van Laer: Of the 132 isolates placed in this genus, 103 were identified as *B. versatilis* Etchells et Bell. This yeast was the most frequently isolated species obtained during the study and was widely distributed in the brines collected each season from all three states. *B. versatilis* was also found in several instances where the brine samples came from vats of salt-stock that were 12–14 months old. Twenty-nine isolates were closely related to *B. sphaericus* Etchells et Bell. Until further study can be made of this group, we prefer to list them as an unnamed variety of *B. sphaericus*. Most of these cultures were obtained in Indiana and Michigan during the 1949 and 1950 brining seasons.

Group II, Genus *Torulopsis* Berlese: The 103 cultures placed in this genus consisted of two species: *T. holmii* (Jörgensen) Lodder accounted for 67 cultures which, with the exception of one isolate obtained in 1948, came from brines collected from nine brining stations during the 1950 season. This species occurred chiefly in brines during the early part of the fermentation. The 36 isolates placed as *T. caroliniana* Etchells et Bell were obtained during two brining seasons (1948 and 1950), and came mostly from brines collected at two Indiana brining stations; however, a few cultures were isolated from Michigan brines.

Group III, *Torulaspora* Lindner: The 68 isolates placed in this genus were identified as *T. rosei* Guillermond and were obtained in about equal numbers from brines collected during the 1948 and 1950 seasons. This yeast was not found in the 1949 brines collected in the regular manner. The cultures were identical as far as cultural, morphological, fermentation, and carbon assimilation reactions were concerned, but differed with respect to sporulation behavior. Some sporulated readily; others produced typical copulation tubes but spores did not develop; still others produced neither copulation tubes nor spores.[2]

Group IV, Genus *Hansenula* Sydow: This genus was represented by

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[2] Dr. L. J. Wickerham kindly checked representative cultures of our *T. rosei* collection and found the carbon assimilation patterns to be the same.

TABLE 3. CLASSIFICATION AND DISTRIBUTION OF 452 YEAST ISOLATES FROM 155 NORTHERN CUCUMBER BRINES.

| Generic Group (Number and Percent of Isolates), and Species | Classification of Isolates | | Distribution of Isolates According to: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Brining Season | | | Vat Brines | | | Brining Stations | | |
| | | | 1948 | 1949 | 1950 | 1948 (52) [1] | 1949 (37) [1] | 1950 (66) [1] | 1948 (12) [2] | 1949 (5) [2] | 1950 (18) [2] |
| | *no.* | *percent* | *no. isol.* | *no. isol.* | *no. isol.* | *no. vats* | *no. vats* | *no. vats* | *no. sta.* | *no. sta.* | *no. sta.* |
| I. BRETTANOMYCES (132; 29.2%) | | | | | | | | | | | |
| *B. versatilis* | 103 | 22.8 | 43 | 27 | 33 | 21 | 17 | 19 | 12 | 5 | 8 |
| *B. sphaericus var.* | 29 | 6.4 | 0 | 15 | 14 | 0 | 12 | 9 | 0 | 4 | 5 |
| II. TORULOPSIS (103; 22.8%) | | | | | | | | | | | |
| *T. holmii* | 67 | 14.8 | 1 | 0 | 66 | 1 | 0 | 23 | 1 | 0 | 9 |
| *T. caroliniana* | 36 | 8.0 | 16 | 0 | 20 | 6 | 0 | 7 | 2 | 0 | 3 |
| III. TORULASPORA (68; 15.0%) | | | | | | | | | | | |
| *T. rosei* | 68 | 15.0 | 35 | 0 | 33 | 17 | 0 | 14 | 7 | 0 | 7 |
| IV. HANSENULA (59; 13.1%) | | | | | | | | | | | |
| *H. subpelliculosa* | 59 | 13.1 | 19 | 24 | 16 | 16 | 15 | 9 | 9 | 4 | 7 |
| V. ZYGOSACCHAROMYCES s.g. (46; 10.2%) | | | | | | | | | | | |
| *Z. halomembranis* | 28 | 6.2 | 7 | 14 | 7 | 4 | 8 | 7 | 2 | 2 | 2 |
| *Z. globiformis* | 14 | 3.1 | 11 | 0 | 3 | 7 | 0 | 2 | 5 | 0 | 1 |
| *Z.* sp. A | 3 | 0.7 | 0 | 1 | 2 | 0 | 1 | 2 | 0 | 1 | 1 |
| *Z. pastori* | 1 | 0.2 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| VI. SACCHAROMYCES s.g. (22; 4.9%) | | | | | | | | | | | |
| *S. globosus* | 22 | 4.9 | 13 | 0 | 9 | 6 | 0 | 4 | 4 | 0 | 3 |
| VII. CANDIDA (7; 1.5%) | | | | | | | | | | | |
| *C. krusei* | 7 | 1.5 | 0 | 0 | 7 | 0 | 0 | 2 | 0 | 0 | 2 |
| VIII. DEBARYOMYCES (5; 1.1%) | | | | | | | | | | | |
| *D. membran.* var. *Holl.* | 5 | 1.1 | 0 | 5 | 0 | 0 | 5 | 0 | 0 | 2 | 0 |
| UNCLASSIFIED | 10 | 2.2 | 1 | 2 | 7 | 1 | 1 | 6 | 1 | 1 | 6 |
| | 452 | 100 | 146 | 89 | 217 | | | | | | |

[1] Number of vat brines collected each year; values listed in each column represent the number of brines where each species was found.

[2] Number of individual brining stations visited each year; values listed in each column represent the number of brining stations where each species was found.

59 cultures of *H. subpelliculosa* Bedford, obtained from representative brining stations in Indiana, Michigan, and Wisconsin. This species was consistently found during all three brining seasons. The cultures were divided into two groups; those that fermented maltose, and those that gave a weak to negative fermentation test for this sugar. Etchells and Bell (1950 *a*) considered that the fermentation of maltose was a weak characteristic for this species because of the variable reactions obtained when a sufficient number of cultures were studied. More recently, Wickerham (1951) also found that *H. subpelliculosa* gave a variable maltose fermentation.

Group V, Genus *Saccharomyces* (Meyen) Reess; subgenus *Zygosaccharomyces* Barker; The 46 isolates placed in this subgenus were allocated to the following four species: *Z. halomembranis* Etchells et Bell, 28 cultures; *Z. globiformis* Kr. et Kb., 14; *Z.* species A, 3; and *Z. pastori* Guillermond, 1. The species *Z. halomembranis* was consistently found in the brines of two Indiana stations during the 3-year study. The isolates placed as *Z. globiformis* were similar but not identical to this species. However, the characteristics were essentially the same as those described in detail by Etchells and Bell (1950 *a*) for their *Z.* species A, obtained from the fermentation of cucumbers brined under southern conditions.

Group VI, Genus *Saccharomyces* (Meyen) Reess; subgenus *Saccharomyces* s.s.: This subgenus was represented by 22 cultures of *S. globosus* Osterw. obtained during the 1948 and 1950 seasons from a total of seven brining stations, two in Wisconsin and five in Michigan. This particular yeast constitutes the chief difference with respect to the individual species found in northern brines as compared to those found in southern brines (Etchells and Bell, 1950 *a*). Although *S. globosus* was not found as frequently as certain of the other species, four active gaseous fermentations were attributed to this yeast. They were observed in 1948 at two brining stations in Michigan and one in Wisconsin, in brines that were 43, 44, 99, and 100 days old.

Group VII, Genus *Candida* Berkhout emend. Diddens et Lodder: The seven cultures placed in this genus were identified as *C. krusei* (A. Cast.) Berkhout and came from two 1950 brines of low salt content (4 and 8 percent). The presence of these isolates in the subsurface brine samples is attributed to film formation on the two sheltered vat brines from which they were obtained. This species was found by Etchells and Bell (1950 *b*) to be associated with film formation on commercial pickle brines of about 5 percent strength.

Group VIII, Genus *Debaryomyces* Klöcker: The five isolates of this genus were identified as the film yeast *D. membranaefaciens* var. *Hollandicus* Lodder. The cultures were obtained from five brines collected during the 1949 season at two brining plants in Indiana. The vats at both stations were sheltered from direct sunlight and provided excellent conditions for film yeast development on the surface of the brines. It is our opinion that the five *Debaryomyces* cultures originated from the surface growth on the brines.

Unclassified Group: Ten of the 452 cultures obtained during the study have not been fully classified. Seven of the unidentified isolates came from six brines of the 1950 season; two were obtained during 1949; and one in 1948.

## Populations of Individual Species

The results for the 3-year study with respect to estimated population trends for the different yeast species occurring in the 155 brines are shown in figure 2. In the preparation of these scatter diagrams, the individual values plotted represent the estimated yeast count as to species in the various brines. The general trend for species activity in each case is represented by the curve drawn through the individual values, calculated from means obtained at 10-day intervals throughout the fermentation period.

Two yeasts, *T. holmii* and *B. versatilis,* show rather clear-cut fermentation trends. The first species occurred chiefly during the early portion of the fermentation; the second dominated the late portion. As mentioned earlier, *T. holmii,* with one exception, was not found in the brines collected during the 1948 and 1949 brining seasons. A possible reason for this was that these brines represented the middle to late periods of fermentation (40 days and beyond). Thus, on the basis of the 1950 season's results, *T. holmii* would not be expected to be found in any large numbers in brines that were over 30 to 40 days in age.

The consistent occurrence of *Hansenula subpelliculosa* from brining stations representative of the three states throughout the three pickling seasons is sufficient to include this species as one of the principal species contributing to the yeast fermentation. Perhaps the same is true for *Torulaspora rosei,* even though it was not obtained from brines collected during the 1949 season. However, during 1949, brines were not obtained from Wisconsin (Cf. tables 1 and 2); whereas the four stations sampled in that state during 1948 accounted for almost three quarters of the *T. rosei* isolates obtained from all 12 stations sampled. Further, the fermentation trend (Cf. figure 2) for this yeast is not fully characterized because plate counts were not made on 11 of the 1948 Wisconsin brines where *T. rosei* represented almost 60 percent of the isolations.

The activity of *Zygosaccharomyces halomembranis* in northern brines is based chiefly on consistent isolations of this species from two Indiana stations during the three brining seasons. Etchells and Bell (1950 *b*) identified this yeast as one of the species responsible for films on sheltered commercial vat brines located in Indiana, Michigan and Wisconsin. This species ferments glucose and maltose strongly and it is our opinion that it exists in commercial brines both as an oxidative and fermentative species, thus accounting for its occurrence in subsurface fermenting brines as well as for its occurrence on the surface of sheltered vat brines. Laboratory tests confirm this assumption.

The dominant position occupied by *Torulopsis caroliniana* in the early portion of southern cucumber fermentations (Etchells and Bell, 1950 *a*) is in sharp contrast to the relatively minor role exhibited by this species in the current study on northern brines. It appears that *T. holmii* is the major species contributing to the early part of the northern fermentations, and *T. caroliniana* is of minor importance. *T. caroliniana* was found for a much longer period in northern than in southern brines; about 90 days versus 40 days. This is attributed, in part, to the fact that even though the former brines generally contain more total acid than the latter, they

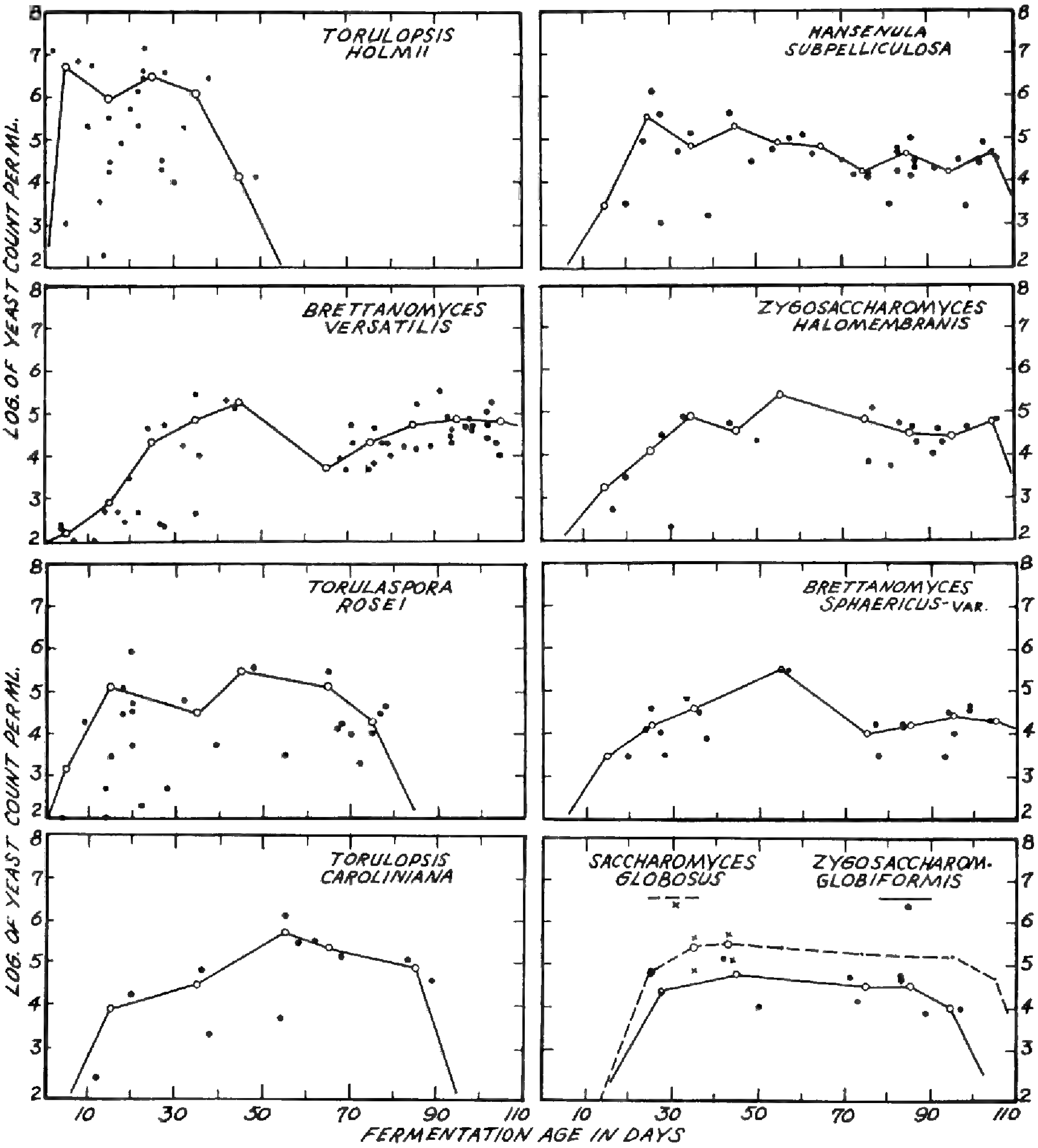

**Figure 2.** Population trends for nine species and one variety of six yeast genera occurring in cucumber fermentations brined under northern conditions.

also are more highly buffered and thus are not as toxic for *T. caroliniana* which is less acid tolerant than the other brine yeast species. Further, there is reason to believe that in some northern brines, *T. caroliniana* may have been missed because they grew out very poorly on the acidified glucose agar containing salt. Colonies which were about 0.1–0.2 mm. in diameter were first considered to be poorly developed lactobacilli colonies growing out, but later proved to be *T. caroliniana.* Upon transfer to less acid media, these cultures gave growth typical of the species. However, since all brines were first screened for the numbers and morphological types of live and dead yeast cells by the direct microscopic counting technique, it is doubtful if many isolates representing substantial populations of this species in brines were overlooked. *T. caroliniana,* because of its extremely small size, can usually be recognized in brine fermentations by microscopic examination.

Of the remaining three species (shown in figure 2), two, the unnamed variety of *Brettanomyces sphaericus* and *Saccharomyces globosus,* should be discussed briefly. The former species occurred in the brines during essentially the same period as did *B. versatilis* although not in as large numbers, or as consistently on a seasonal basis. Further, *B. sphaericus* var. was the only species, other than *B. versatilis*, that was found in brines after a 12–14 months' storage period. *S. globosus* occurred in several instances at rather widespread brining stations, and in rather high populations (400,000 to 500,000 per ml.). In a few cases it was found to be the principal yeast responsible for the vigorous gaseous fermentation that was observed when the brine samples were collected. Although this yeast species was obtained less frequently than most of the others, it cannot be omitted from important consideration as contributing to the gaseous fermentation in certain northern brines, ranging from 25 to over 100 days in age. As indicated before, the 50 unnamed isolates of *Zygosaccharomyces* (sp. A) obtained and described by Etchells and Bell (1950 *a*) from southern fermentations are considered to be the same as the 14 isolates placed as *Z. globiformis* in the present report. In both studies, this yeast represented about the same proportion of total isolations; 3.1 and 3.5 percent respectively for the northern and southern brine yeast studies.

## Yeast Sequence in the Fermentation

A general picture as to yeast sequence in the fermentation of cucumbers under northern brining conditions based on the 3-year study is presented in figure 3. In the preparation of this diagram only data regarding five of the fermentative yeast species found in the brines were used. It is our opinion that these five yeasts were the principal species that contributed most consistently to the general yeast fermentation. The lesser species, *T. caroliniana, S. globosus, Z. globiformis, Z.* sp. A, *Z. pastori,* and the variety of *B. sphaericus* are not shown. *Candida krusei* and *Debaryomyces membranaefaciens* var. *Holl.* were excluded on the basis that they were only very minor species, and because they probably originated during sampling from films on vat brines and thus were not a part of the subsurface yeast fermentation.

## Influence of Room Temperature Incubation on Vat Brine Samples

During late October of the 1949 season, one quart samples of cucumbers and brine were collected by the plant chemist of one of the cooperating pickle plants from 21 vats located at six of their brining stations in Indiana, Michigan, and Wisconsin. These samples were incubated at room temperature in the control laboratory of the plant for about two weeks.

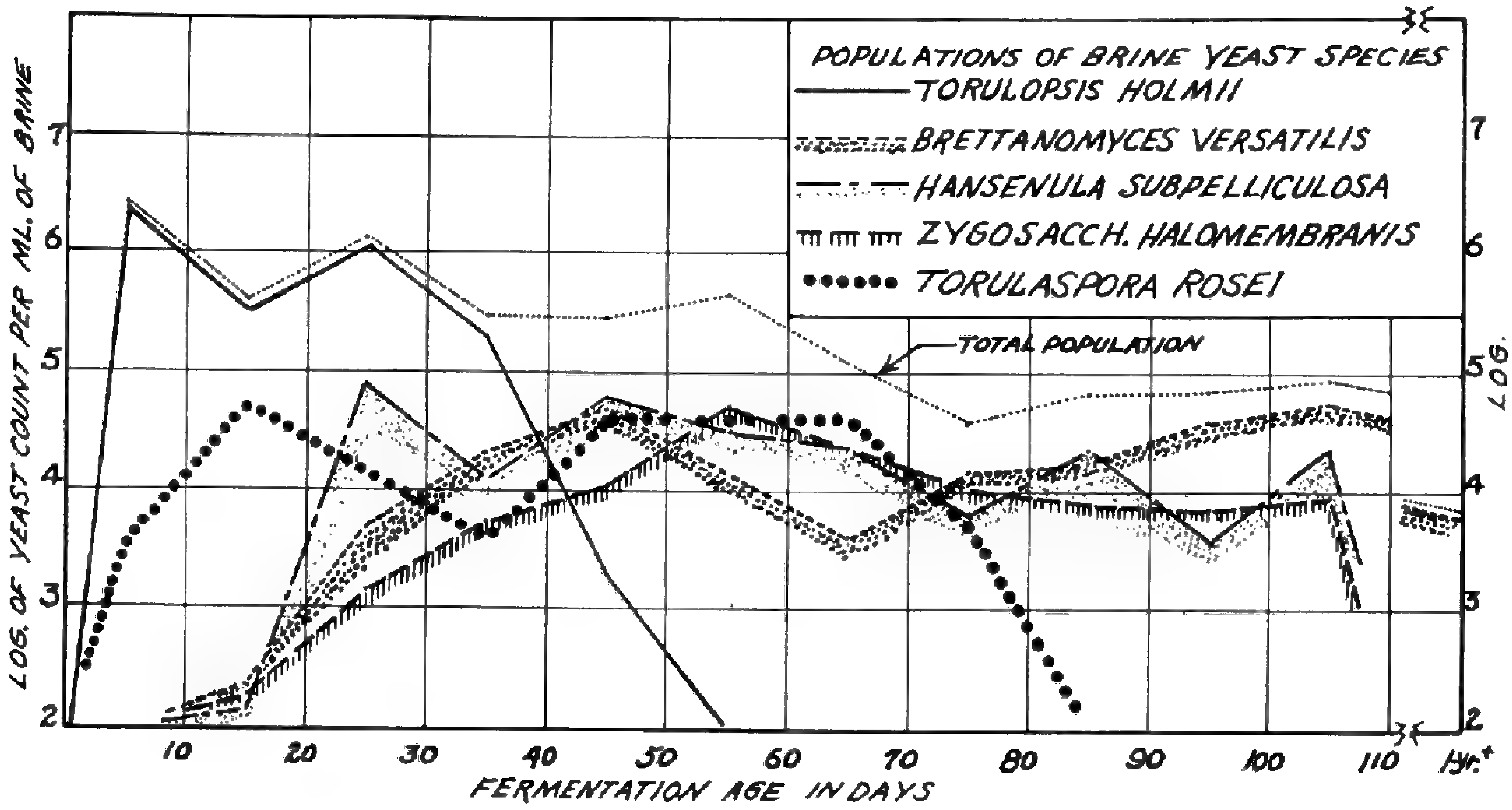

**Figure 3.** Yeast populations according to sequence of species in the fermentation of cucumbers brined under northern conditions.

Subsequent examination by us for the numbers and types of yeasts present is shown in table 4. Of the 55 isolates obtained, 40, or 73 percent, were *Brettanomyces versatilis*. This represents about a threefold increase in the numbers of this species compared to those obtained from brines in the same age group, but handled in the regular manner. Because of this very apparent difference in the numbers of *B. versatilis* present in the incubated brines, the 55 isolates, representing four yeast species, were not included in our results for the 1949 study. It is worth mentioning however, that five isolates of *T. rosei* were found in two of the incubated brines from one Wisconsin station. It will be recalled that this yeast was not found in the regular brines for 1949 and this was attributed in part to the fact that brining stations in Wisconsin were not visited during that season.

## Pattern of Brine Yeast Species in Cucumber Fermentations

During the past five years the authors have isolated close to 1,900 yeast cultures from commercial cucumber fermentations. So far, the isolates directly related to the gaseous fermentation and subsequent storage period

TABLE 4. CLASSIFICATION OF 55 YEAST ISOLATES FROM 21 NORTHERN CUCUMBER BRINES WHICH WERE INCUBATED AT ROOM TEMPERATURE PRIOR TO EXAMINATION (1949 SEASON).

| | | | Chem. Exam. of Brines | | | | Yeast Found and Number of Isolations | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Brettanomyces | | Hansenula | Zygosacch. | Torulaspora | |
| Brining Station (Code) | Vat No. | Age of Vat Brines | Salt Conc. by Wt. | Acidity as Lactic | pH | Yeast Plate Count per ml. of Brine | *B. versatilis* | *B. Sphaericus* var. | *H. subpelliculosa* | *Z. halomembranis* | *T. rosei* | Station Totals |
| | | *days* | *percent* | *percent* | | *in thous.* | | | | | | |
| NJ | 10 | 71 | . . . | . . . | . . . | 28 | 3 | | | | | (26) |
| | 12 | 71 | 13 | 0.63 | 3.6 | . . . | | | 2 | | | |
| | 19 | 77 | 12 | .73 | 3.7 | . . . | 2 | | | | | |
| | 20 | 97 | 14 | .54 | 3.7 | 400 | 2 | | | | | |
| | 23 | 79 | 13 | .75 | 3.6 | 140 | 3 | | | 2 | | |
| | 27 | 76 | 13 | .68 | 3.6 | . . . | 1 | | | | | |
| | 28 | 76 | 13 | .59 | 3.6 | 800 | 2 | | | | | |
| | 41 | 63 | 13 | .66 | 3.8 | 68 | 3 | | | | | |
| | 43 | 69 | 14 | .61 | 3.9 | 10 | 3 | | | | | |
| | 46 | 56 | 14 | .50 | 4.0 | 710 | 3 | | | | | |
| KR | 6 | 76 | 13 | 0.56 | 3.8 | 260 | 2 | | 1 | | | (16) |
| | 26 | 73 | 13 | .55 | 3.7 | 240 | 2 | | | | | |
| | 32 | 64 | 12 | .52 | 3.6 | . . . | 2 | | | 1 | | |
| | 35 | 57 | 13 | .68 | 3.6 | . . . | | 1 | 1 | | | |
| | 41 | 79 | 13 | .41 | 3.6 | 370 | 3 | | | | | |
| | 42 | 73 | 13 | .32 | 3.8 | 160 | 2 | | 1 | | | |
| PL | 27 | 69 | . . . | . . . | . . . | 12 | | | | | 2 | (5) |
| | 28 | 77 | . . . | . . . | . . . | 23 | | | | | 3 | |
| CL | 33 | 70 | 12 | 0.57 | 3.6 | . . . | 2 | | | | | (2) |
| LA | 23 | 76 | 12 | 0.58 | 3.6 | 28 | 3 | | 1 | | | (4) |
| BA | 13 | 93 | 16 | 0.66 | 3.3 | . . . | 2 | | | | | (2) |
| | | | | | | Total | 40 | 1 | 6 | 3 | 5 | 55 |
| | | | | | | % of Total | 73 | 2 | 11 | 5 | 9 | 100% |

have been classified into nine species and one variety of six genera. Based on the study of southern brines (Etchells and Bell, 1950 *a*) and on the current work, a probable pattern of brine yeast species (shown in table 5) has been prepared. From the work done to date, it becomes apparent that the pattern of species in brines from both northern and southern areas is very similar, although not necessarily identical. The occurrence of *S. globosus* in northern brines is the principal floral difference encountered to date. This overall pattern for yeasts in cucumber fermentations certainly does not mean that additional species could not be found; the limiting factors for obtaining minor yeast species in cucumber fermentations has been discussed before (Cf. Etchells and Bell, 1950 *a*). Nor does it mean that certain species of *Candida*, *Debaryomyces*, *Rhodotorula*, and *Endomycopsis* will not occasionally be obtained from brines at the time cucumbers are brined (initial sampling), or in connection with the subsurface sampling of vats having luxuriant surface films.

TABLE 5. PATTERN OF PRINCIPAL BRINE YEAST SPECIES IN COMMERCIAL CUCUMBER FERMENTATIONS.[1]

| Species Found in Northern Brines | YEAST | Species Found in Southern Brines [2] |
|---|---|---|
| | BRETTANOMYCES | |
| + | *B. versatilis* | + |
| — | *B. sphaericus* | + |
| + | *B. sphaericus* var. | — |
| | TORULOPSIS | |
| + | *T. caroliniana* | + |
| + | *T. holmii* | + |
| | TORULASPORA | |
| + | *T. rosei* | + |
| | HANSENULA | |
| + | *H. subpelliculosa* | + |
| | ZYGOSACCHAROMYCES | |
| + | *Z. halomembranis* | + |
| + | *Z. globiformis* | + |
| | SACCHAROMYCES | |
| + | *S. globosus* | — |

[1] Based on 1,896 isolates obtained from fermenting brines collected during five brining seasons (1946–50) from both northern and southern brining areas.

[2] Compiled from the study by Etchells and Bell (1950*a*).

## SUMMARY

A study of the yeasts predominating during the fermentation of cucumbers under conditions typical of brining areas in Indiana, Michigan, and Wisconsin is presented. During three brining seasons (1948–50), 452 yeast isolates were obtained from 155 vat brines collected from 22 individual brining stations, operated by eight commercial pickle companies, in the above three states. Most of the isolations were made during a fermentation period of 2 to 105 days, although a few cultures came from vat brines that were 12 to 14 months old. During the period of observation the brines ranged from 4 to 18 percent salt by weight; 0.27 to 1.16 percent acid (calc. as lactic); and, 4.8 to 3.1 with respect to pH values.

The 452 yeast cultures were reduced to the following species listed in the order of frequency of isolation: *Brettanomyces versatilis* Etchells et Bell, 103 isolates (22.8%); *Torulaspora rosei* Guillermond, 68 (15.0%); *Torulopsis holmii* (Jörgensen) Lodder, 67 (14.8%); *Hansenula subpelliculosa* Bedford, 59 (13.1%); *Torulopsis caroliniana* Etchells et Bell, 36 (8.0%); *Brettanomyces sphaericus* var., 29 (6.4%); *Zygosaccharomyces halomembranis* Etchells et Bell, 28 (6.2%); *Saccharomyces globosus* Osterw., 22 (4.9%); *Zygosaccharomyces globiformis* Kr. et Kb., 14 (3.1%); *Candida krusei* (A. Cast.) Berkhout, 7 (1.5%); *Debaryomyces membranaefaciens* var. *Hollandicus* Lodder, 5 (1.1%); *Zygosaccharomyces* sp. A, 3 (0.7%); *Zygosaccharomyces pastori* Guillermond, 1 (0.2%); and 10 (2.2%) isolates not fully classified. The presence of a few cultures of the film yeasts *C. krusei* and *D. membranaefaciens* var. *Holl.* was attributed to heavy surface film formation on the vat brines from which subsurface brine samples were obtained.

Results on the most likely sequence of yeasts occurring during the fermentation demonstrated that two species, *Torulopsis holmii* and *Brettanomyces versatilis,* were outstanding. The first yeast predominated during the early period of fermentation (2 to 30 days) and was followed by the second yeast which was most prevalent during the late stage of fermentation (70 to 110 days), but was still present in brines after 12 to 14 months' storage. Between the above two extremes in yeast sequence, the species *Torulaspora rosei, Hansenula subpelliculosa,* and *Zygosaccharomyces halomembranis* were active.

## ACKNOWLEDGMENTS

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# MORPHOLOGY AND PIGMENTATION OF CERTAIN YEASTS FROM BRINES AND THE CUCUMBER PLANT

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## GENERAL INTRODUCTION [1, 2]

The purpose of this publication is to acquaint teachers, students, and research workers interested in the study of yeasts with some of our observations on the colonial and cellular morphology of the common yeast species associated with fermentations in brine.

The illustrative material shown, and hitherto unpublished, was compiled during the past several years in connection with our taxonomic studies on the principal species of yeasts associated with the gaseous fermentation of commercially brined cucumbers (*6*, *11*), as well as investigations on the identity of the types responsible for film formation on brines (*7*).

In addition to the above sources, material relating to recent work (unpublished) on the pigmented yeasts that occur on the cucumber plant has been included. Further, certain yeast species associated with meat brines are illustrated. The latter work represents a phase of investigations on meat microbiology being conducted in the Department of Animal Industry of the North Carolina Agricultural Experiment Station in cooperation with the Bureau of Animal Industry (USDA) Beltsville, Maryland.

The material presented is divided into three major parts: film-forming brine yeasts; subsurface brine yeasts; and, yeasts from the cucumber plant. Each is organized to permit ready comparison of the striking influence of cultural media on: colonial morphology; cellular morphology; film formation (for some species), and, in some instances, colonial pigmentation. In all, species and varieties of yeasts belonging to 12 genera are shown. It is our hope that the illustrative material will benefit other workers and serve to supplement the monographs, bulletins and articles on methods and classification we have found useful in our yeast work (*1*, *3*, *4*, *14*, *16*, *17*, *20*, *21*).

## MEDIA AND METHODS

Because most of the cultural media used and techniques employed have been described in detail elsewhere, they will only be mentioned briefly here.

VEGETABLE-JUICE AGAR; as described by Wickerham *et al.* (*22*) and modified by Etchells and Bell (*6*). SYNTHETIC VEGETABLE-JUICE AGAR; a chemically defined medium designed to simulate vegetable-juice prepared for us by Dr. W. J. Peterson, Head, Department of Chemistry, North Carolina State College. GLUCOSE AGAR; as prepared by Etchells and Bell (*6*). GLUCOSE-SALT AGAR; as above but containing 8 percent salt by weight. SYNTHETIC AGAR-A; the glucose-mineral-salts medium used by Stelling-Dekker (*20*) plus 0.01 percent yeast extract. SYNTHETIC AGAR-B; prepared from Wickerham's (*21*) yeast nitrogen base medium as follows; heat sterilize in separate containers an equal amount of 3 percent agar, and an equal amount of double strength nitrogen base medium plus 4 percent glucose; then mix the contents of the two containers together before the agar cools and pour plates. SYNTHETIC BROTH-B; a heat sterilized, single strength, liquid form of the above medium (omit agar). Used for growing yeast cells in the tests for the presence and nature of carotenoid pigments. CORNMEAL AGAR; prepared according to Skinner *et al.* (*19*) and employed in the test for mycelium production by use of point inoculations as described by Wickerham and Rettger (*23*), and Wickerham (*21*). Salt-tolerance tests were made in the divided culture dishes of Etchells and Bell (*7*), using a liquid medium consisting of cucumber brine adjusted to cover a range from 5 to 20 percent salt by weight and fortified by the addition of glucose and ethyl alcohol in 1.0 percent amounts (*7*). Tests for growth in ethyl alcohol were made in regular culture dishes containing nutrient broth plus 3 percent ethyl alcohol as the carbon source. Stained cell preparations were made by the Kopeloff and Cohen modification of the Gram stain (*15*). Wet mount cell preparations were used to show living cells and spores from vegetable-juice agar cultures. Cells were suspended in erythrosin (1–10,000) buffered at pH 4.6, placed on a slide and the cover slip pressed down tightly and sealed with immersion oil.

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[1] **The authors gratefully acknowledge the grant from the National Pickle Packers Association, Chicago, Illinois to the North Carolina Agricultural Experiment Station, that made this publication possible by underwriting the cost of reproducing the natural color and black and white photographs.**

[2] Paper No. 449 of the Journal Series of the North Carolina Agricultural Experiment Station.

## FILM-FORMING BRINE YEASTS[3]

It has been mentioned in an earlier report (6) that yeasts associated with cucumber brines are divided into two general groups. Those that produce a gaseous fermentation in the brine and those that produce luxuriant, wrinkled films on the surface of brines exposed to air but sheltered from direct sunlight. It is not uncommon to find that the two groups are confused in the literature on cucumber pickling.

Film formation on 40 commercial cucumber brines obtained during 1947 and 1948 in five states (North Carolina, Georgia, Michigan, Indiana and Wisconsin) has been attributed to species of *Debaryomyces*, *Zygosaccharomyces*, *Endomycopsis*, and *Candida* (7). The predominating species found were *D. membranaefaciens* var. *Hollandicus*, and *Z. halomembranis*. They were also the most salt-tolerant. Yeasts belonging to the genus *Debaryomyces* were the most widespread and were found on brines in all five states.

A similar study was done in 1950 on the film yeasts from 23 commercial brines in Indiana, Michigan and Wisconsin (*10*). Emphasis here was placed on brines less than two months old and with salt concentrations of about 10 percent. The two predominating yeasts found were the same as obtained in the earlier study. However, the presence of cultures of *Pichia alcoholophila* and *Hansenula anomala* appeared to be related to the lower salt-content of the brines.

Salt-tolerance tests have since shown that the above two yeasts grew poorly if at all above 10 percent. The same is true for *Candida krusei* obtained from low salt-content dill pickle brines in the 1947–48 study.

In addition to brined cucumbers, film-forming yeasts are found in connection with a number of other similarly preserved foods. For example, Mrak and Bonar (*18*) investigated 28 cultures isolated from surface films on 27 samples of various brined foods (dill pickles, salt-stock pickles, Zucca melon, green olives, Sicilian olives, dill weed, cauliflower, and ham brine). They found film yeasts that belonged to three genera: *Debaryomyces*, 16 cultures; *Pichia*, 9; and *Mycoderma*, 3. The *Debaryomyces* species were the most widely distributed in the brines. They were also found to be the most salt-tolerant (up to 24%).

Etchells and Costilow (*9*) investigated the nature of film-forming yeasts on commercial meat brines (bacon sides, hams, beef tongues and Canadian bacon). A total of 89 yeast isolates was obtained and all were identified as belonging to the genus *Debaryomyces*. Eighty-six cultures were placed as *D. membranaefaciens* var. *Hollandicus*. The remaining three cultures were non-film-forming species that came from subsurface brine samples; these were classified as being closely related to *D. klockeri*. This yeast was also found to be the predominating type found in subsurface samples from bacon brines during a prolonged curing period.

More recently, Zenitani (*24*), isolated 29 yeast cultures from a Japanese fishery-fermentation product known as "Shiokara." Generic placement of the cultures was a follows: *Debaryomyces*, 19; *Zygosaccharomyces*, 8; *Hansenula* and *Torulaspora*, 1 each.

It is apparent that film-forming species of *Debaryomyces* are the most widely distributed yeasts associated with food brines. Other species in the approximate order of their importance would be; *Zygosaccharomyces halomembranis*, *Endomycopsis ohmeri* (and variety *minor*), *Candida krusei*, *Hansenula anomala* and *Pichia alcoholophila*.

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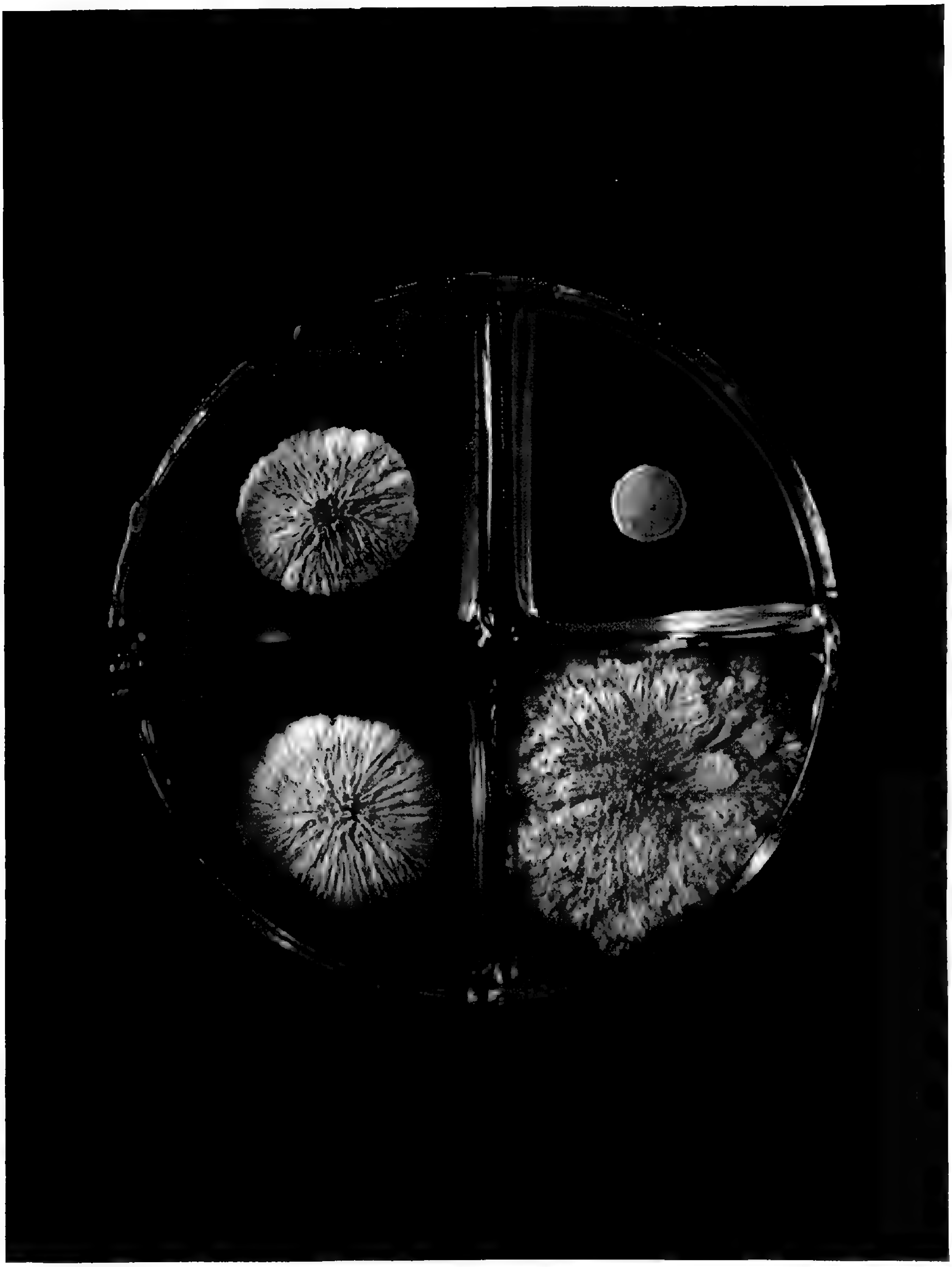
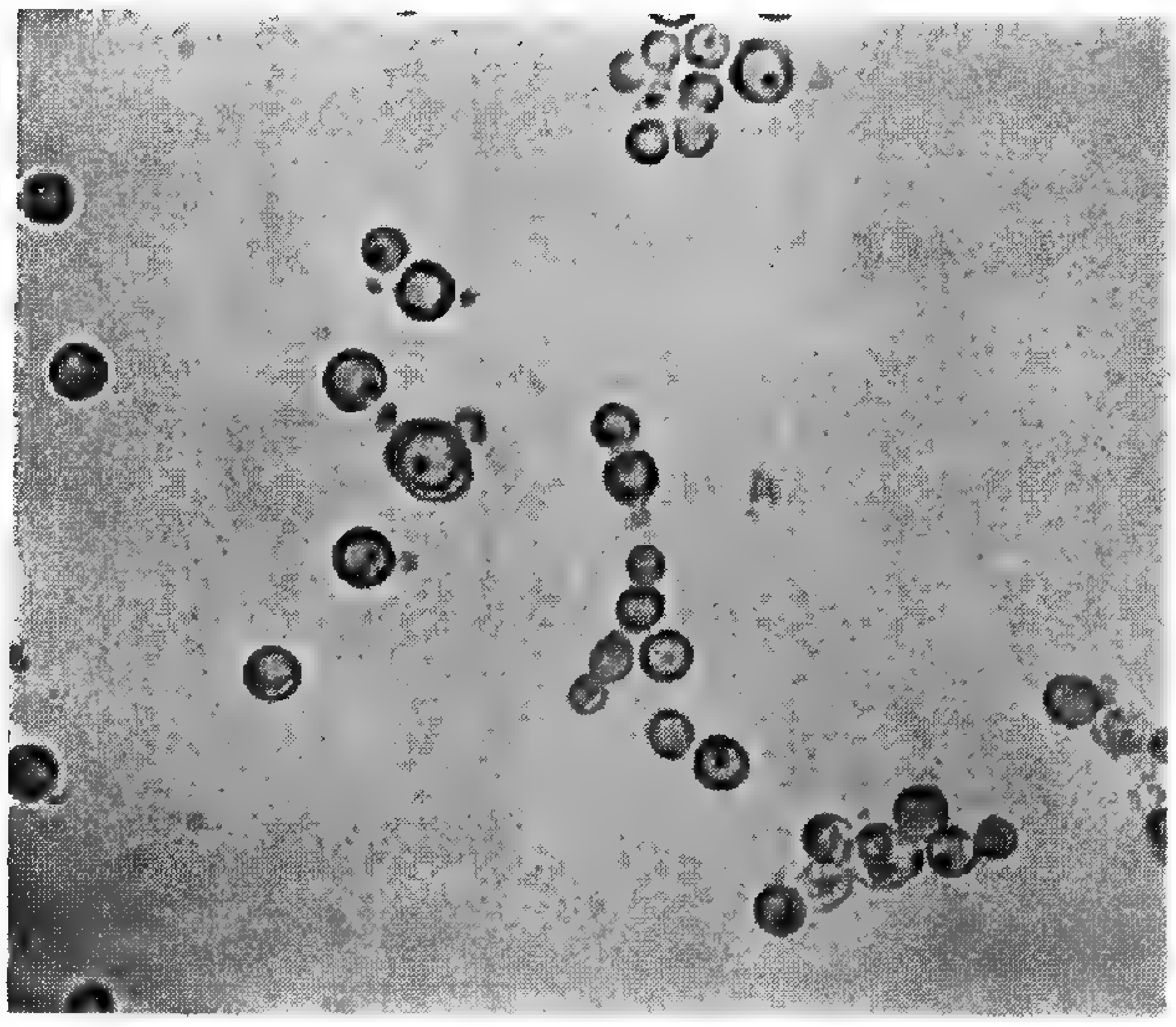
[3] Since this article was prepared, the important new book, "The Yeasts — A Taxonomic Study," by the Dutch workers, J. Lodder and N. J. W. Kreger-Van Rij, has appeared. Thus, we have not had an opportunity to consider their proposed changes in yeast classification.

Debaryomyces

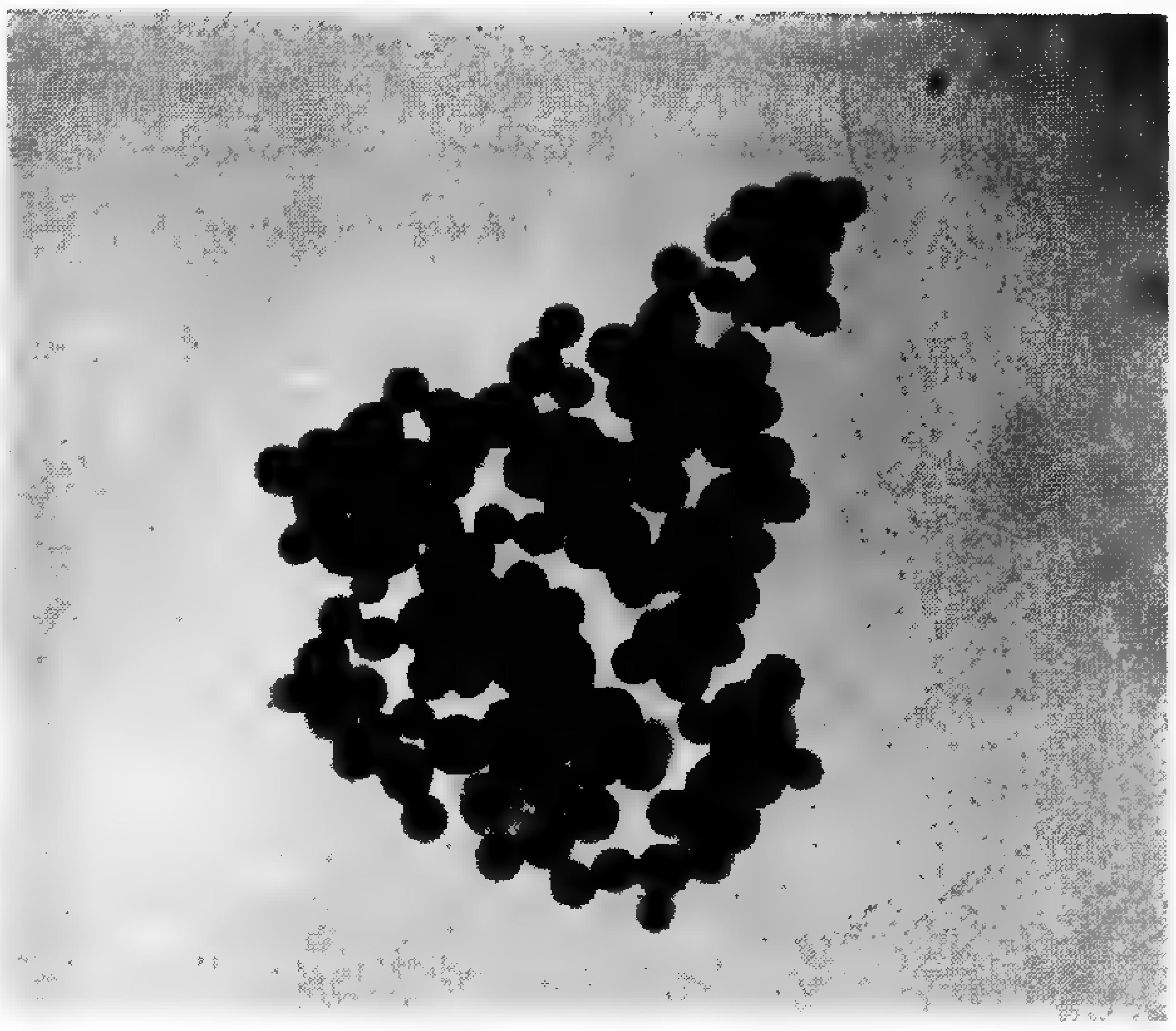


Vegetable-juice agar Synthetic agar-A
Glucose agar Glucose-salt agar

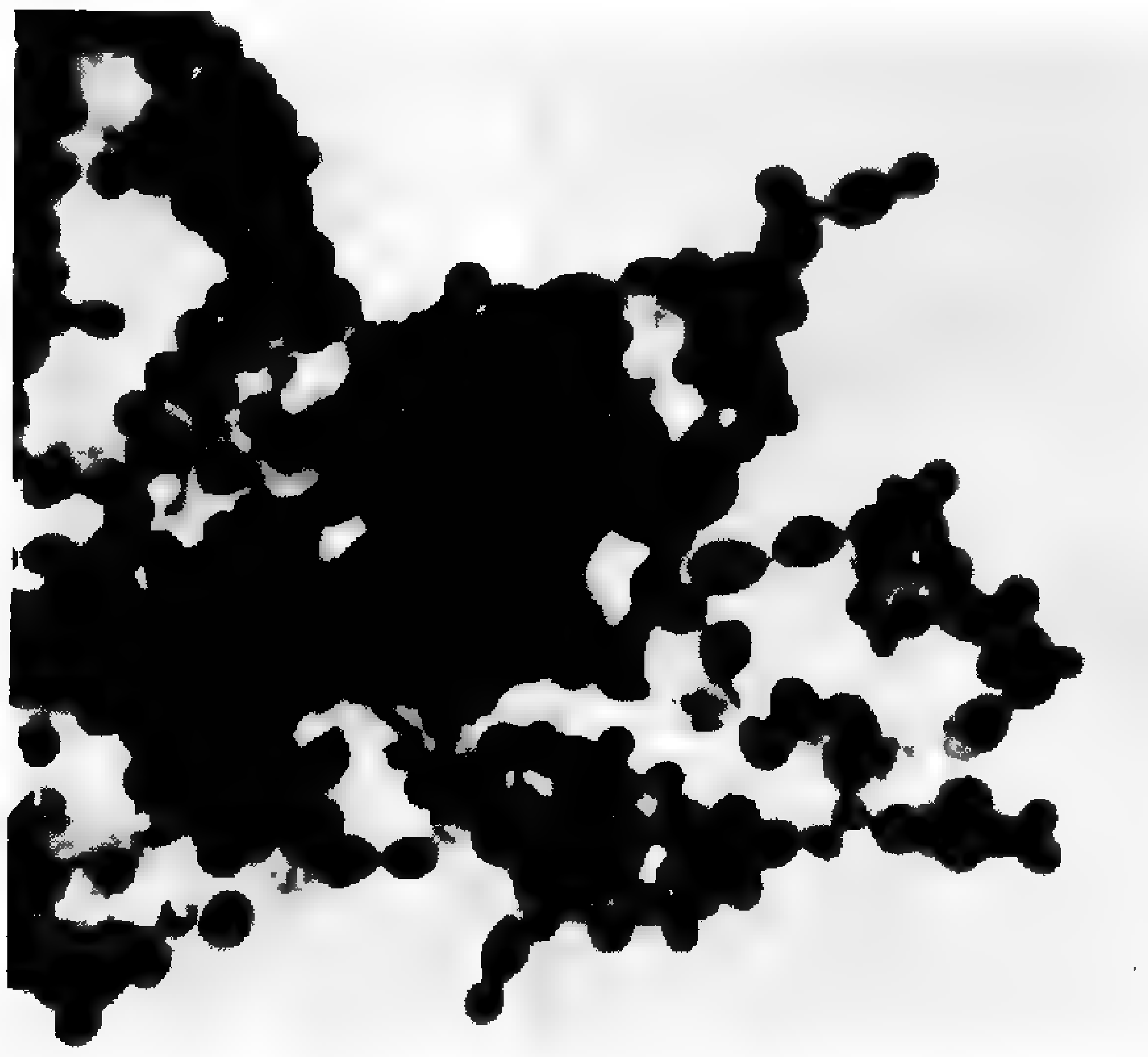
A. Comparative growth by *Debaryomyces membranaefaciens* var. *Hollandicus* Lodder (FY-36, Georgia strain) on different cultural media after 6 weeks' incubation at room temperature. Actual size. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.



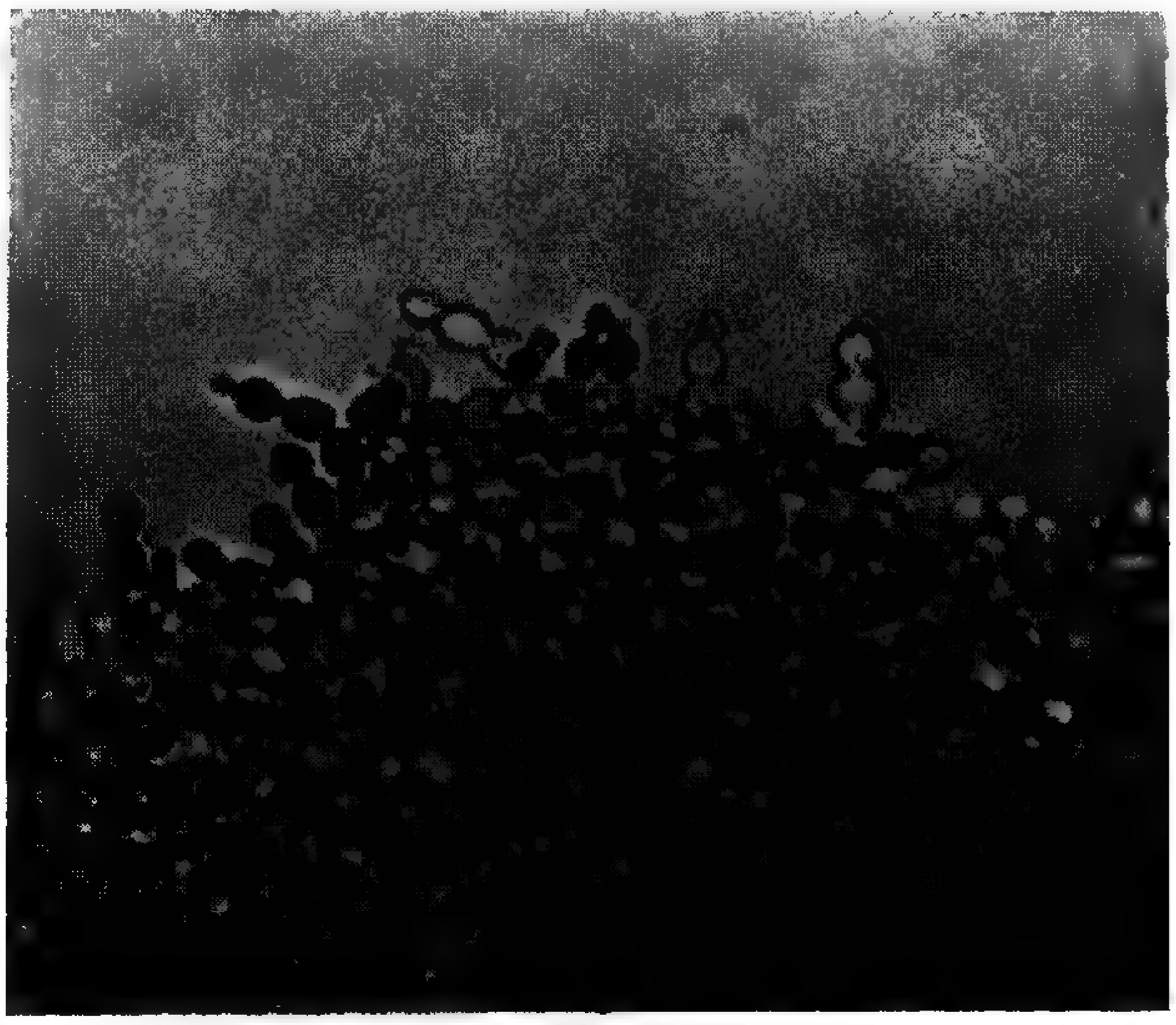
1. Sporulated cells from vegetable-juice agar at 2 months. Note rough spore (upper left); others completely fill asci. Unstained, × 1500.



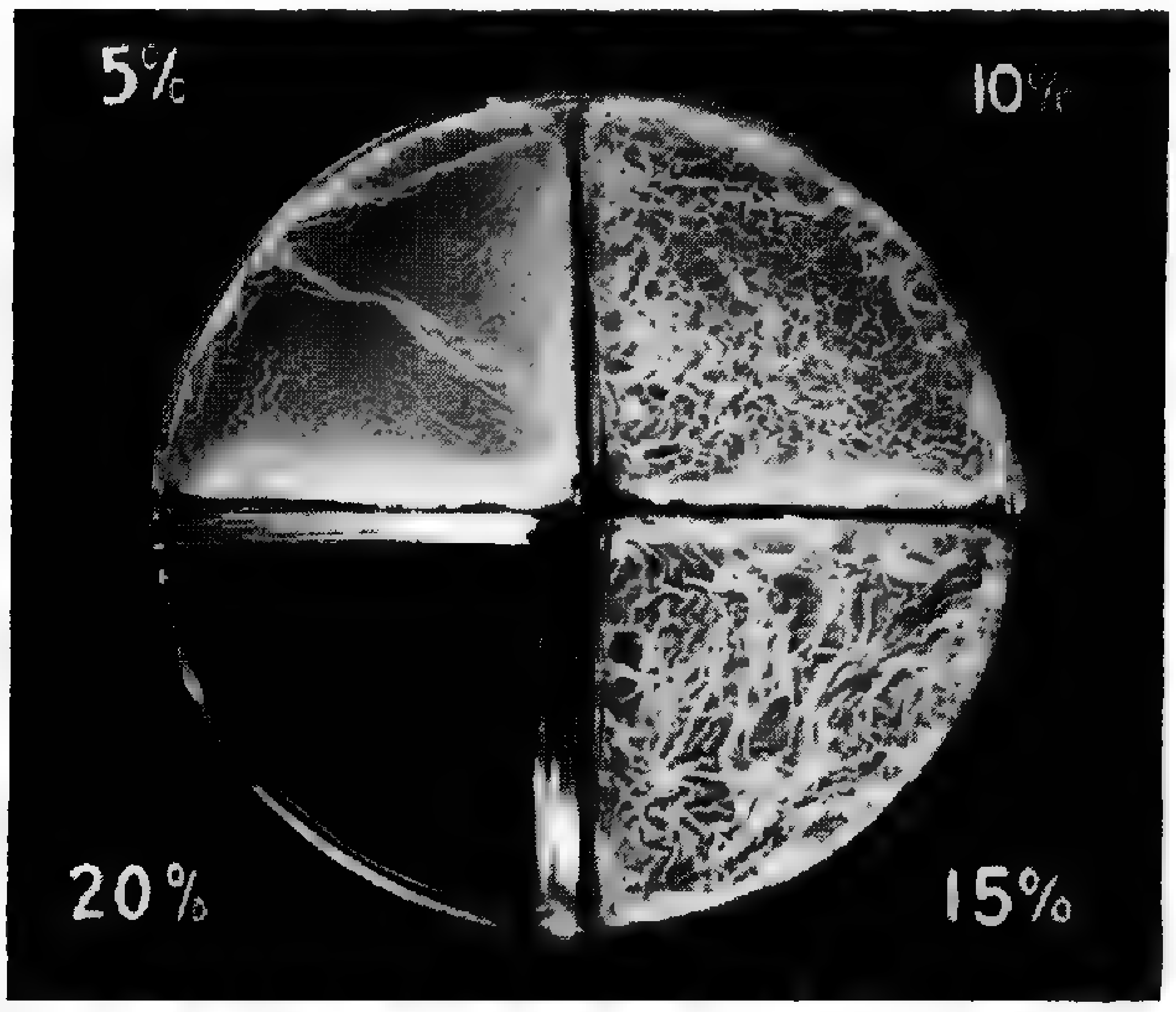
2. Round to oval cells from synthetic agar-A, 7-day old culture. Gram stained, × 1500.



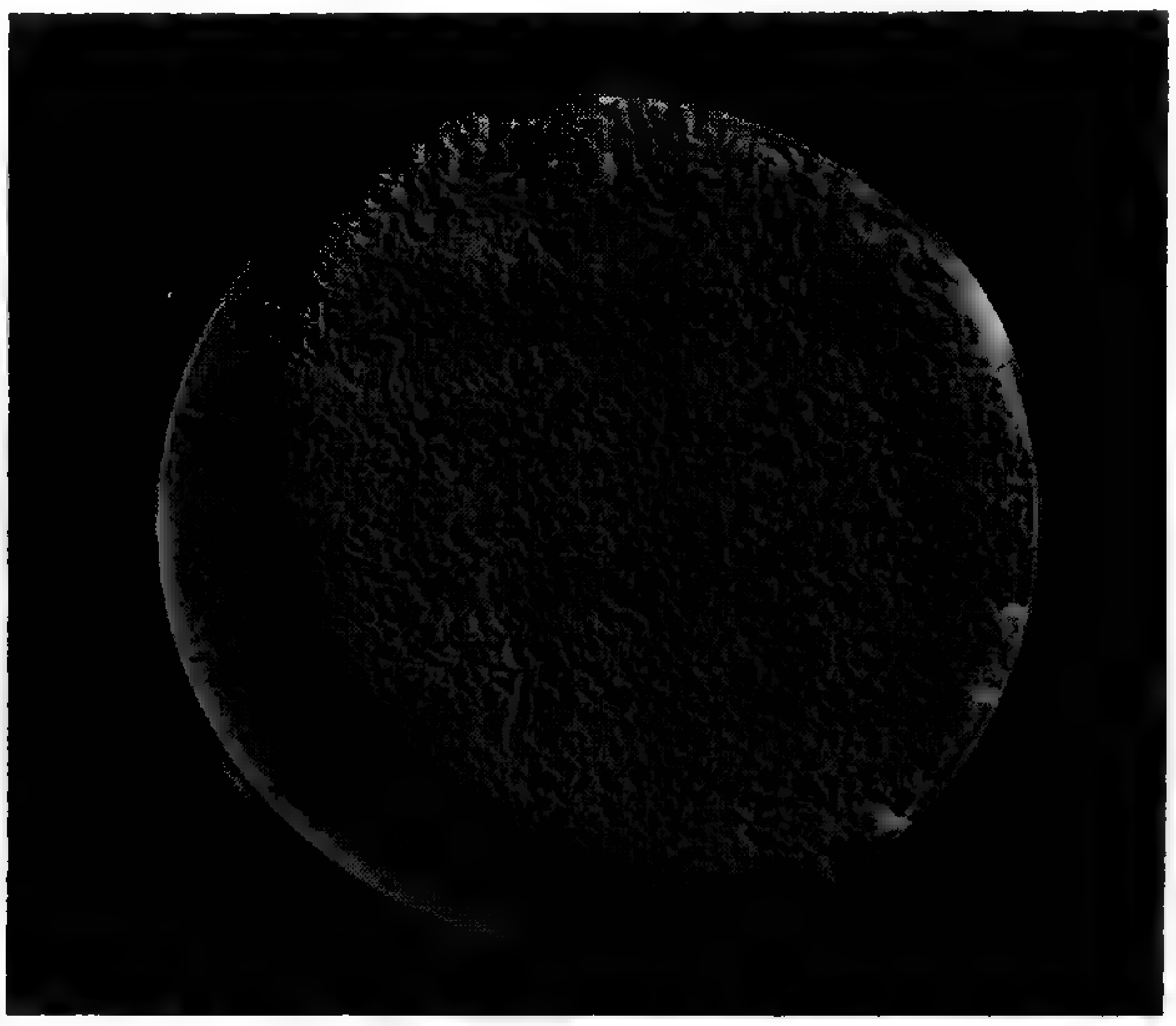
3. Cells from film on 10% salt cucumber brine, 5 days old. Gram stained, × 1500.



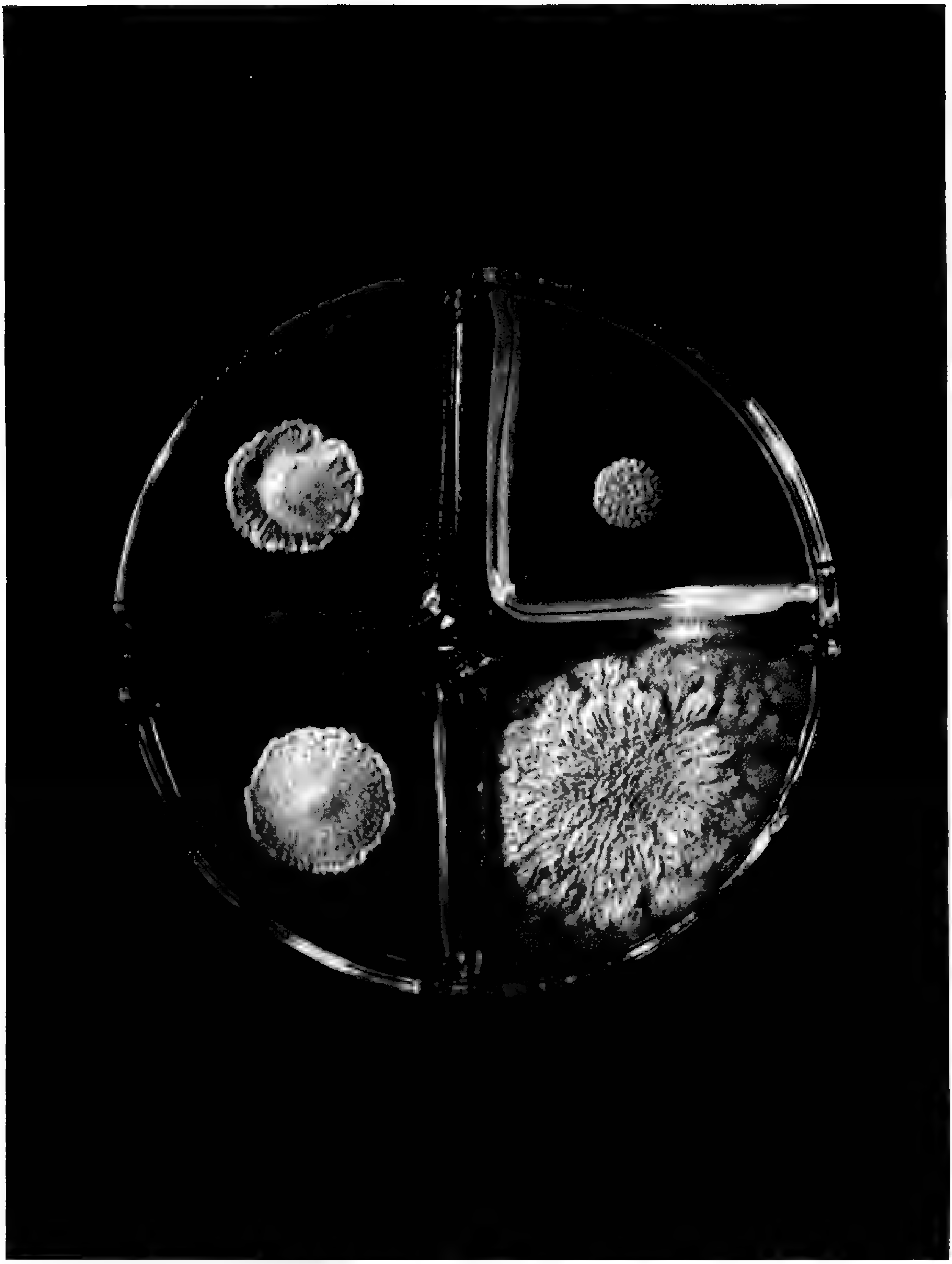
4. These cells show negative mycelium test on cornmeal agar at 3 weeks. Unstained, × 650; enlarged, × 2.



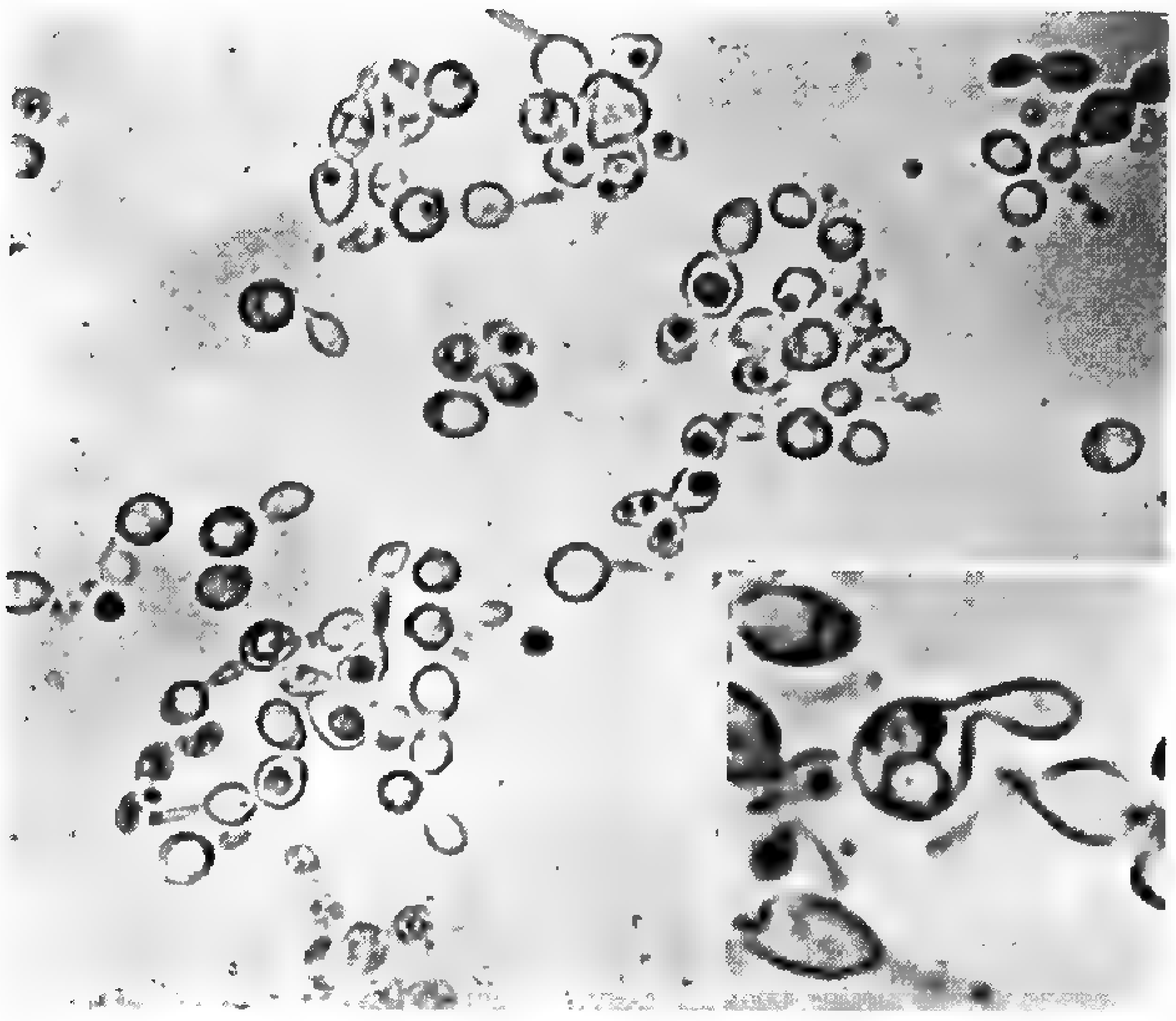
5. Salt-tolerance test at 7 days shows good growth at 3 brine concentrations; 10 days required for heavy growth at 20%. × ½.



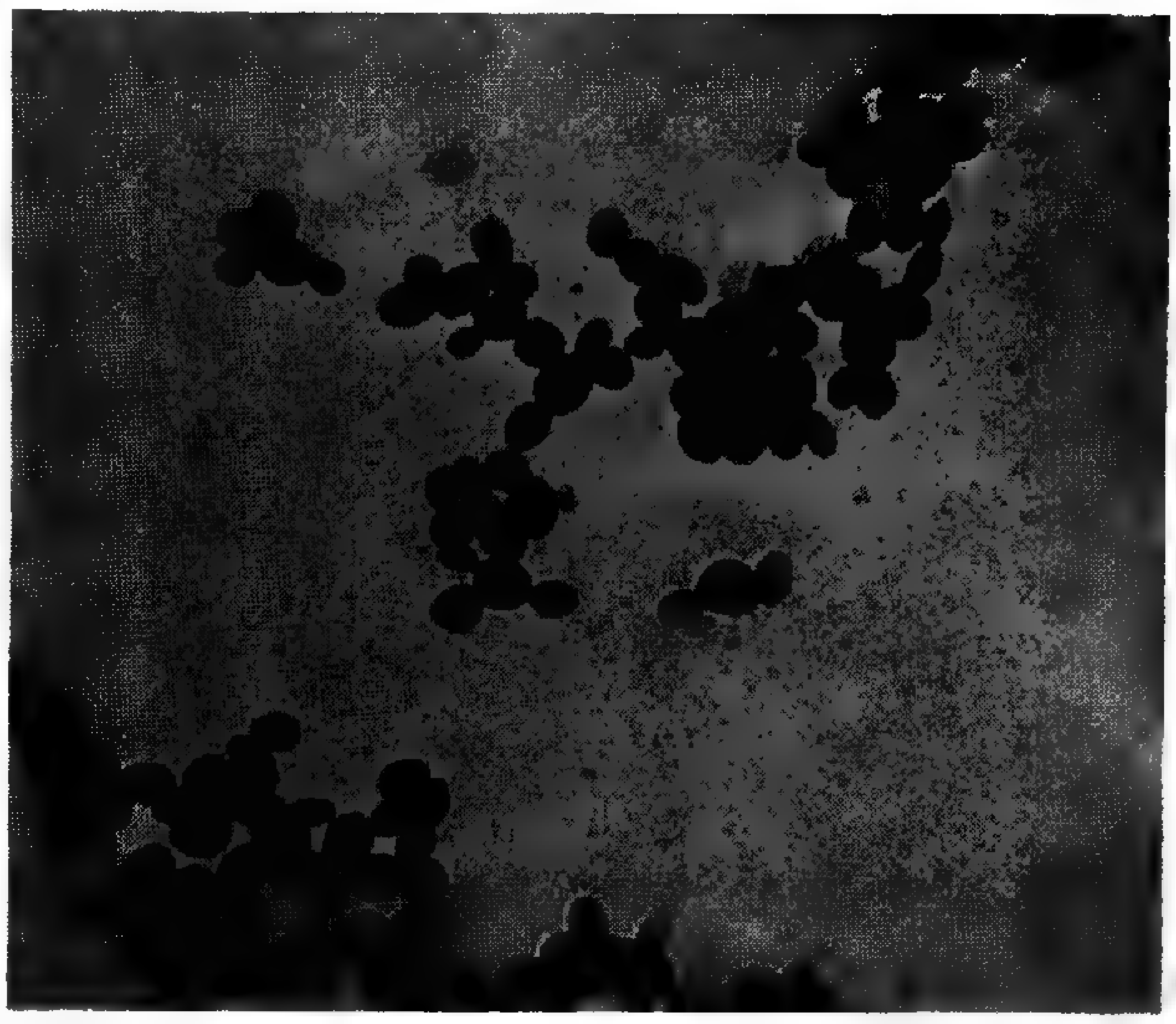
6. Heavy film formation on ethyl alcohol medium at 4 days. × ½.



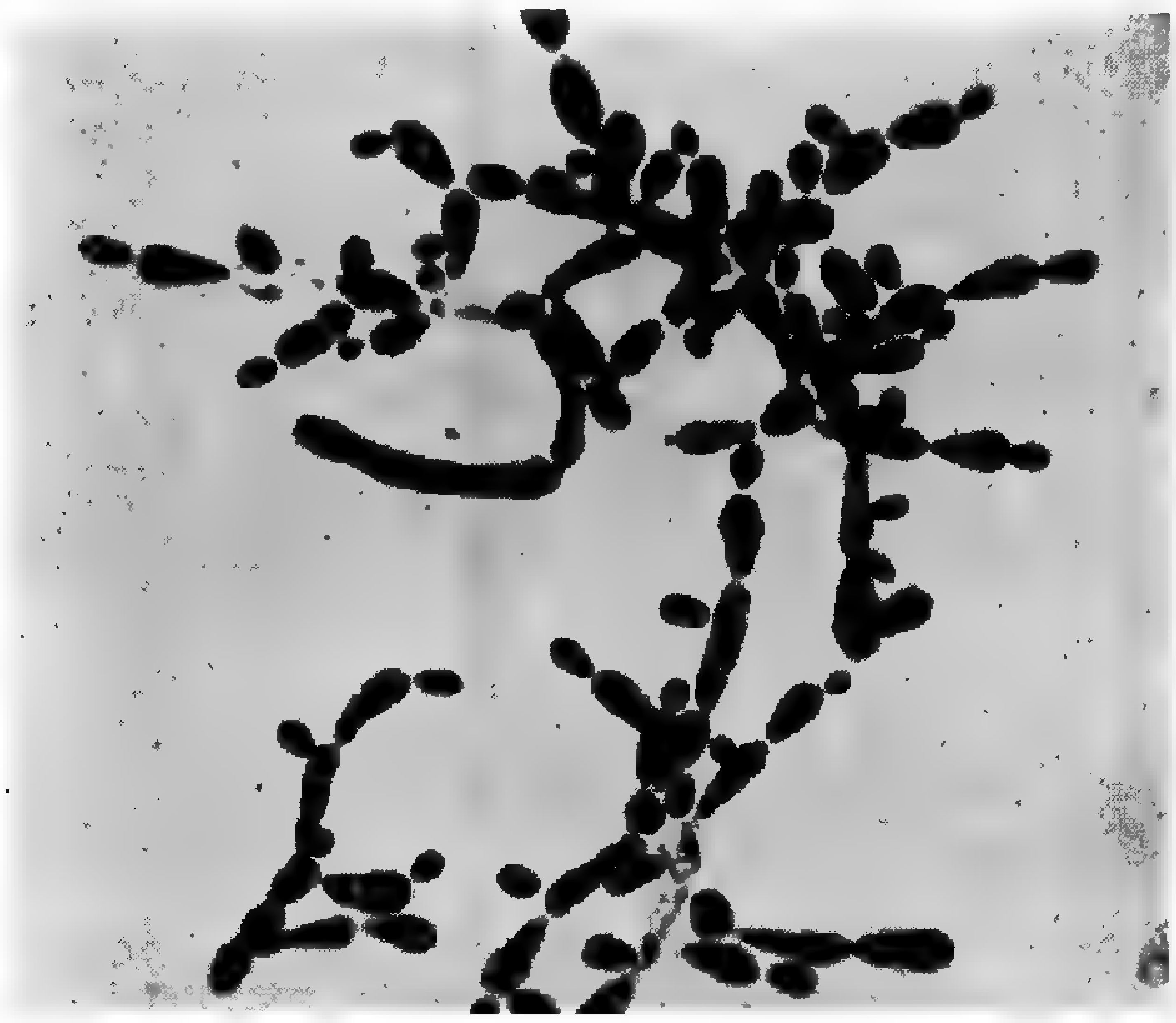
B. Comparative growth by *Debaryomyces membranaefaciens* var. *Hollandicus* Lodder (NFY-20, Wisconsin strain) on different cultural media after 6 weeks' incubation at room temperature. Actual size. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.



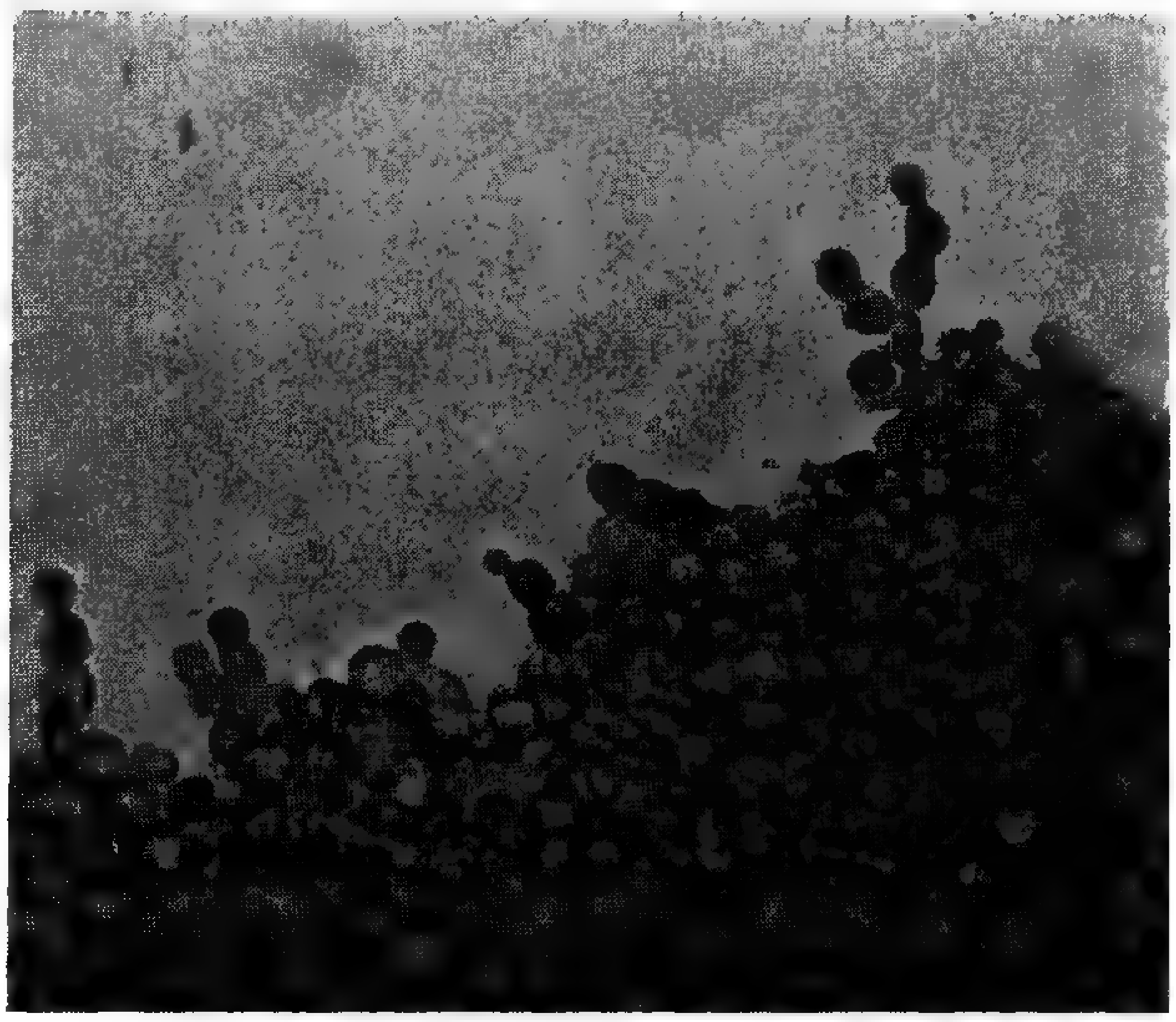
7. Tubular cells and single spores from vegetable-juice agar at 2 months. Unstained, × 1500. Insert; ascus with 2 spores, enlarged, × 2.



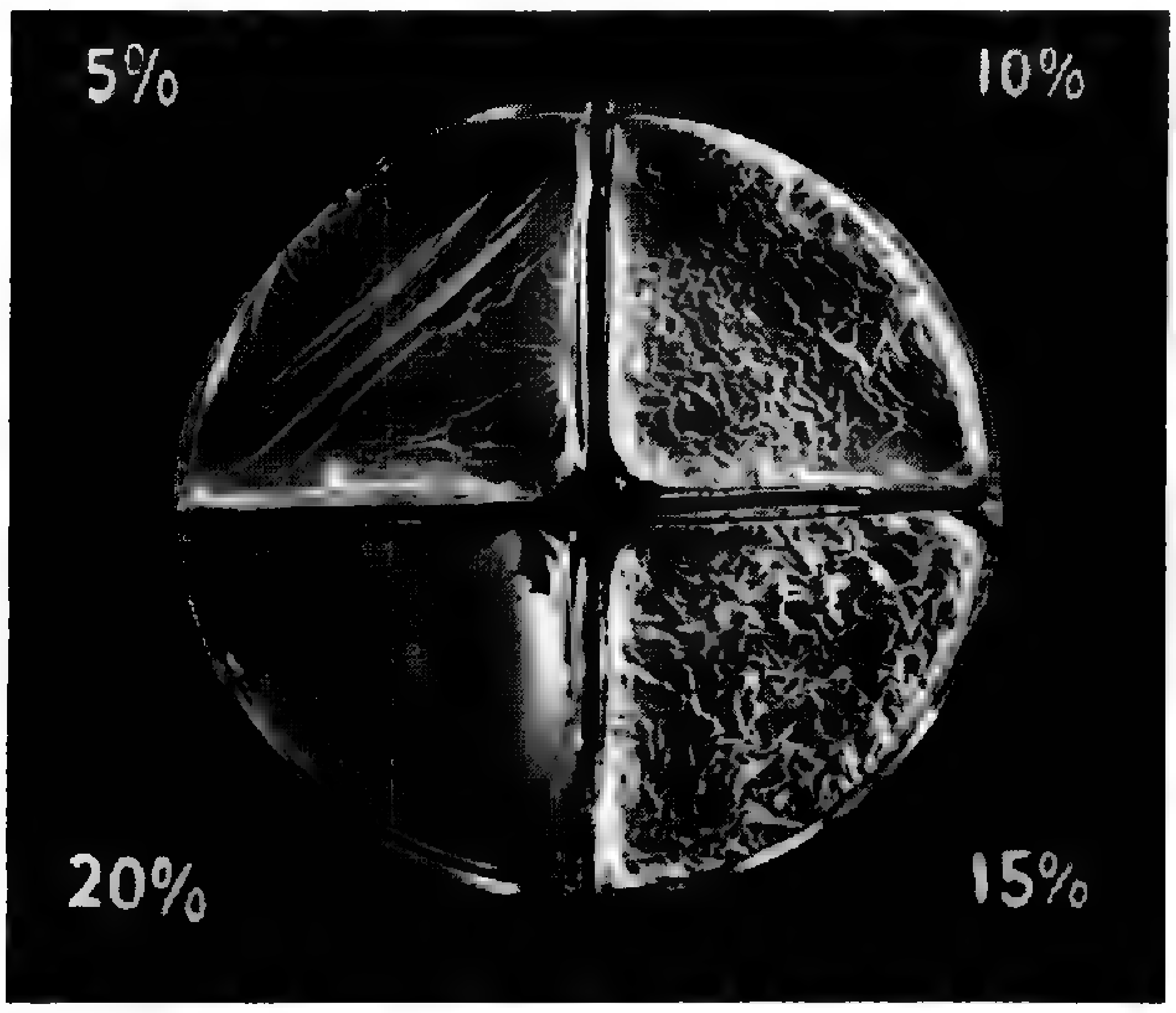
8. Round to oval cells from synthetic agar-A after 7 days. Gram stained, × 1500.



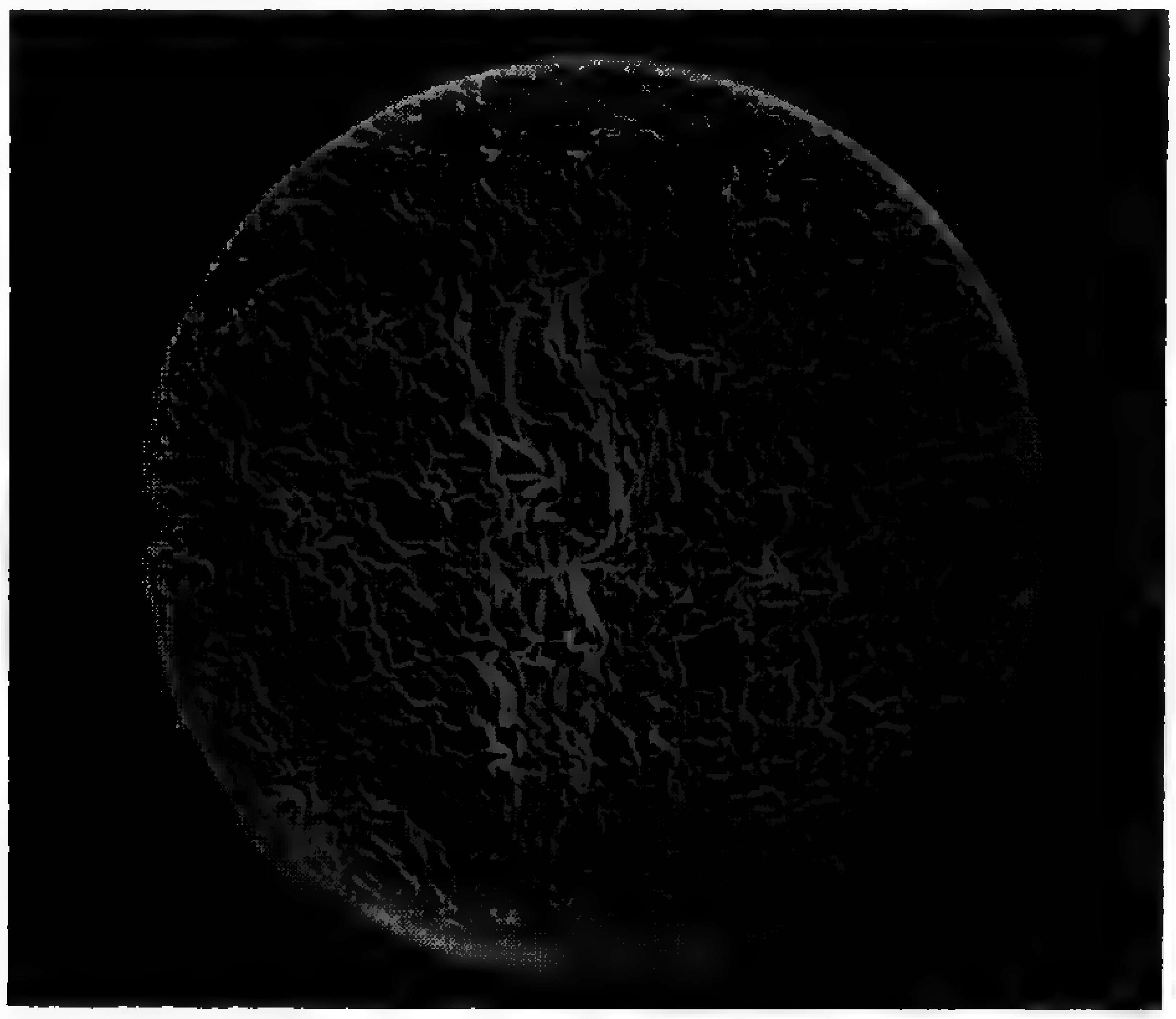
9. Elongated cells from film on 10% salt cucumber brine, 48 hours. Gram stained, × 1500.



10. Cells from cornmeal agar show negative mycelium test at 3 weeks. Unstained, × 950; enlarged, × 2.

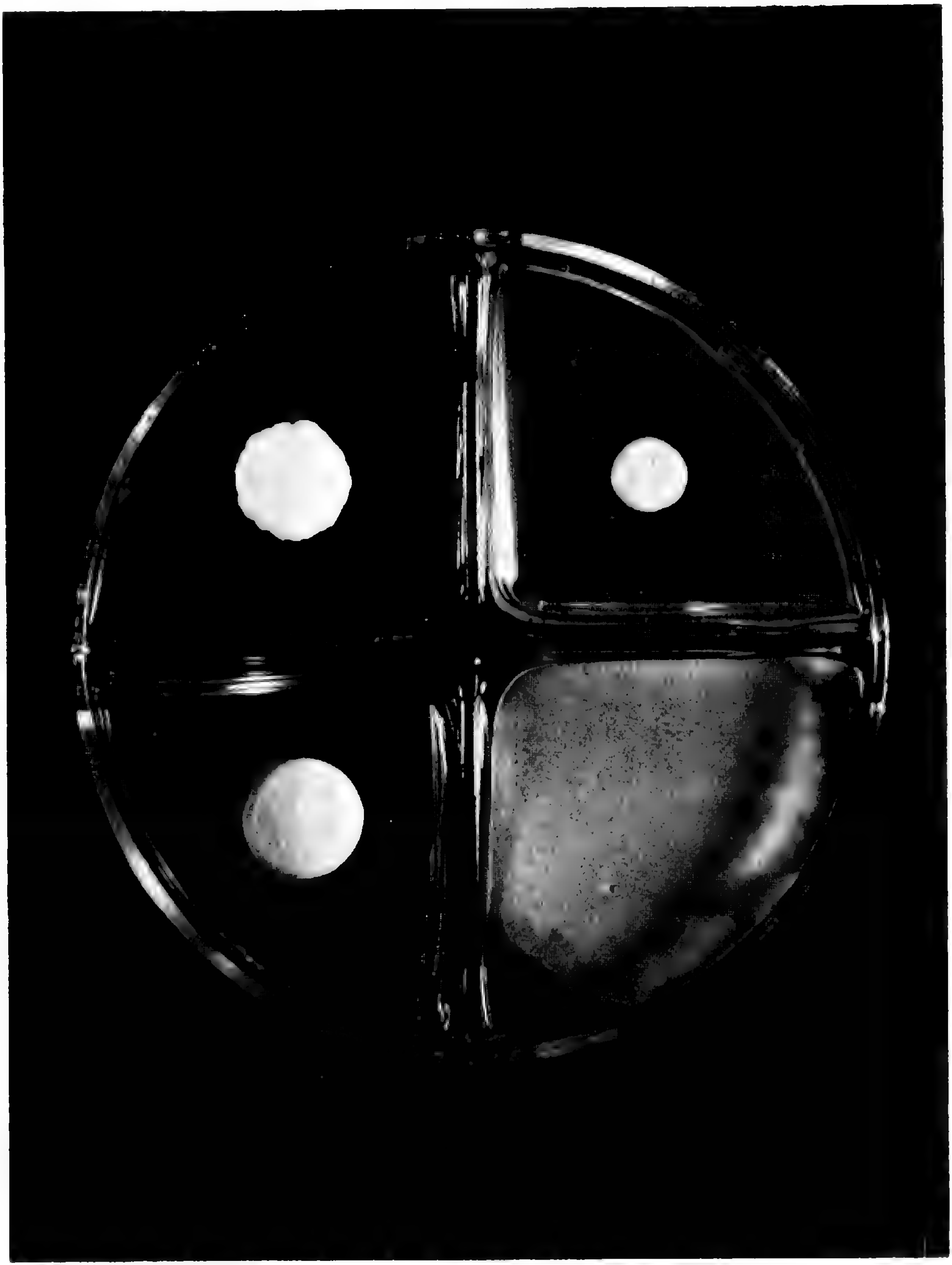


11. Salt-tolerance test at 12 days with films at all 4 brine strengths. × ½.



12. Heavy film formation on ethyl alcohol medium at 4 days. × ½.

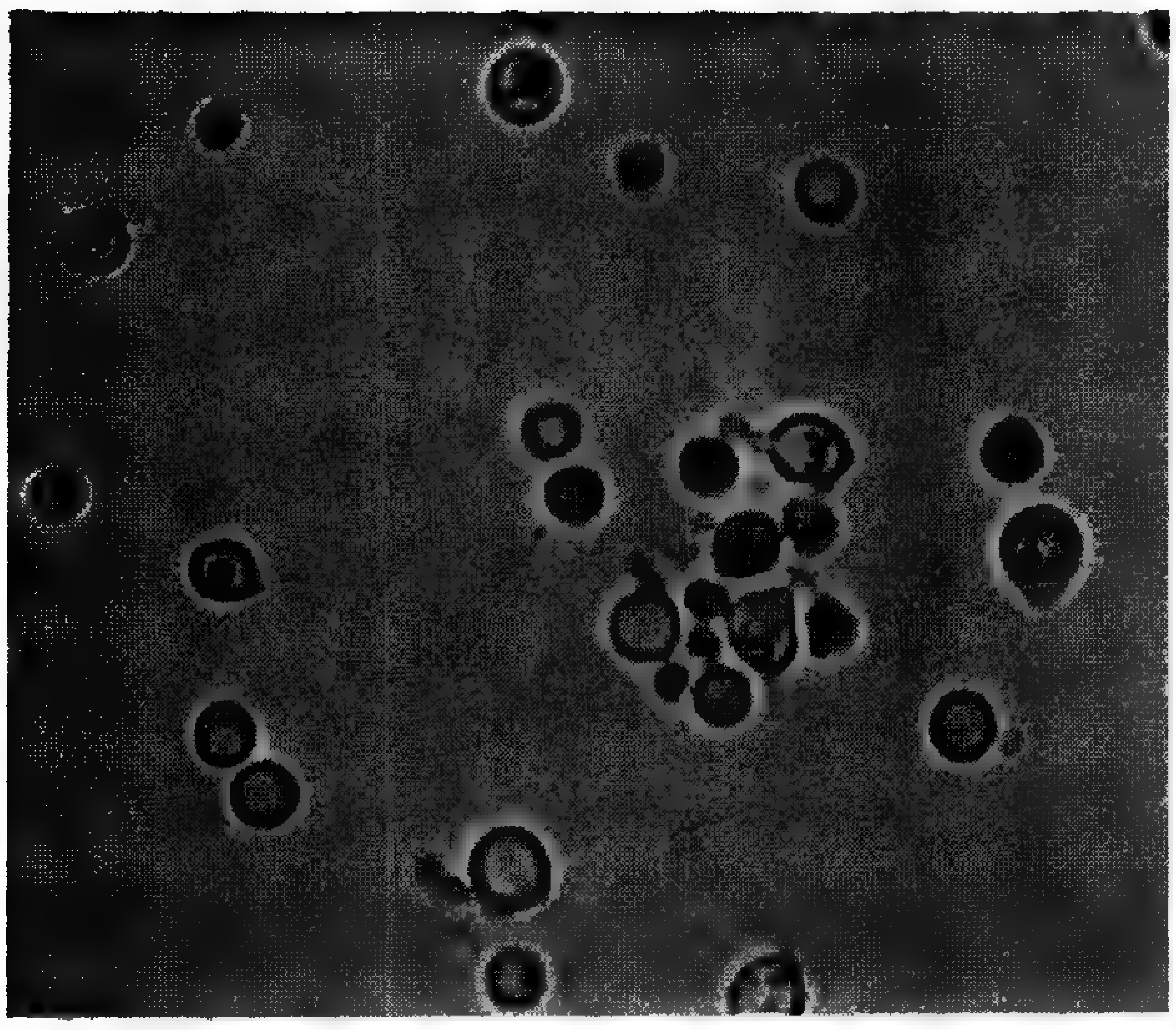
Debaryomyces



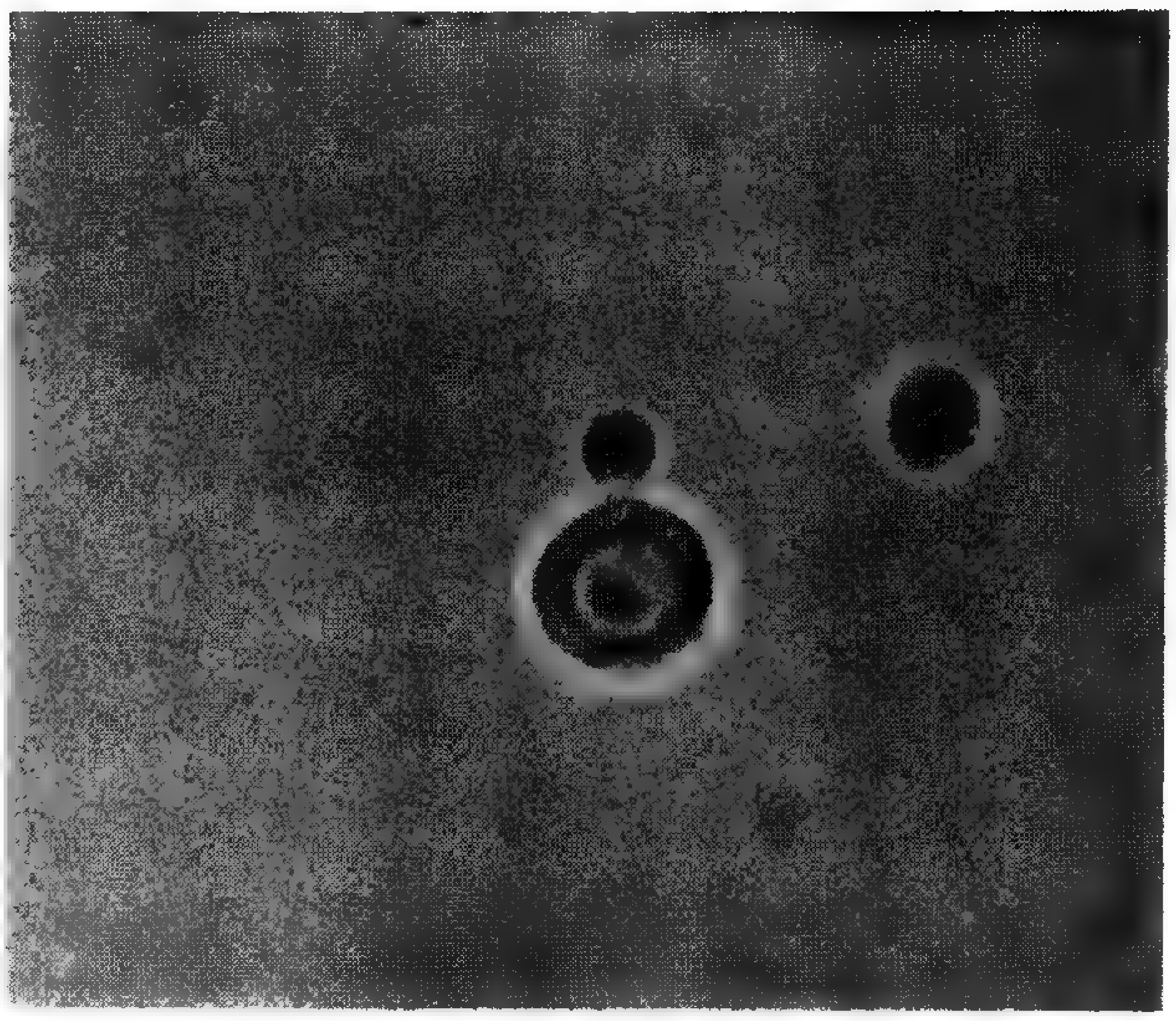
Vegetable-juice agar Synthetic agar-A

Glucose agar Glucose-salt agar

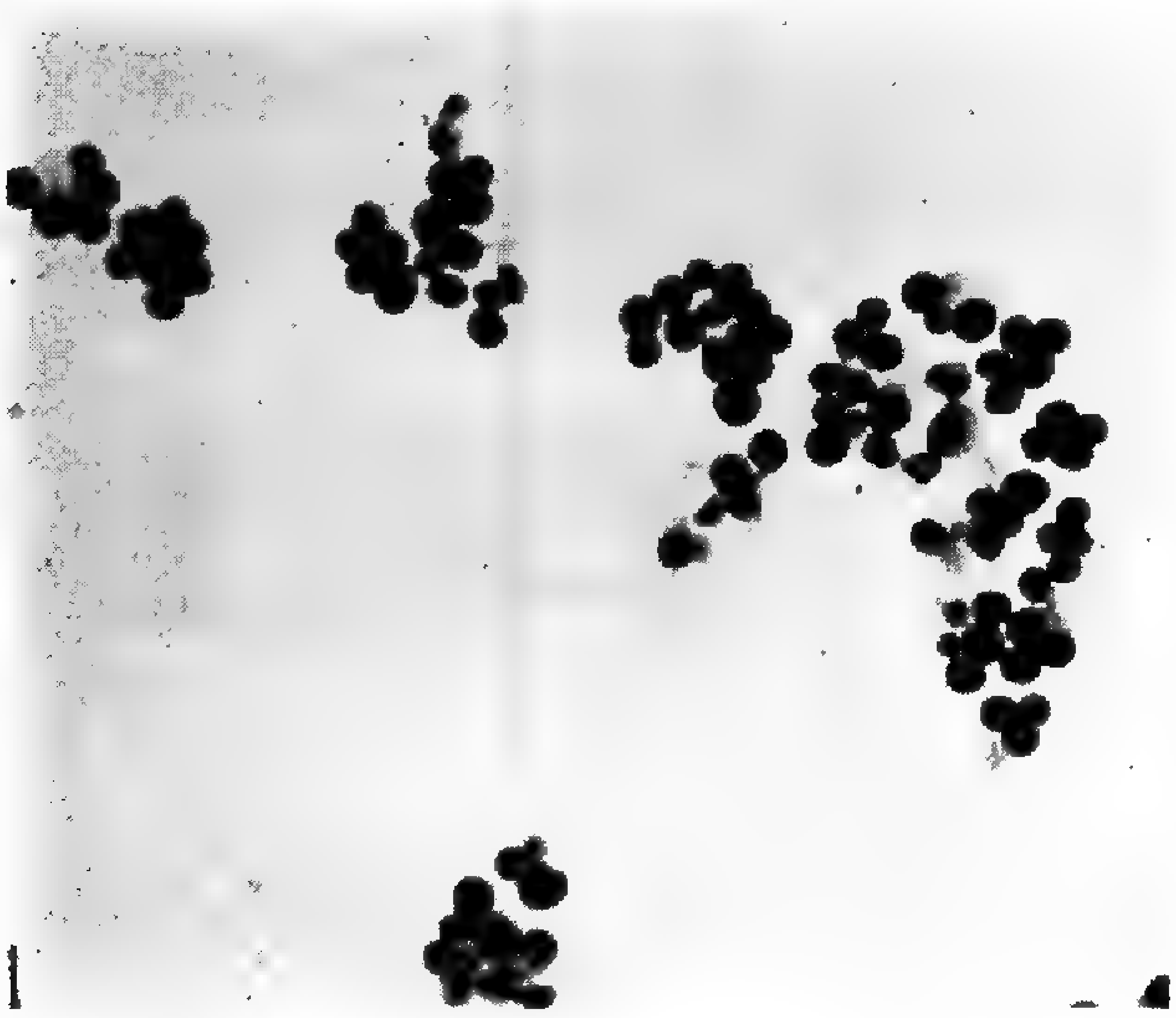
13. Comparative growth by a smooth species of *Debaryomyces* (FY-34) on different cultural media after 6 weeks' incubation at room temperature. Slightly enlarged. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.



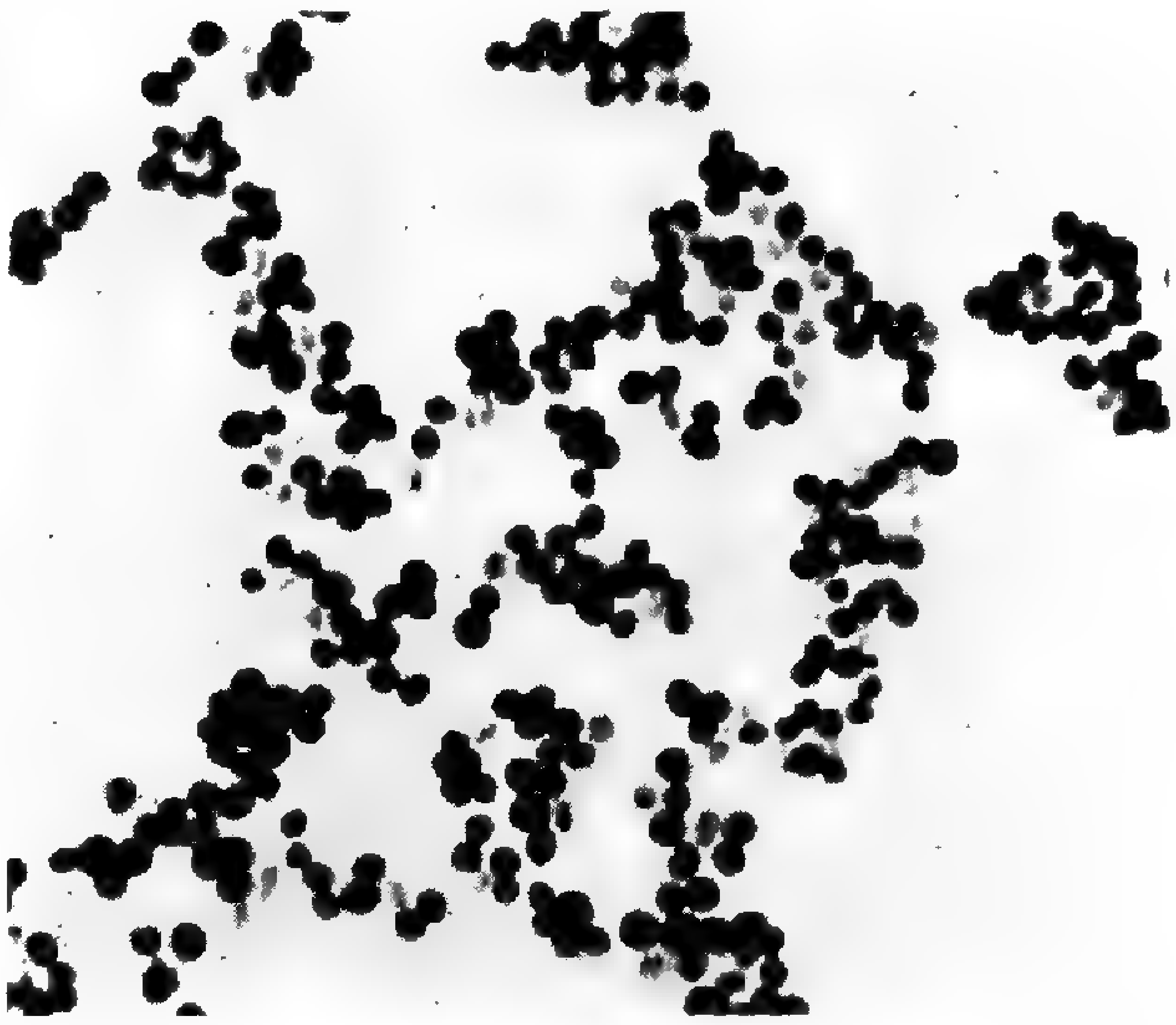
14. Round cells from vegetable-juice agar at 2 months; ascus filled with single spore at right center. Unstained, × 1500.



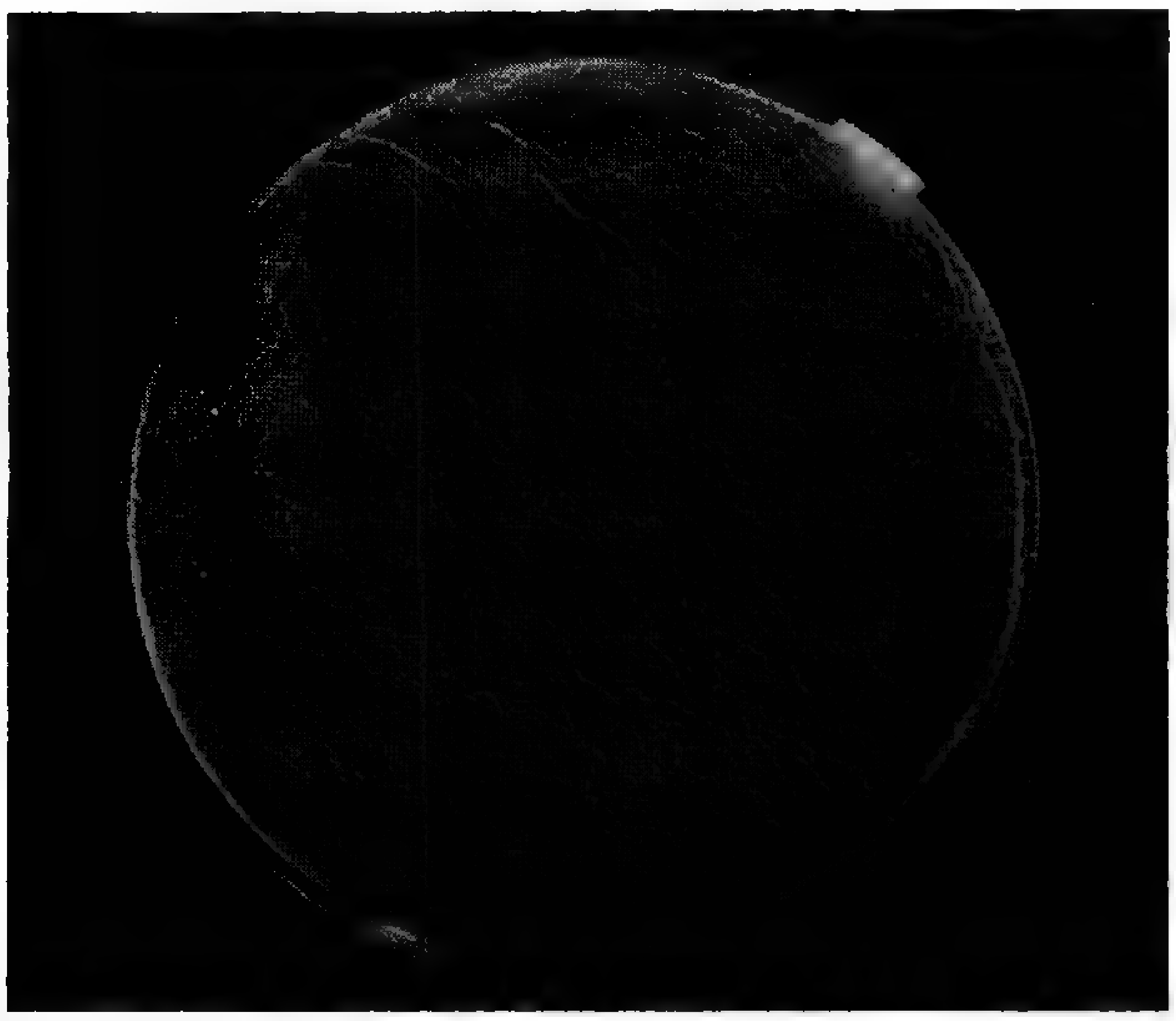
15. Typical ascus with rough spore and centrally located oil drop. From vegetable-juice agar at 2 months. Unstained, × 1500; enlarged, × 2.



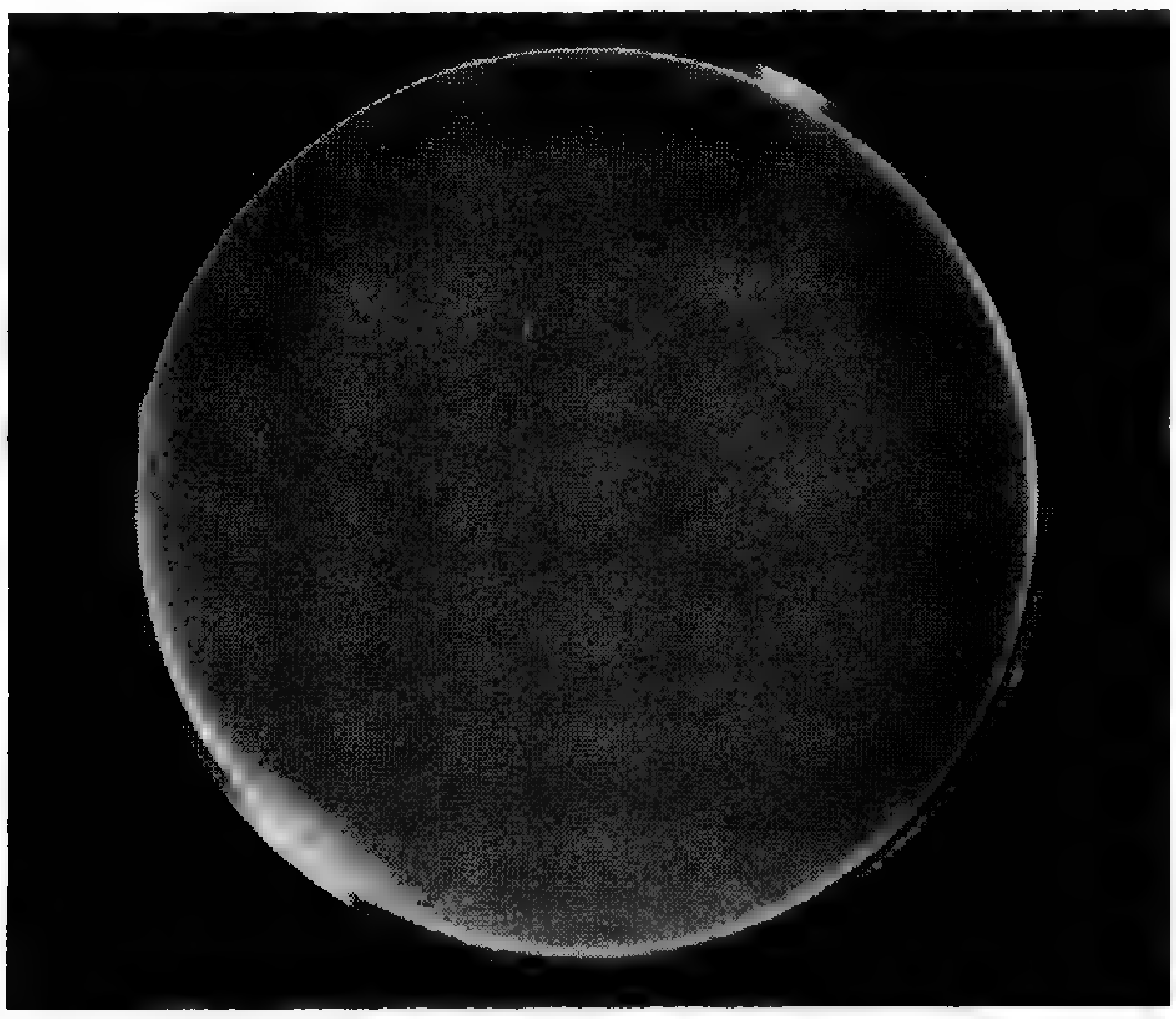
16. Cells from synthetic agar-A after 7 days. Gram stained, × 1500.



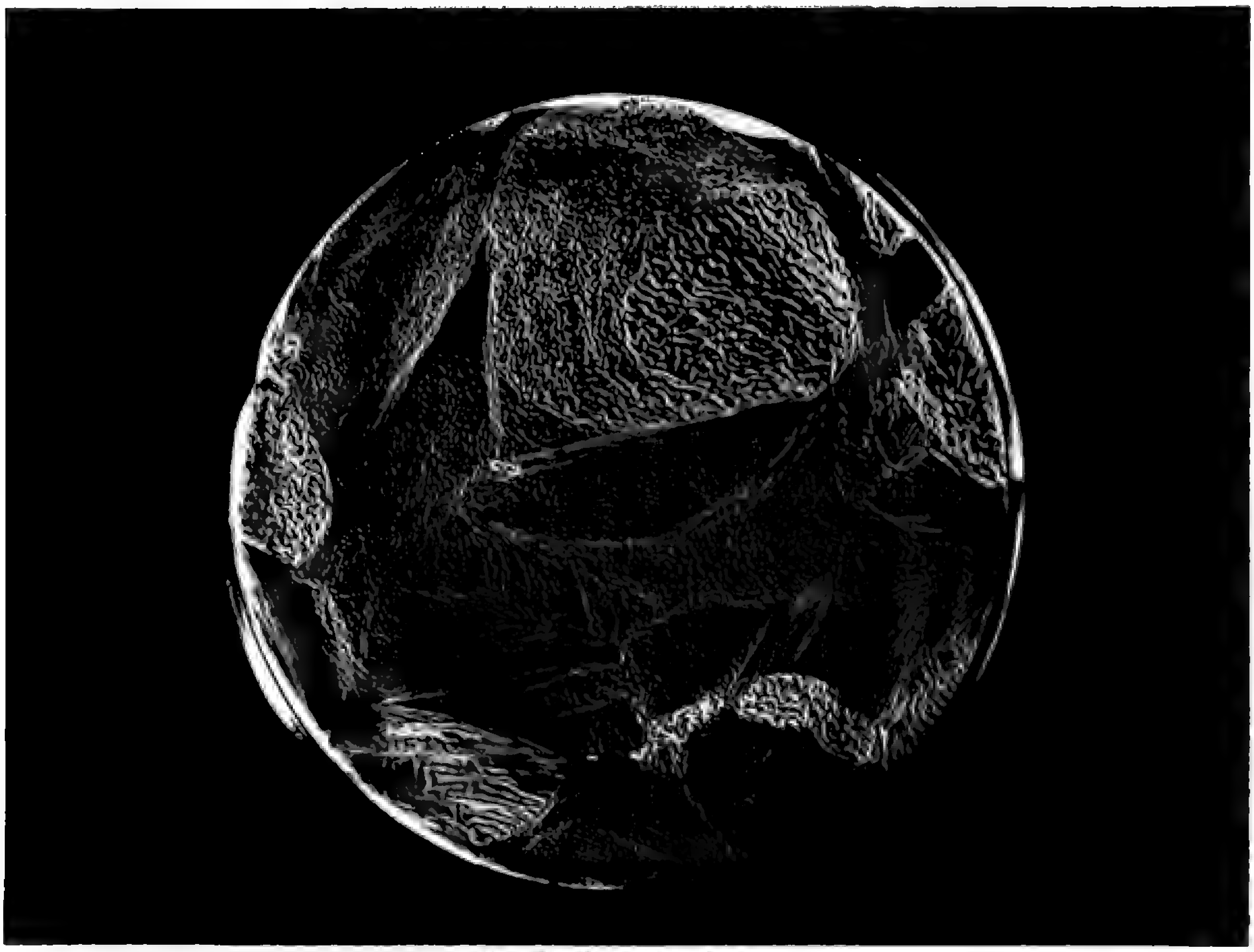
17. Cells from film on 10% salt cucumber brine after 5 days. Gram stained, × 1500.



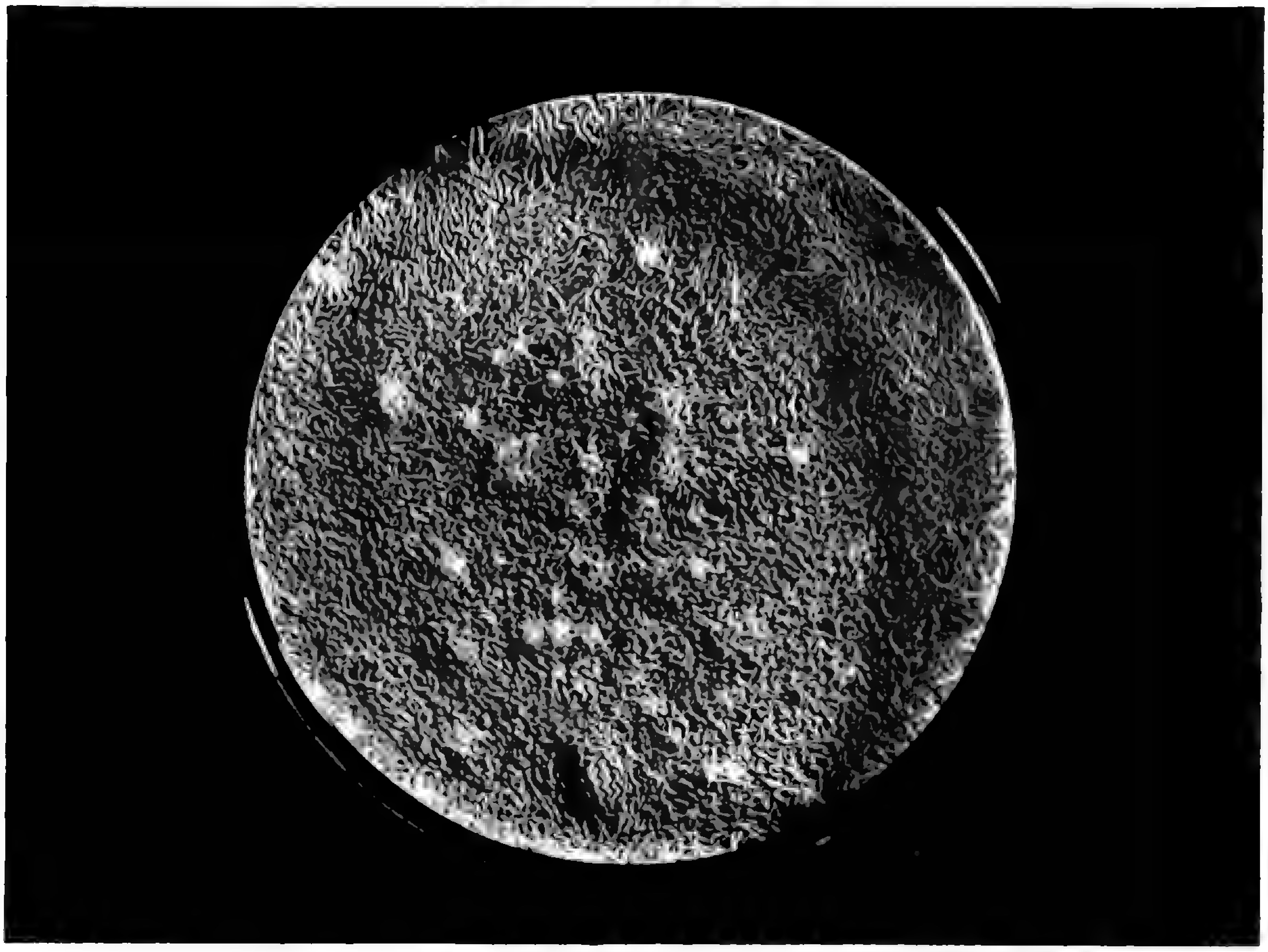
18. Film formation at 3 days on 7% salt cucumber brine. × ½.



19. This yeast forms a very thin film on ethyl alcohol medium. × ½.



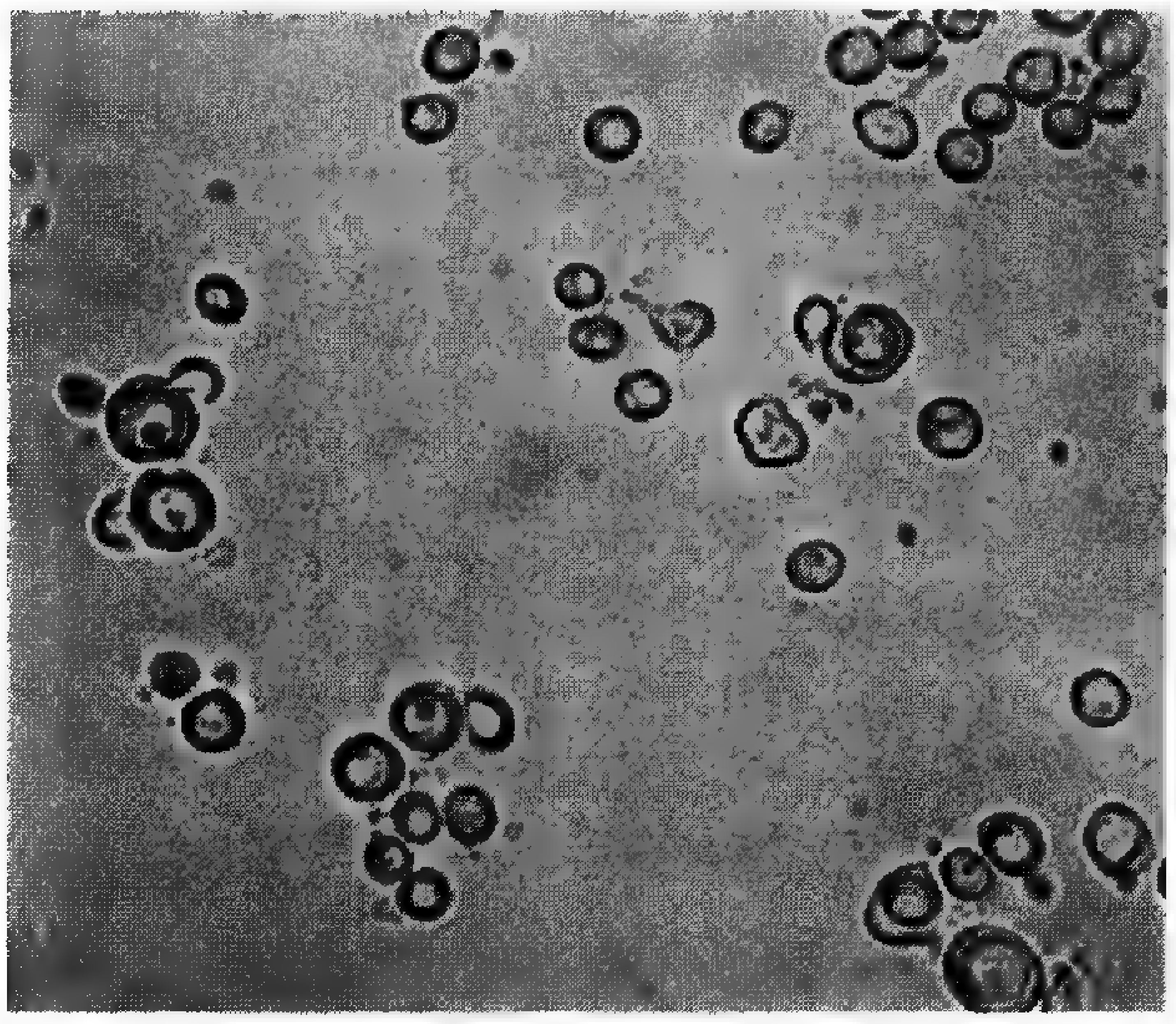
20. Beef tongue brine



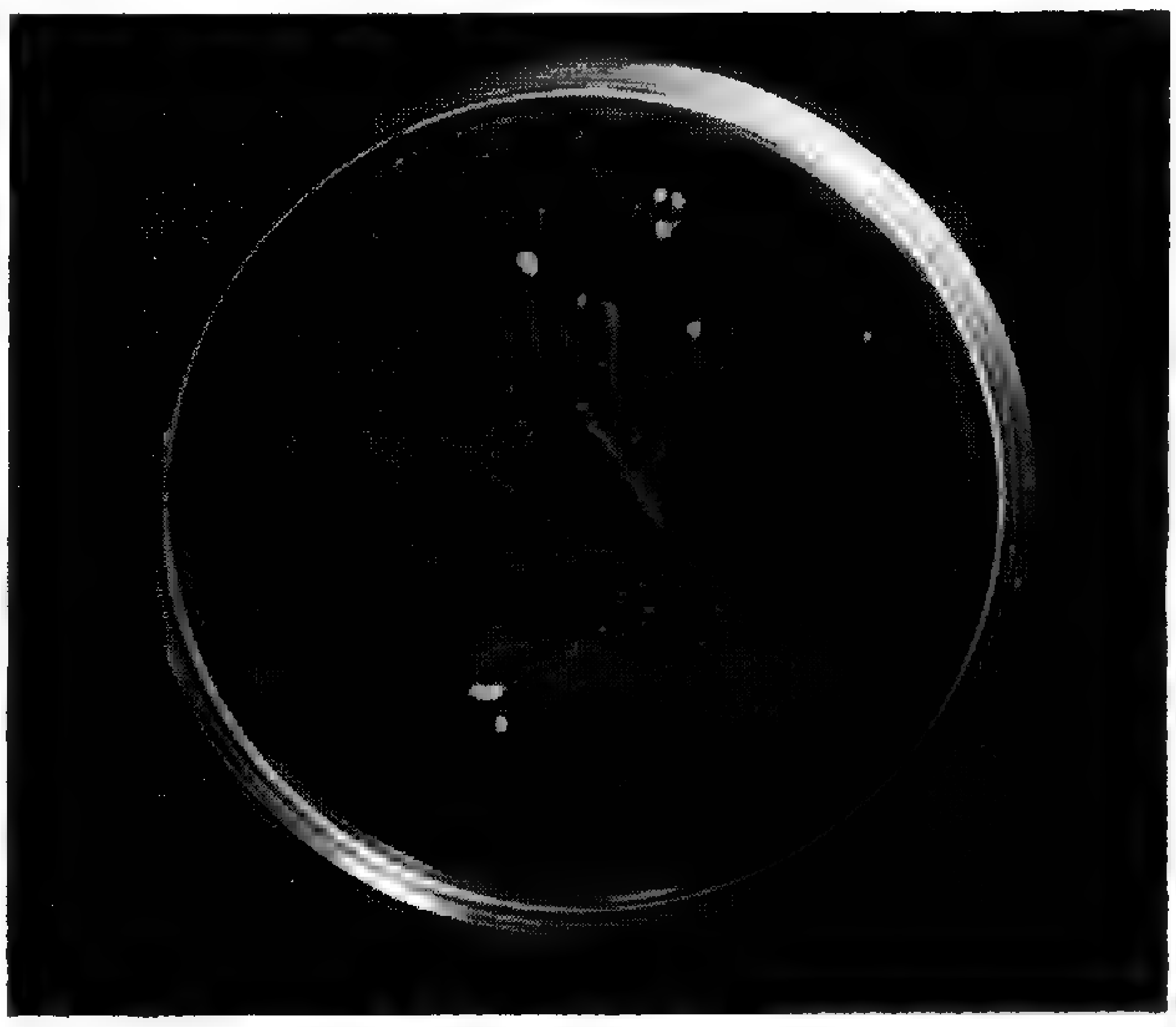
21. Ham brine

Naturally occurring films on commercial curing brines from beef tongues (above) and hams (below) after 7 days' incubation at room temperature. Slightly reduced in size. The principal yeast species responsible for these films is the Georgia strain of *D. membranaefaciens* var. *Hollandicus* (shown on pages 268, 269). SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF SUBSURFACE SPECIES OF *DEBARYOMYCES* FROM BRINED BACON SIDES.

*DEBARYOMYCES* SP. (Y-6-BA)

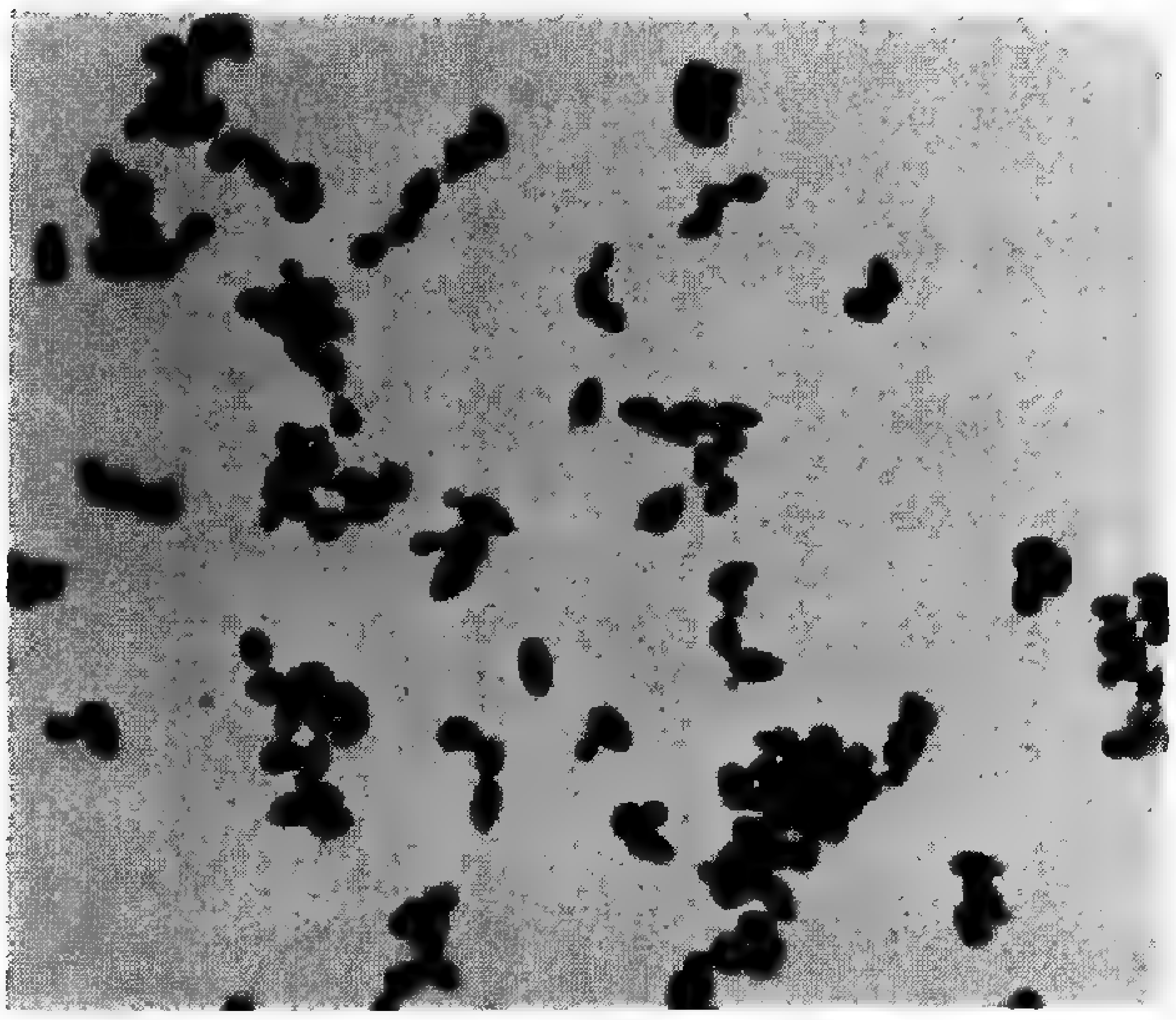


22. Several typical asci with single rough spores; from vegetable-juice agar at 2 months. Unstained, × 1500.

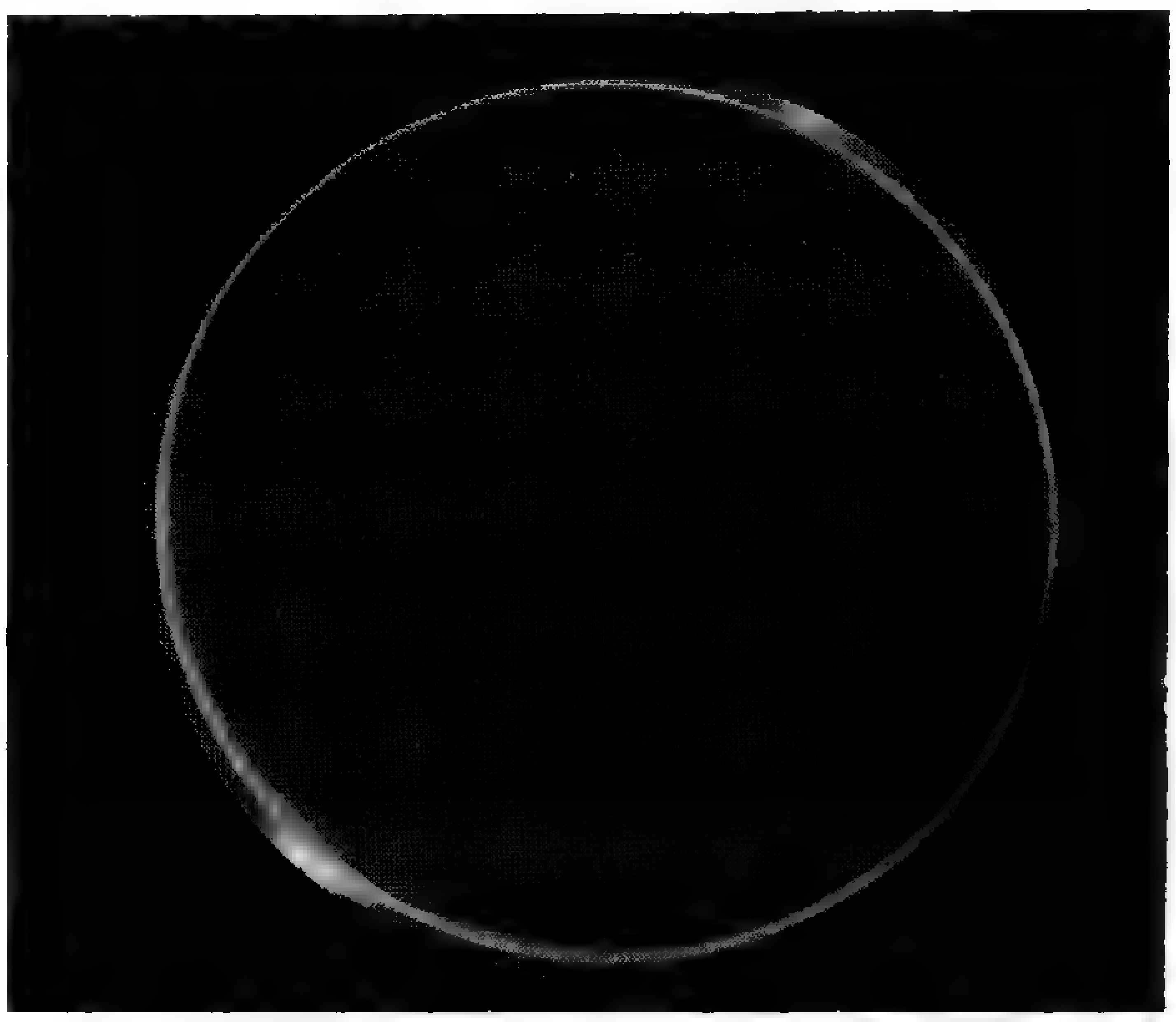


23. Absence of film or subsurface growth in ethyl alcohol medium at 3 days is typical of this species. × ½.

*DEBARYOMYCES* SP. (Y-37-BA)



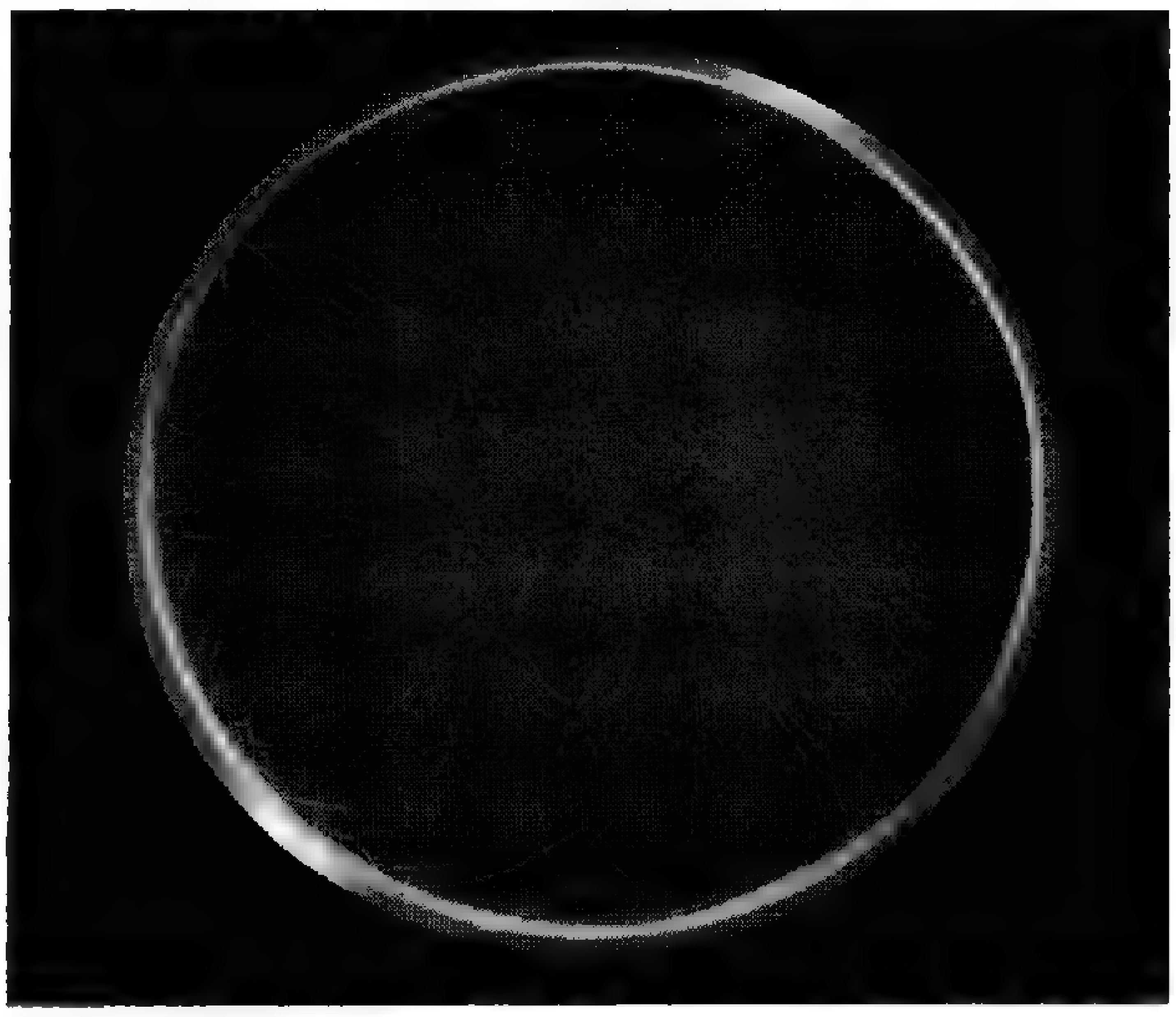
24. Somewhat pointed cells from film on 5% salt cucumber brine after 48 hours. Gram stained, × 1500.



25. Very thin climbing scum is formed by this yeast on ethyl alcohol medium at 3 days. × ½.

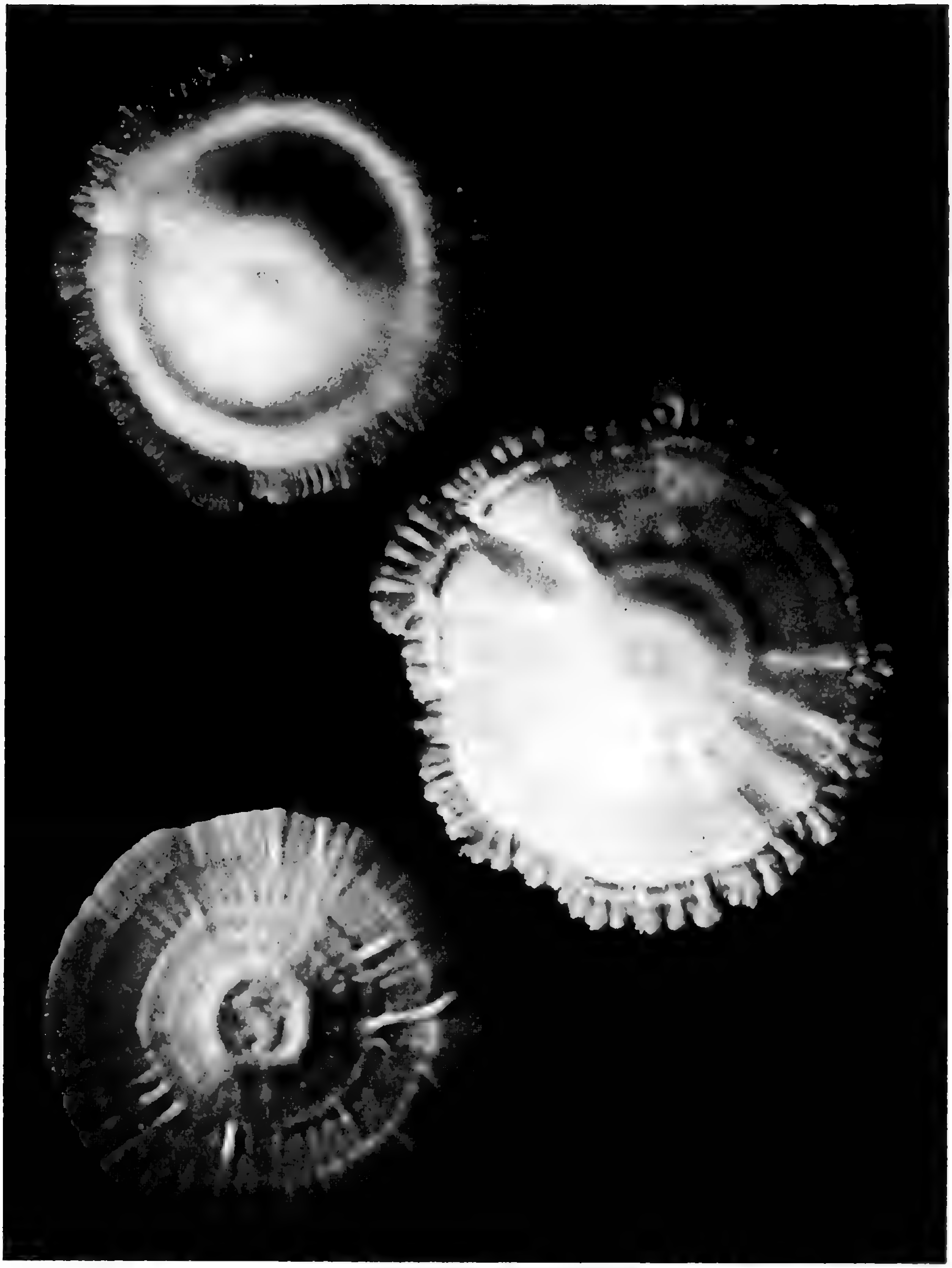
*DEBARYOMYCES* SP. (Y-40-BA)

26. Masses of round cells from film on 5% salt cucumber brine after 48 hours. Gram stained, × 1500.



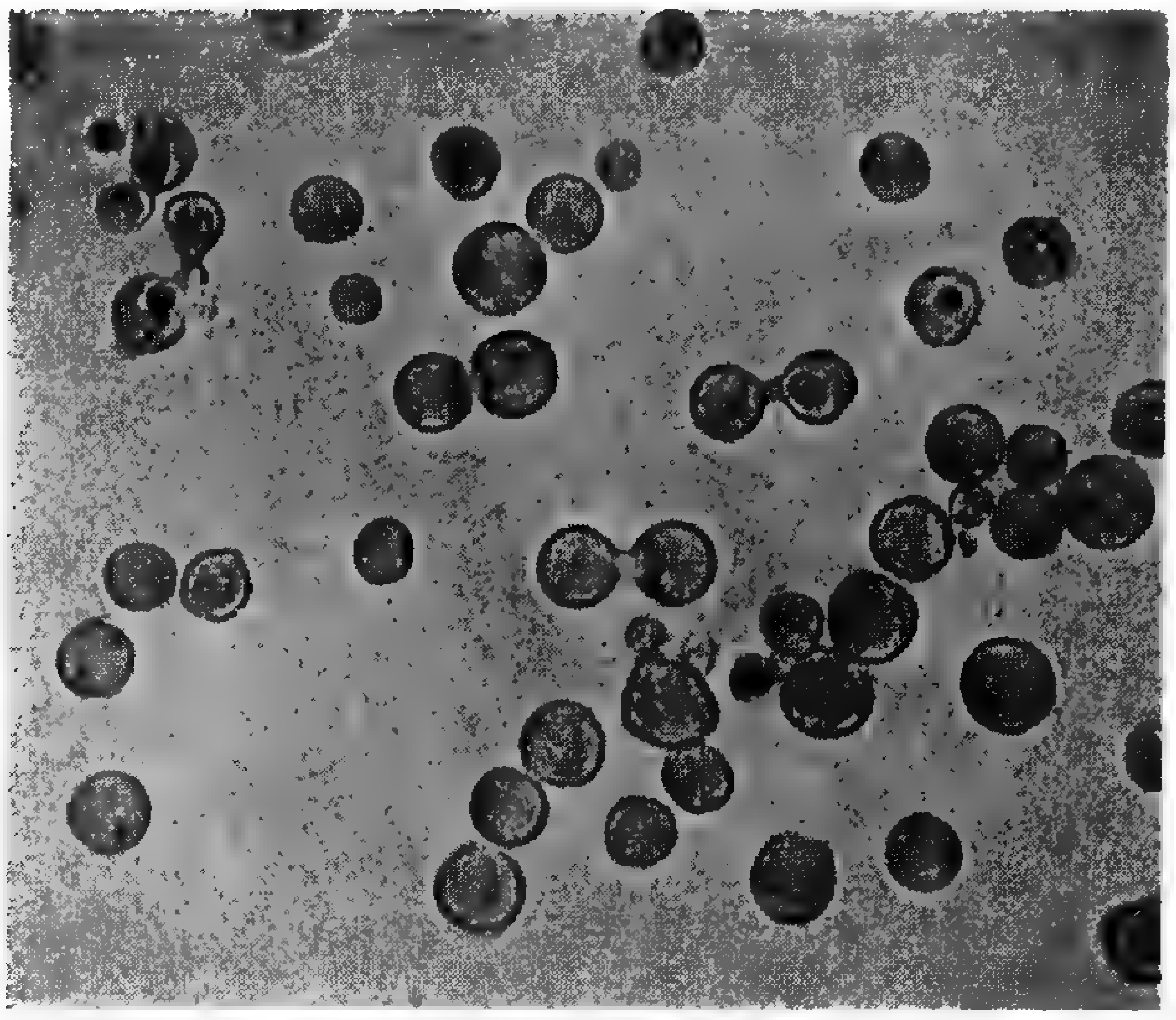
27. Thin film formation on ethyl alcohol medium at 3 days is typical of this species. × ½.

Zygosaccharomyces

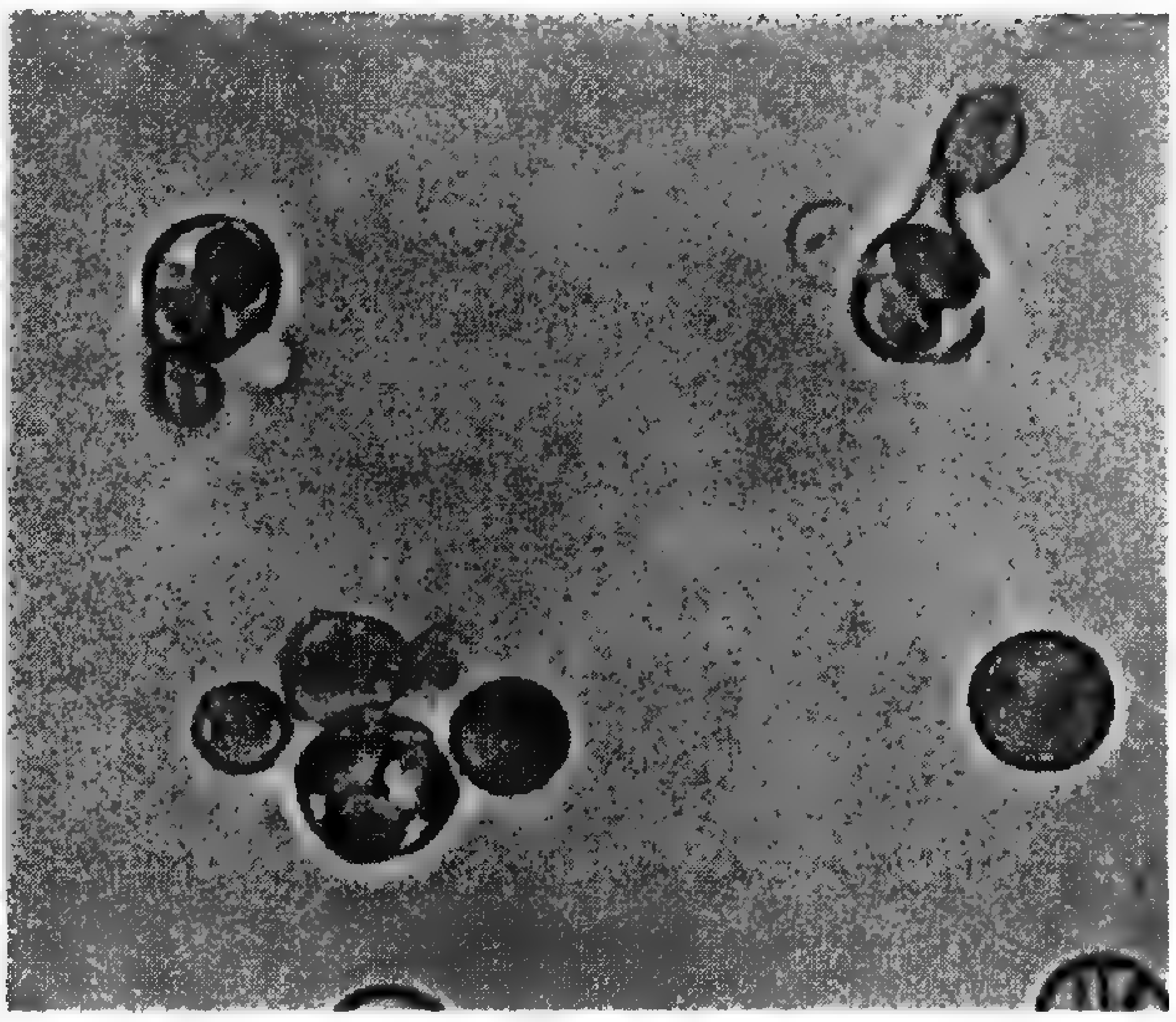


Vegetable-juice agar Glucose agar
Synthetic agar-A

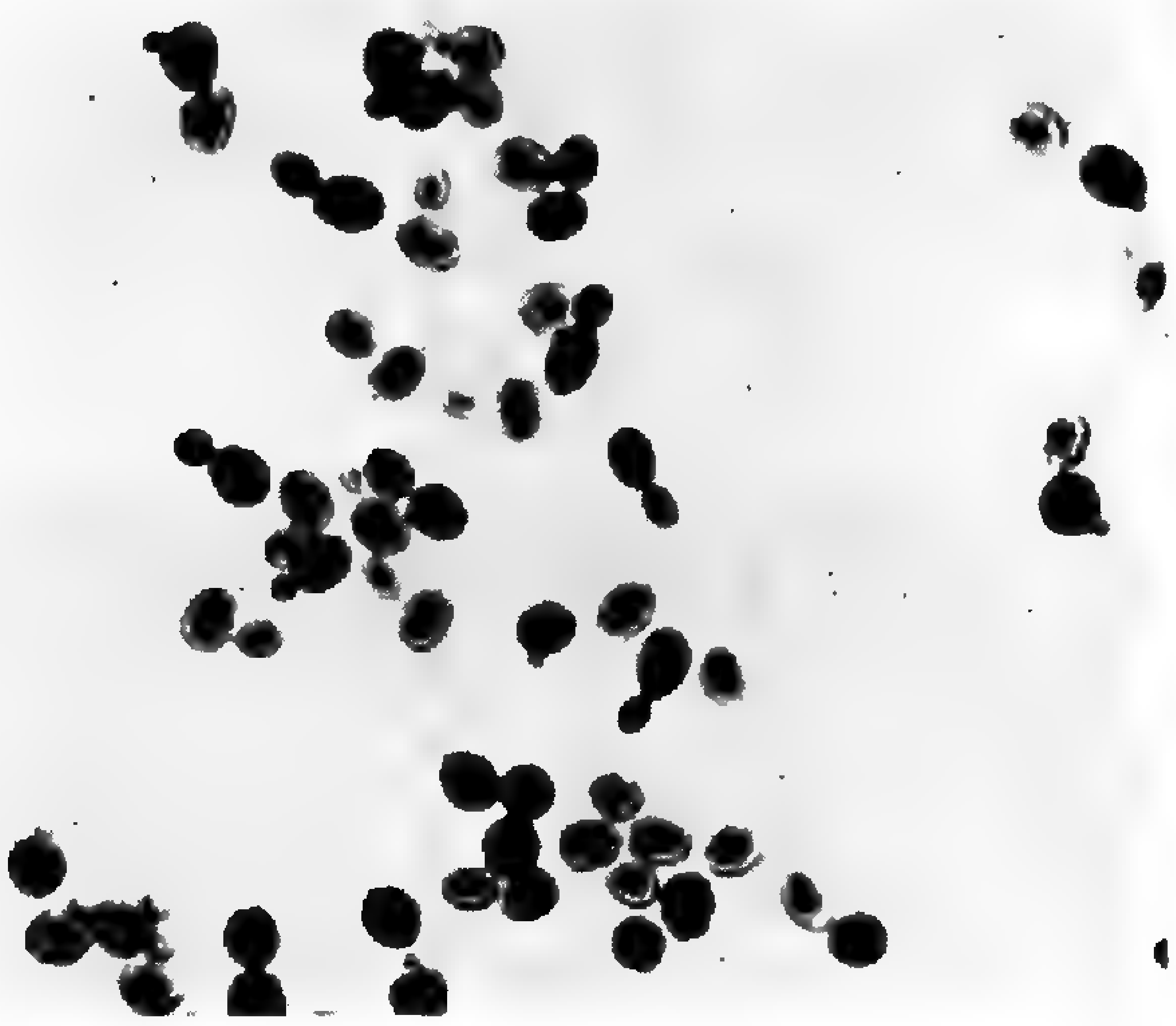
28. Comparative growth by *Zygosaccharomyces halomembranis* Etchells & Bell (Y-1000) on different cultural media after 6 weeks' incubation at room temperature. Colonies enlarged, × 3. In cucumber brines from Michigan, Wisconsin and Indiana, this species occurs both as a surface and subsurface yeast. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.



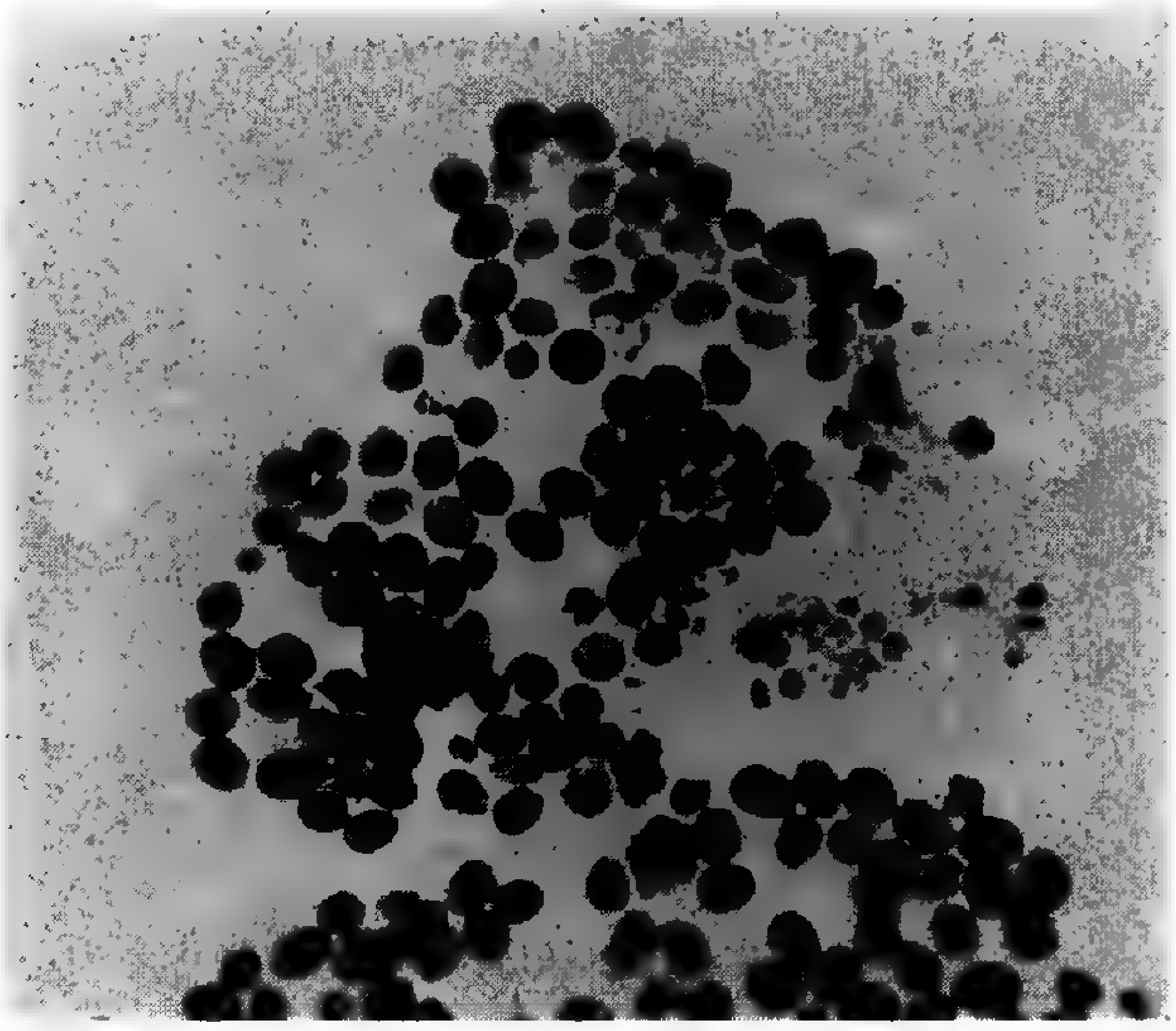
29. Early stage of sporulation, with conjugated round cells; from vegetable-juice agar at 3 weeks. Unstained, × 1500.



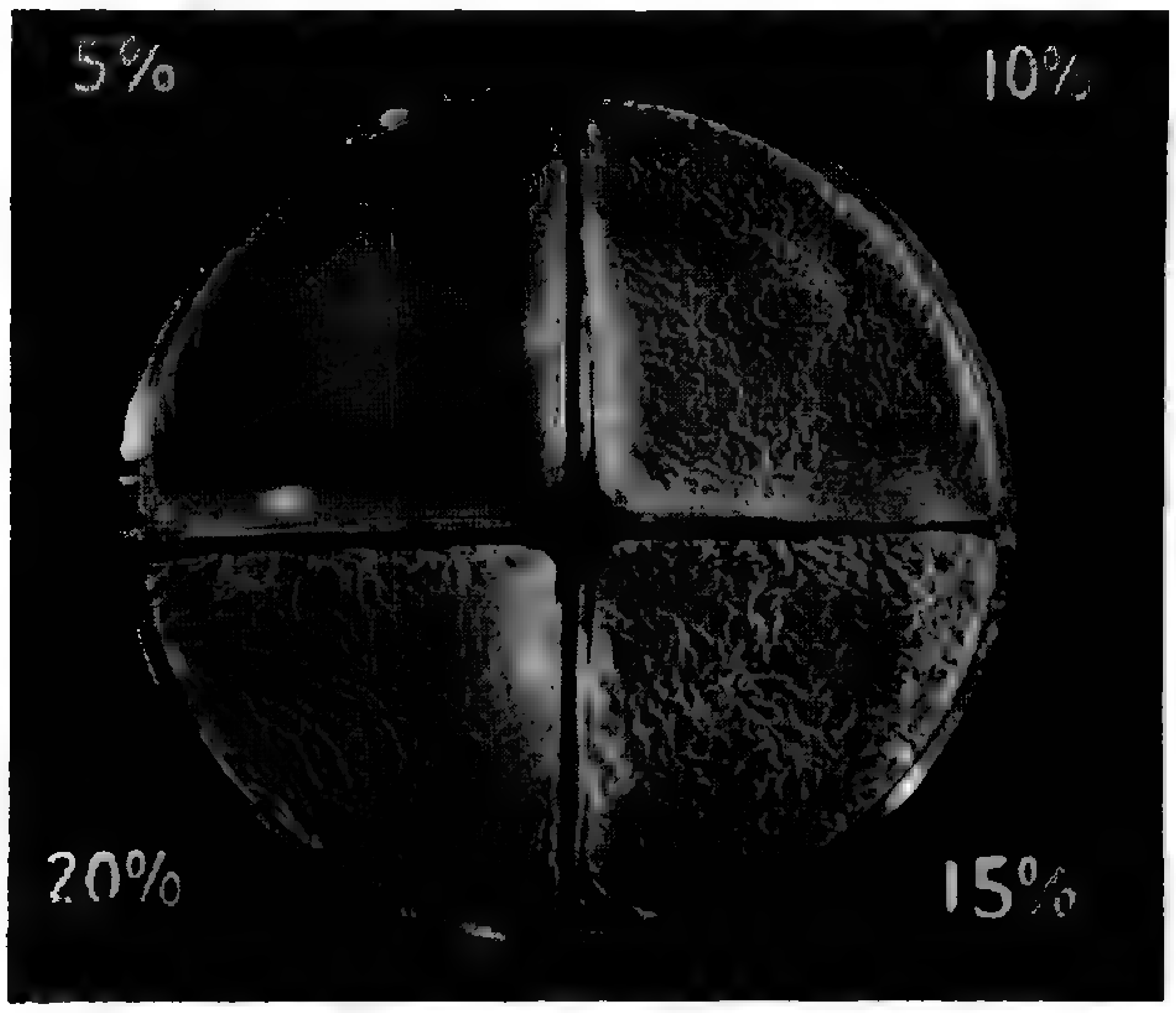
30. Fully developed asci with 2 and 3 oval spores each; from vegetable-juice agar at 1 month. Unstained, × 1500; enlarged, × 2.



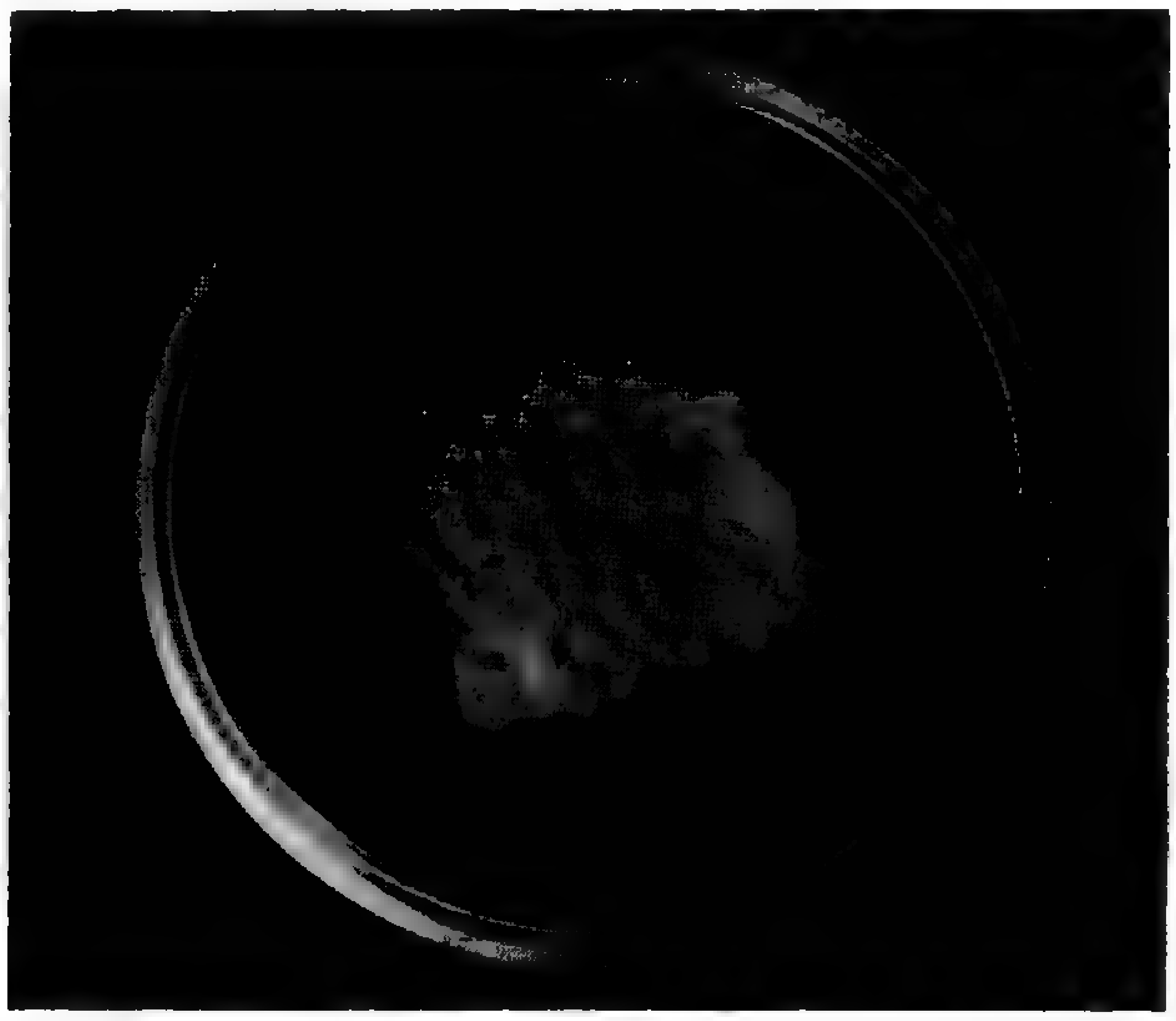
31. Young cells, 48 hours old, from film on 10% salt cucumber brine. Gram stained, × 1500.



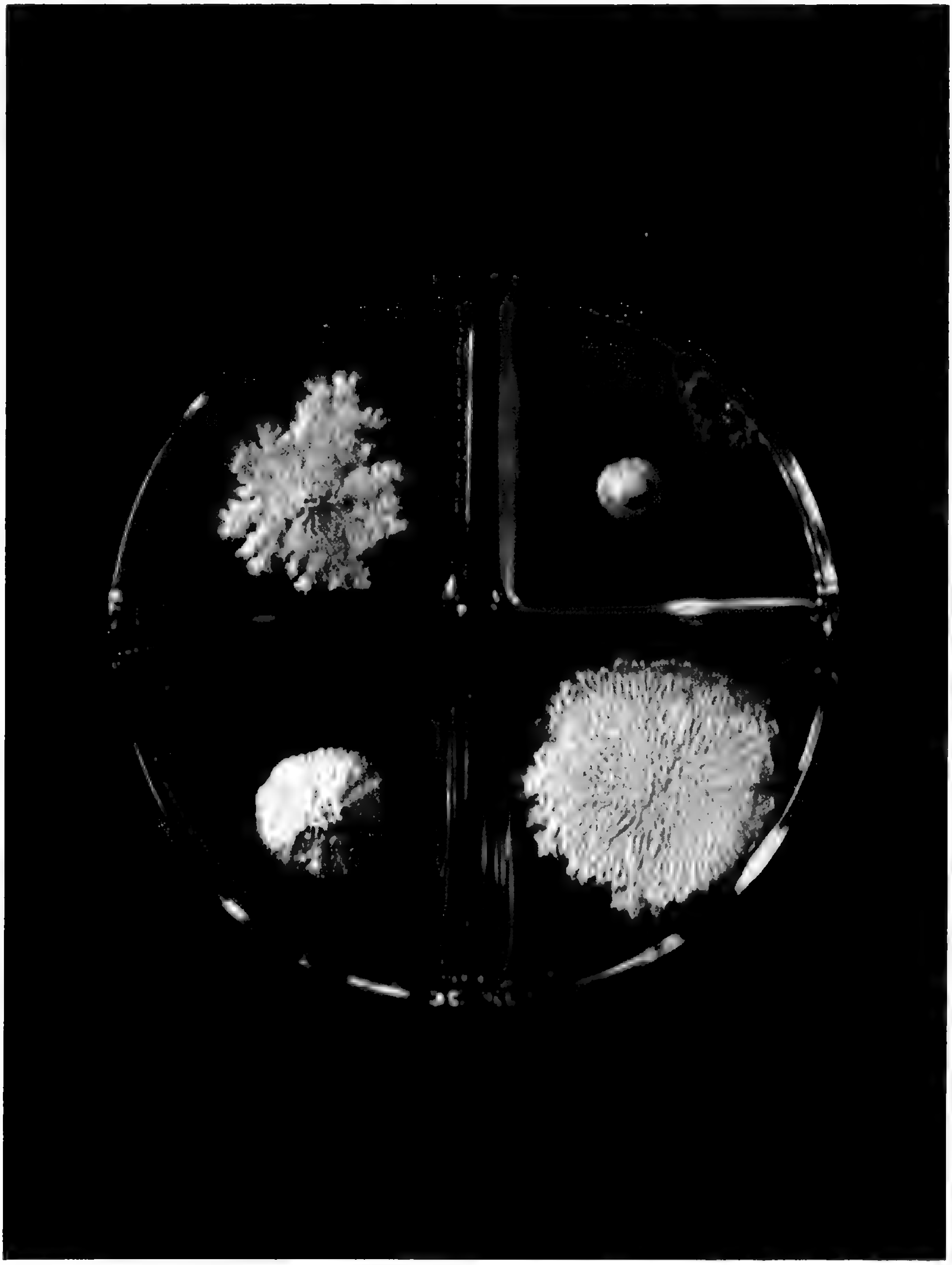
32. Masses of older cells, 5 days old, from film on 10% salt cucumber brine. Gram stained, × 1500.



33. Salt-tolerance test at 5 days shows heavy film formation at all 4 salt concentrations. × ½.



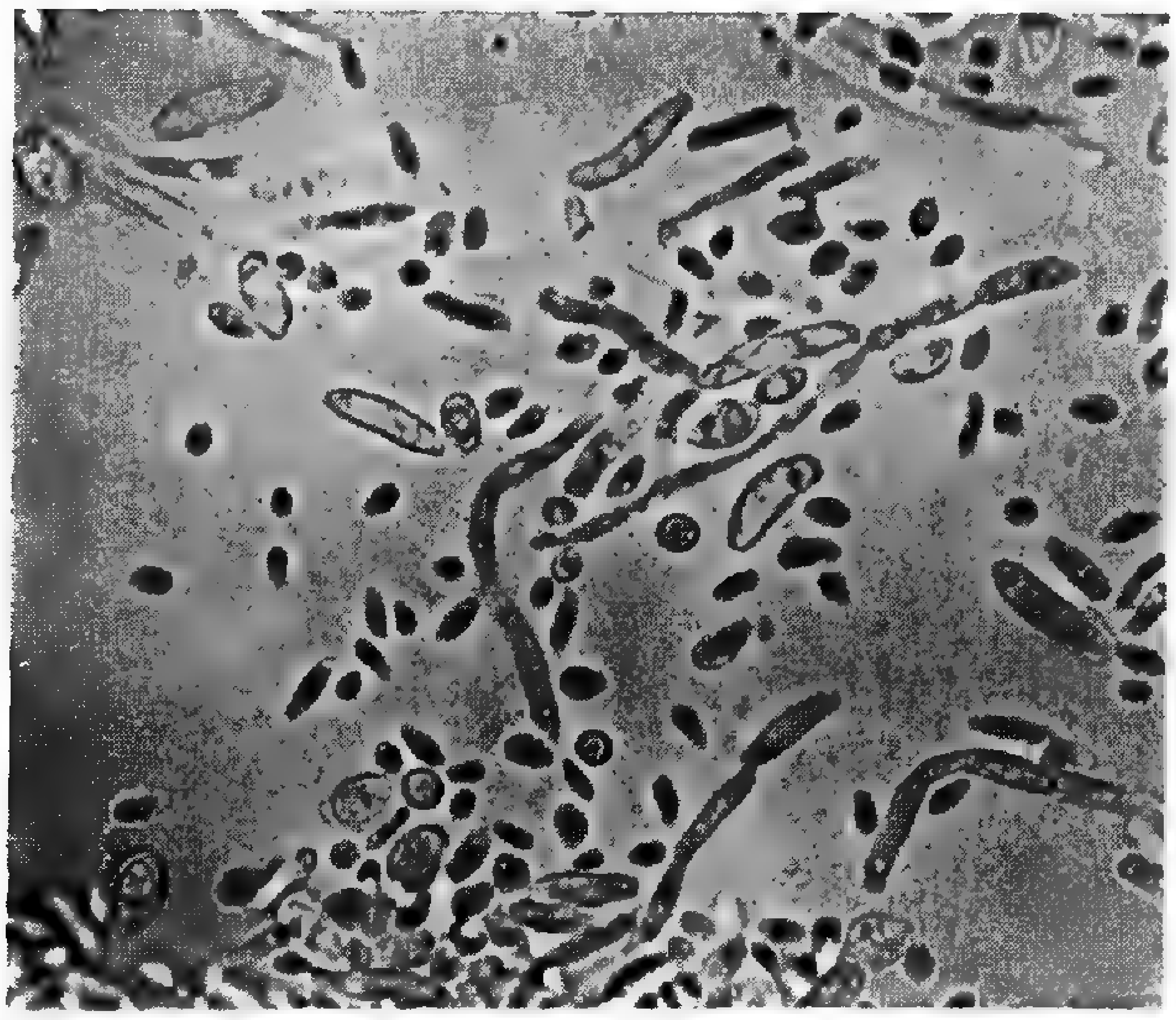
34. Subsurface growth but no film formation on ethyl alcohol medium is typical for this species. × ½.



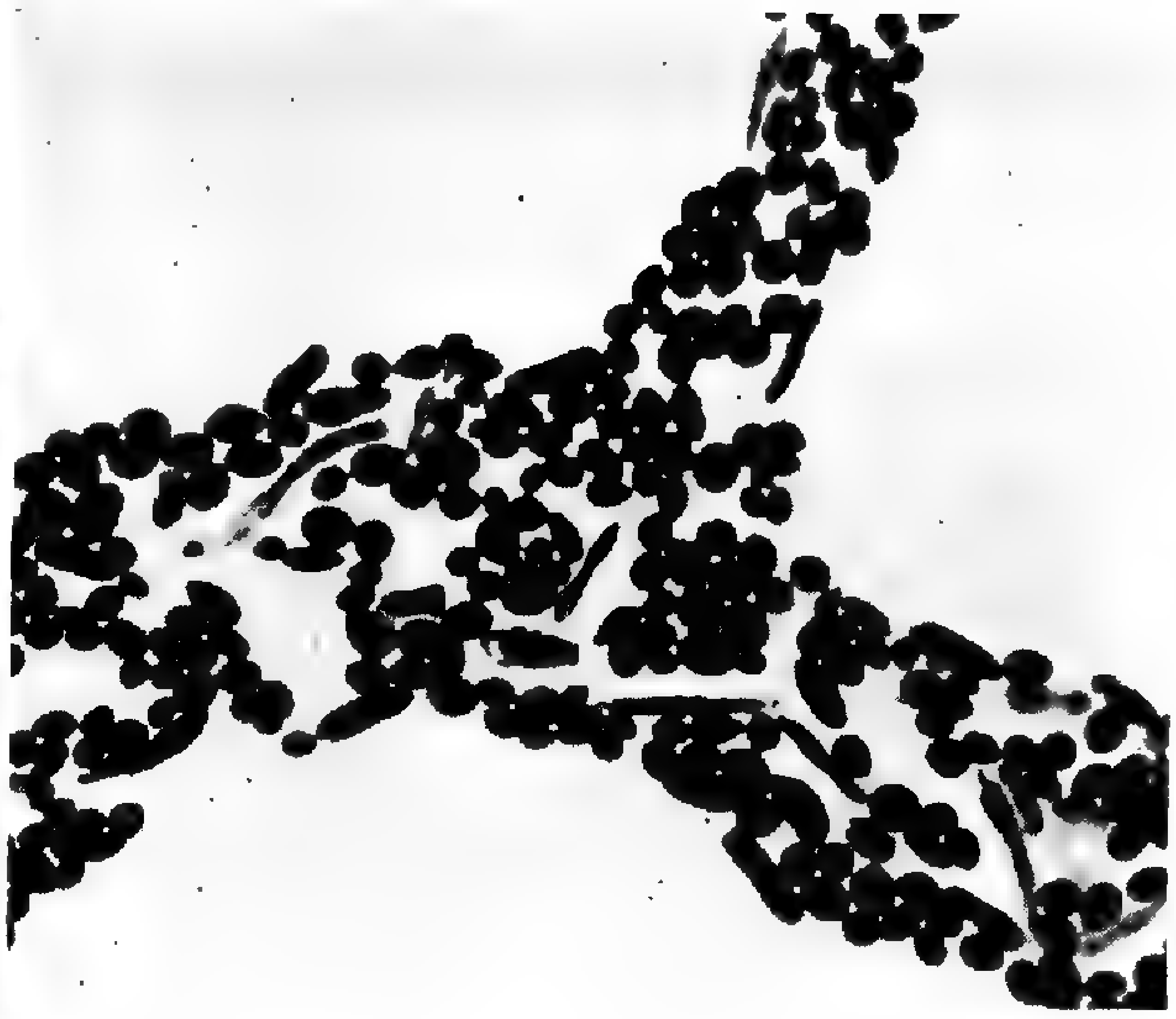
Vegetable-juice agar — Synthetic agar-A

Glucose agar — Glucose-salt agar

C. Comparative growth by *Endomycopsis ohmeri* Etchells & Bell (FY-25) on different cultural media after 6 weeks' incubation at room temperature. Actual size. So far this species has only been isolated from North Carolina brines. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.

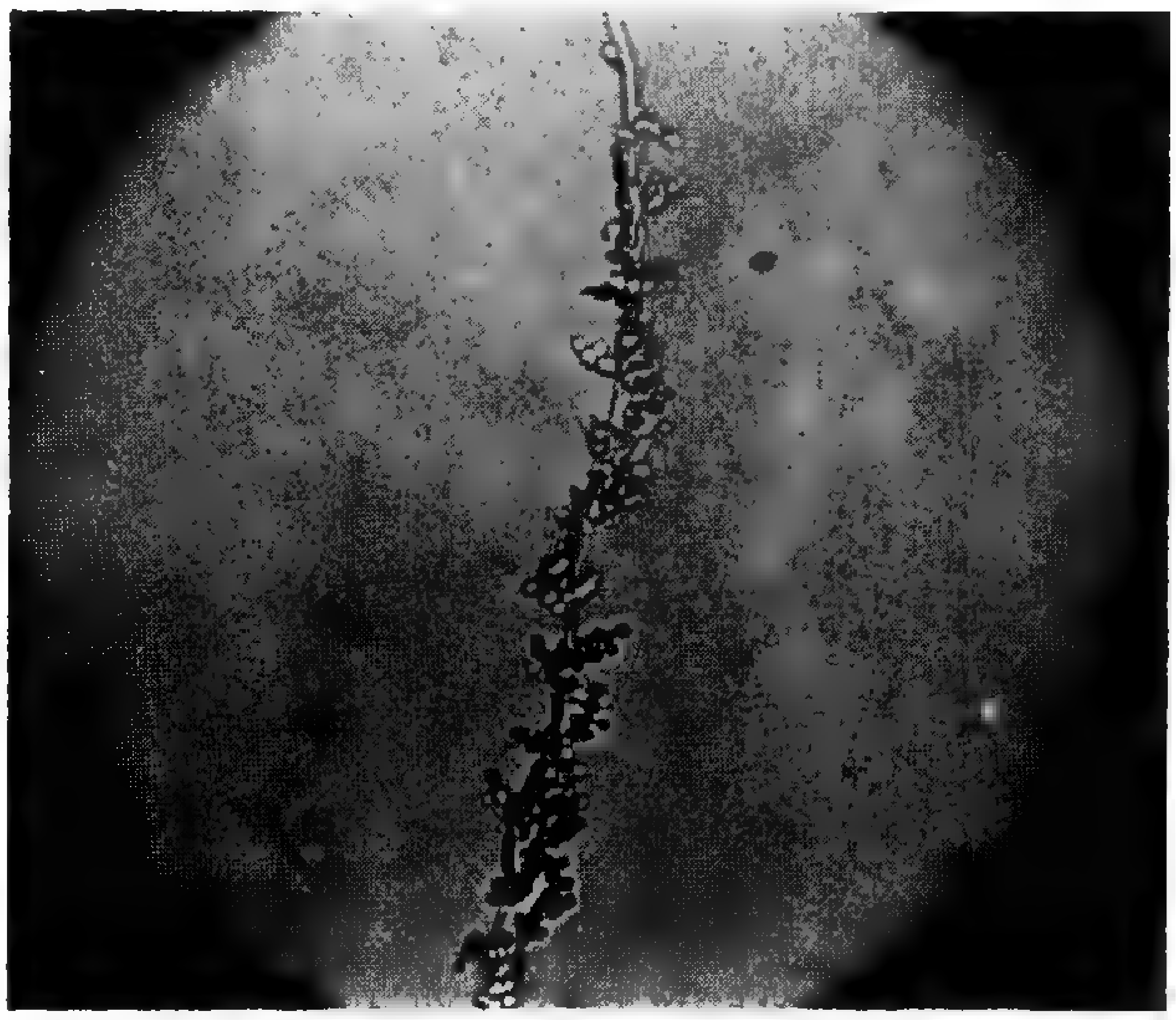


35. Pleomorphic cells from vegetable-juice agar after 4 months. No spores present. Unstained, × 1500.

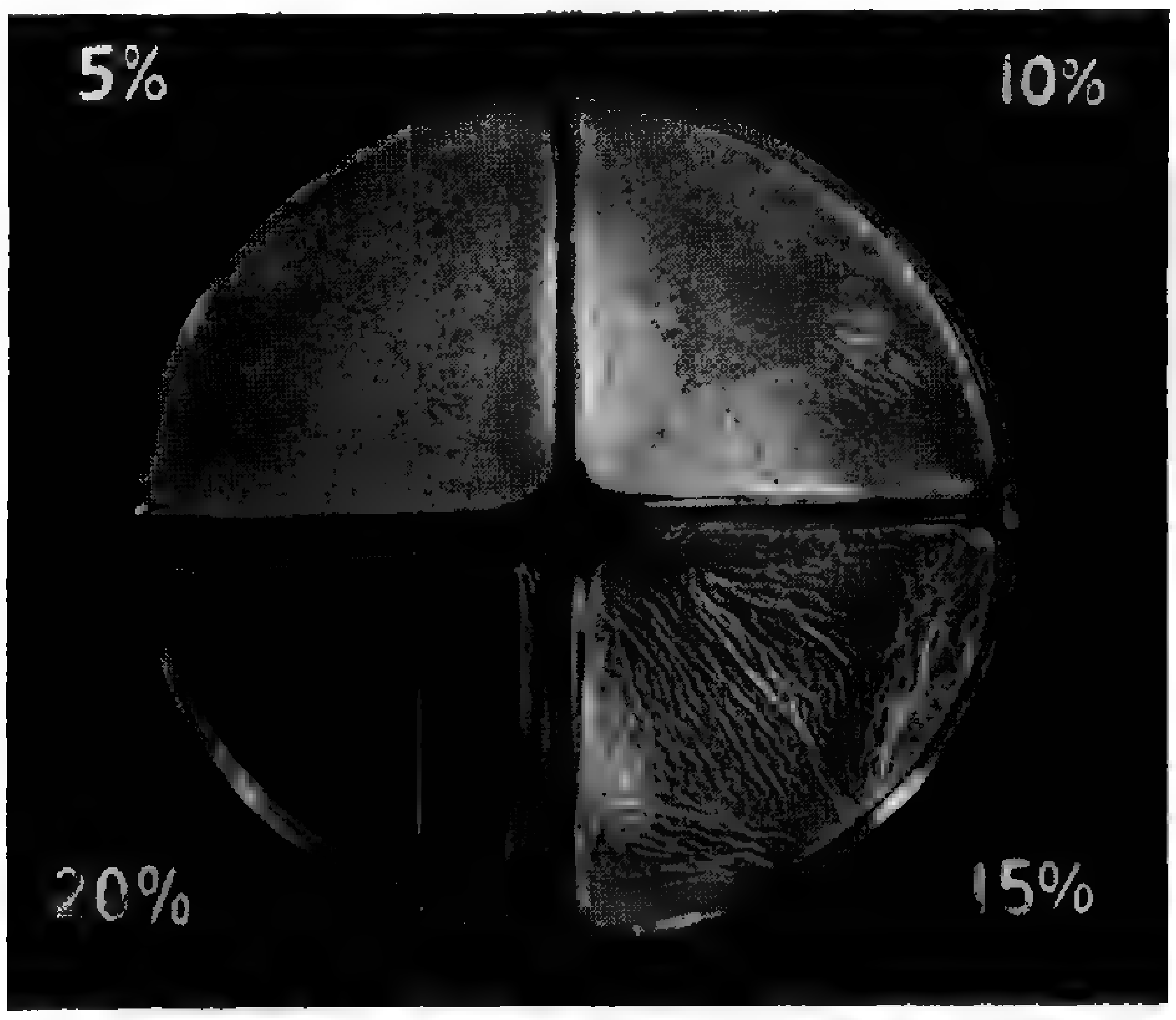


36. Typical cells from synthetic agar-A after 7 days. Gram stained, × 1500.

37. Elongated cells from film on 10% salt brine after 48 hours. Gram stained, × 1500.

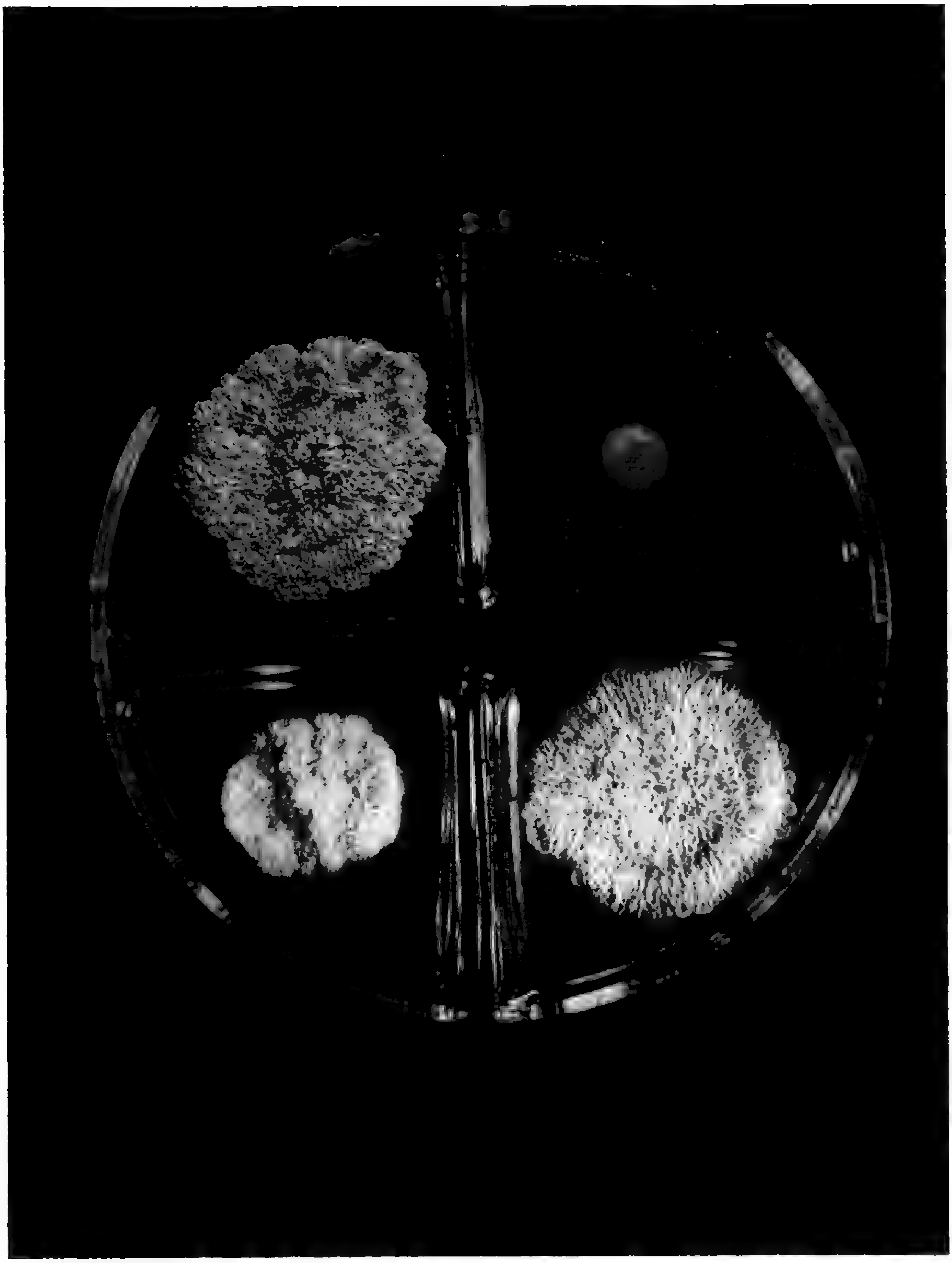


38. Single, long mycelial thread with clusters of cells; from cornmeal agar after 3 weeks. Unstained, × 650.



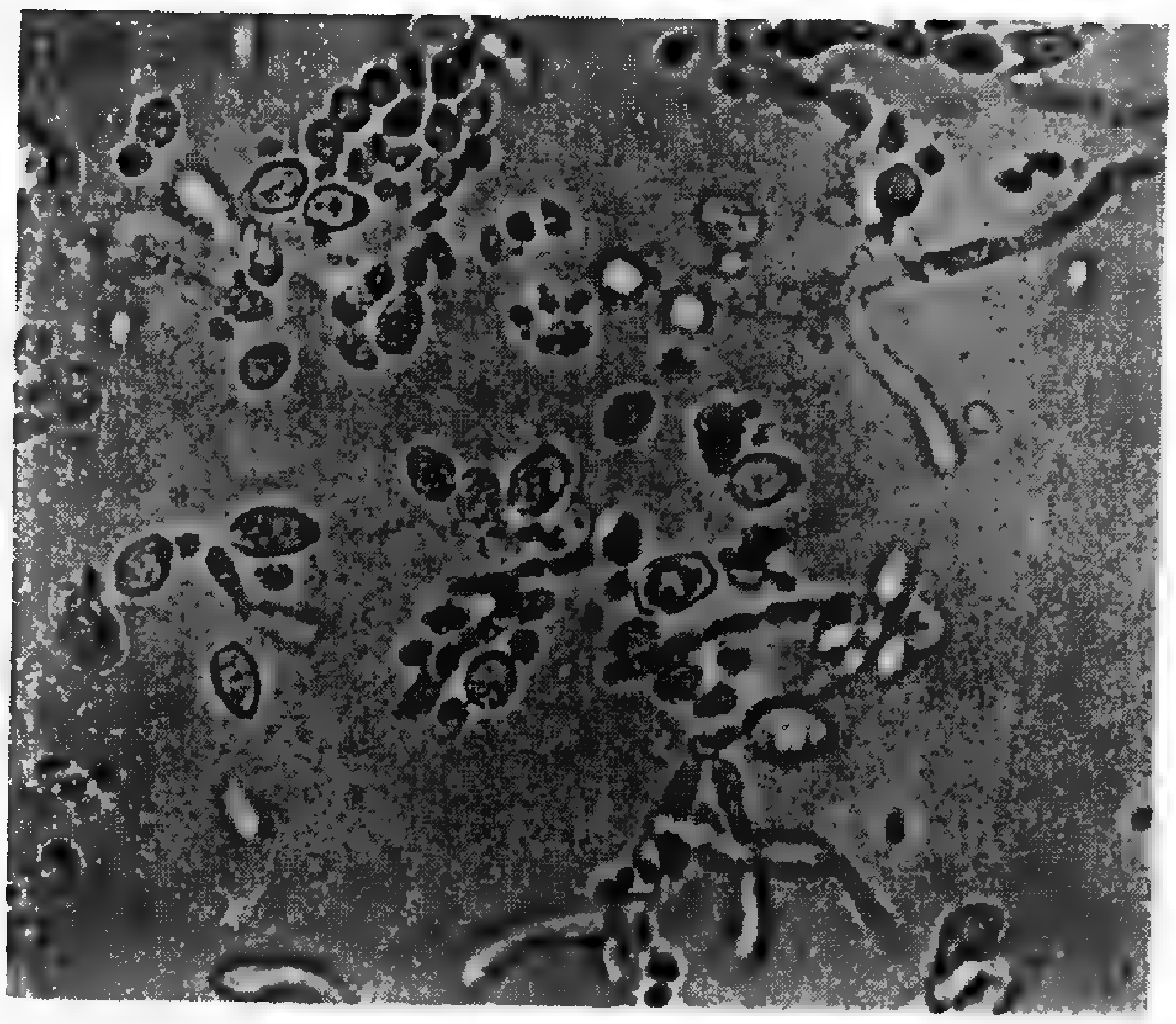
39. Salt-tolerance test shows film growth on 15% brine but not 20% at 5 days. Films disintegrate quickly at 5 and 10%. × ⅓.

40. Good film growth occurs in 4 days on ethyl alcohol medium. × ½.

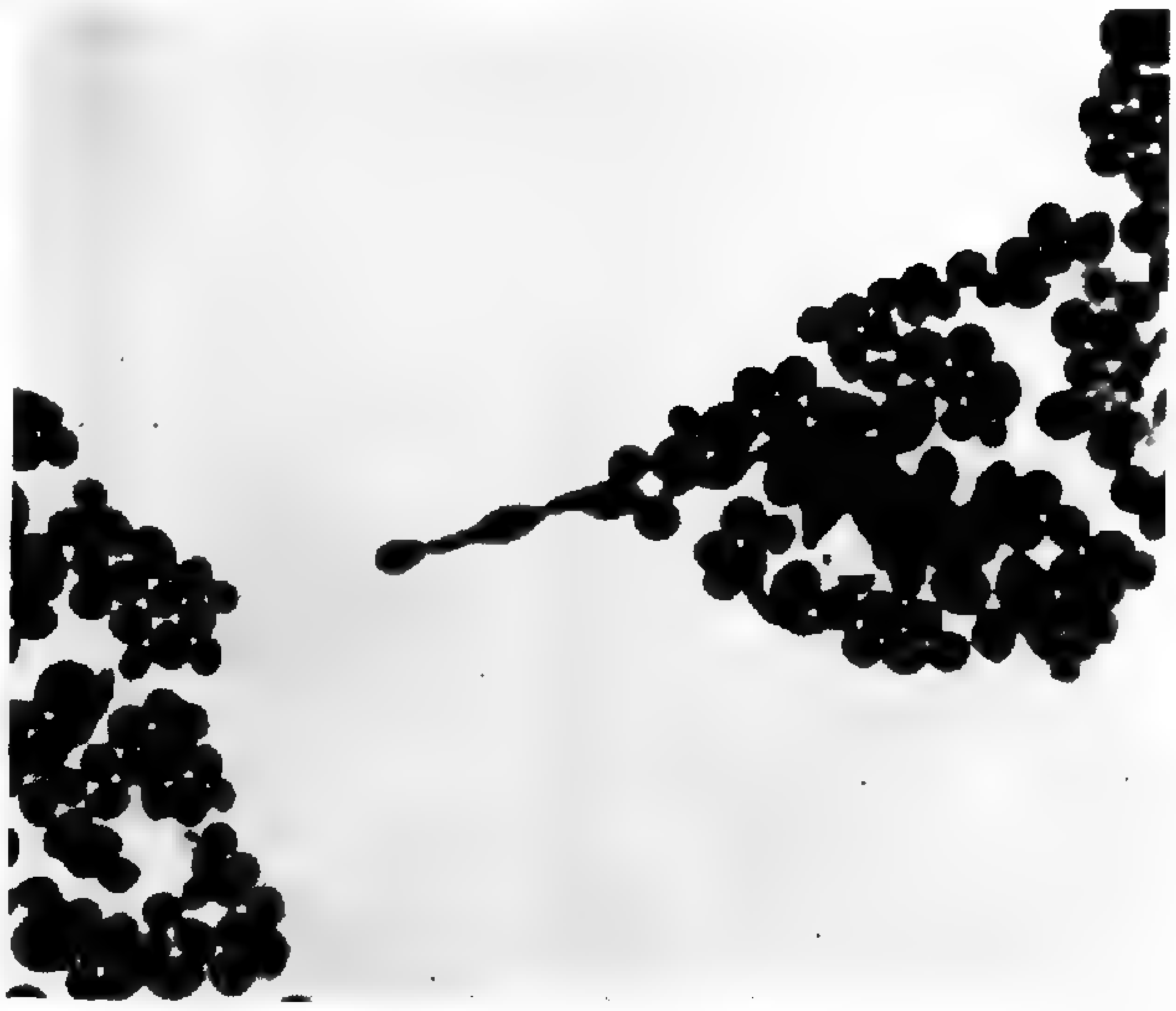


| | |
|---|---|
| Vegetable-juice agar | Synthetic agar-A |
| Glucose agar | Glucose-salt agar |

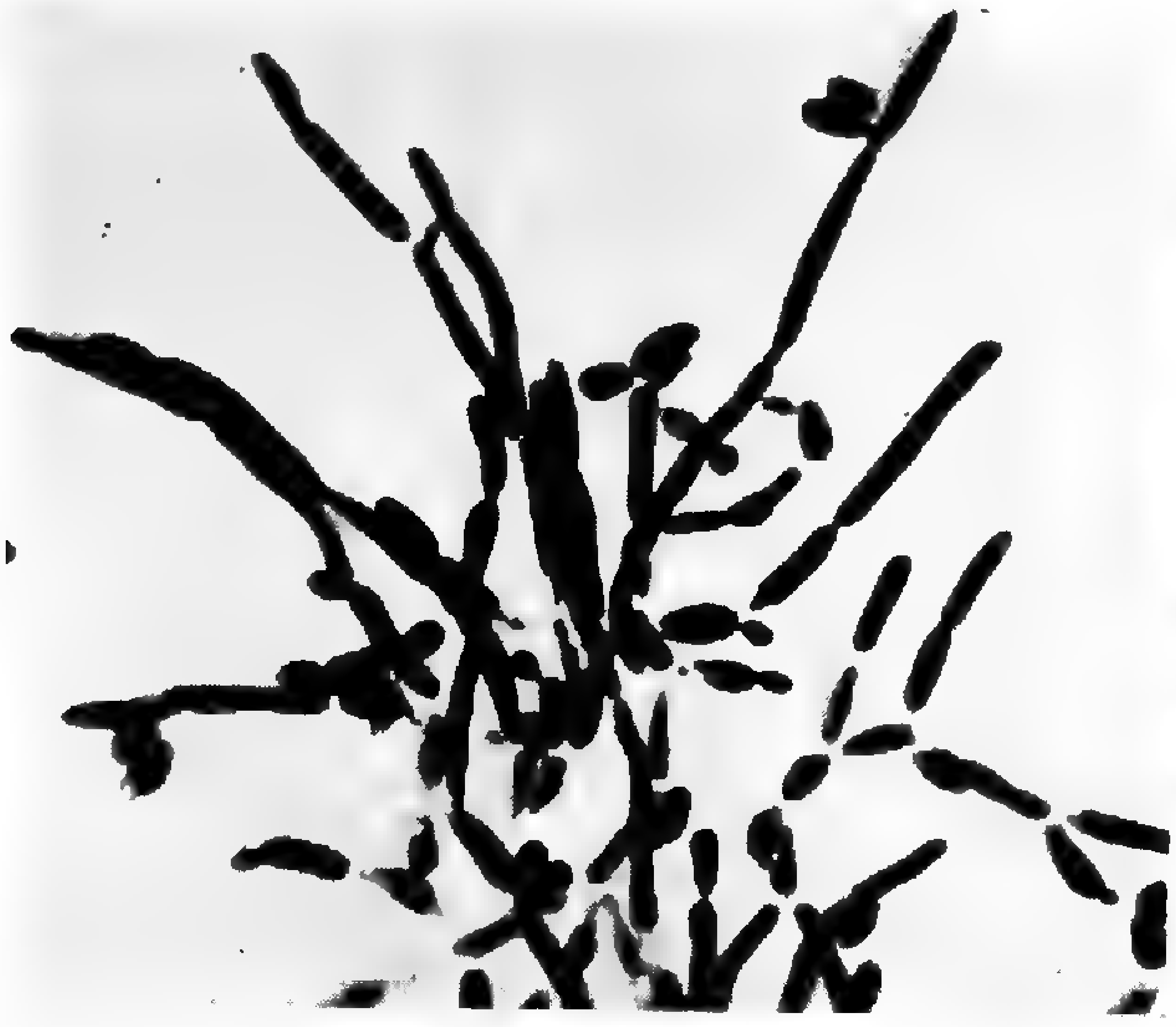
41. Comparative growth by *Endomycopsis ohmeri* var. *minor* Etchells & Bell (FY-1) on different cultural media after 6 weeks' incubation at room temperature. Slightly enlarged. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.



42. Pleomorphic cells from vegetable-juice agar after 4 months. Single spore in ascus (arrow). Unstained, × 1500.

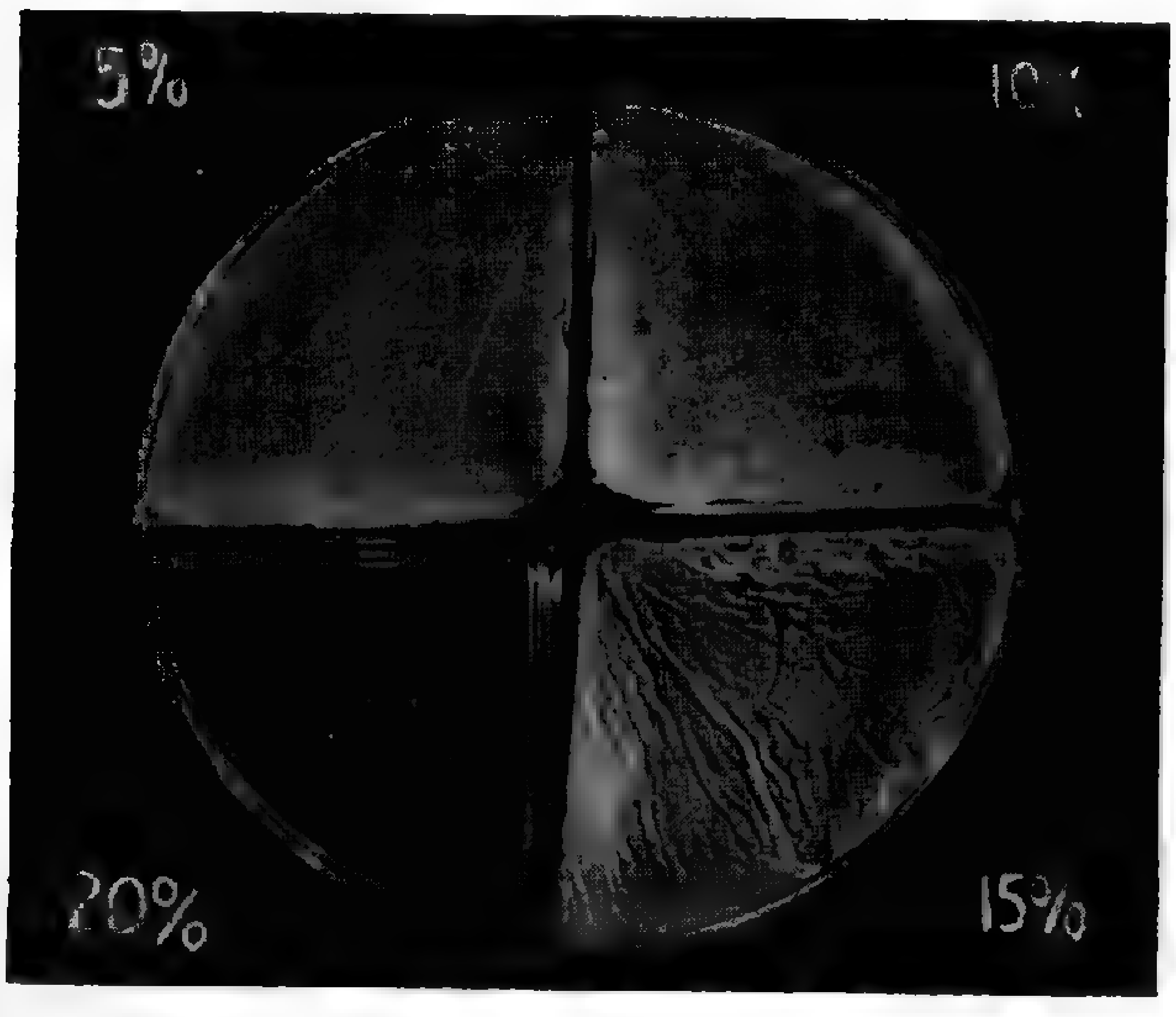


43. Cells from synthetic agar-A after 7 days. Gram stained, × 1500.

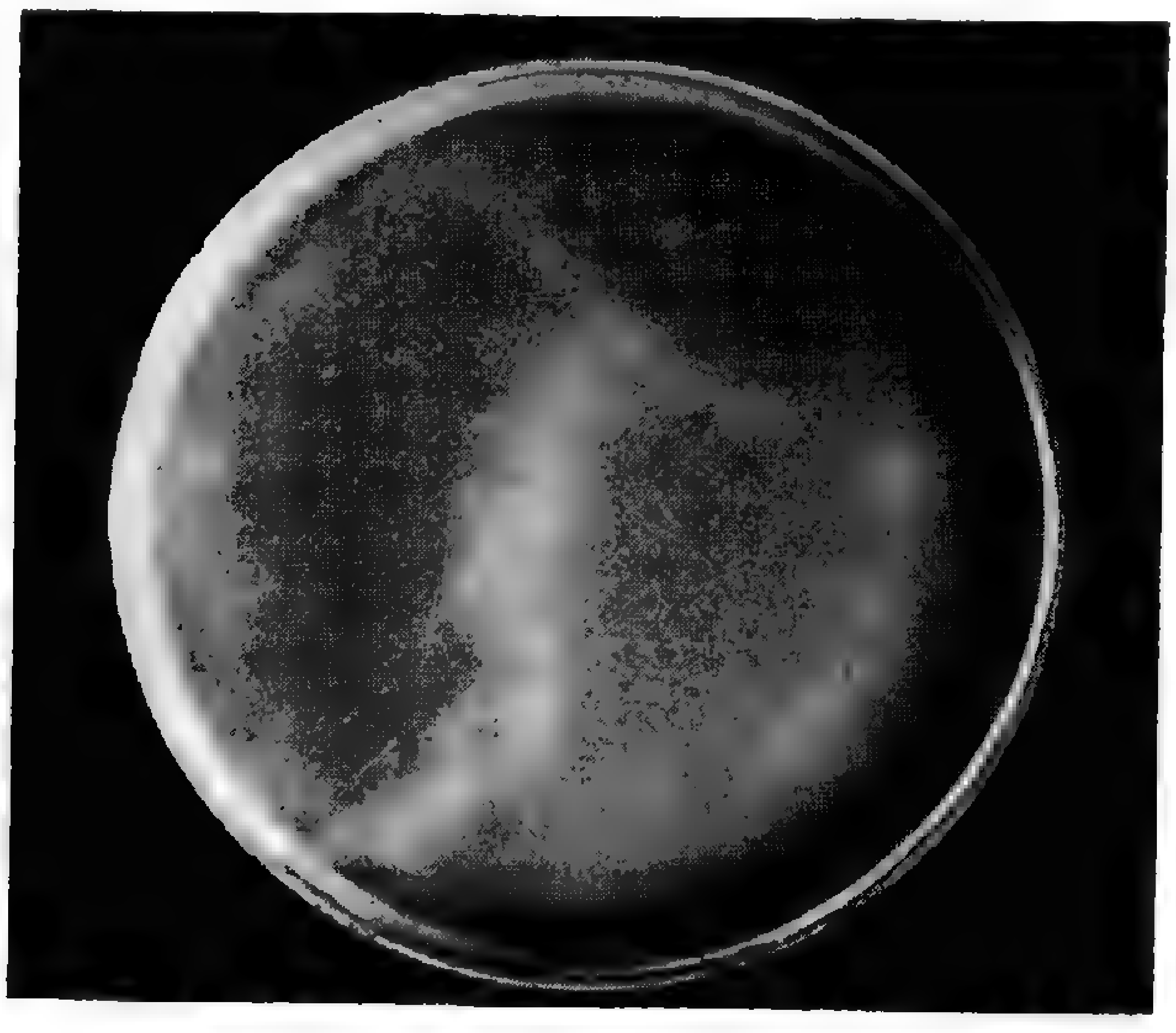


44. Elongated cells from film on 10% salt brine after 48 hours. Gram stained, × 1500.

45. Mycelium formation on cornmeal agar after 3 weeks; unstained, × 650. Insert, 2 spores from mycelium, enlarged, × 2.

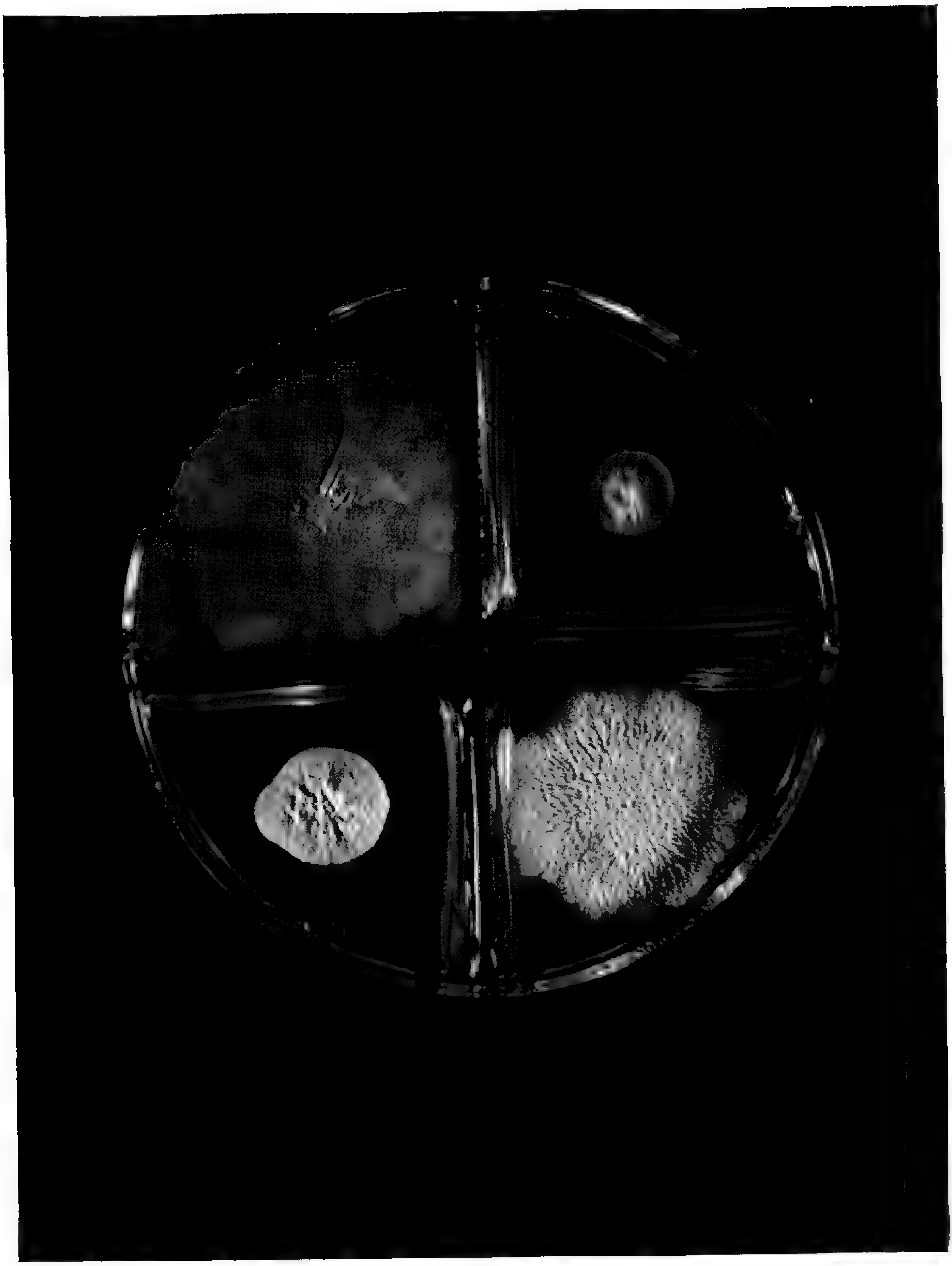


46. Salt-tolerance test shows film growth on 15% brine but not 20% at 5 days. Films on 5 and 10% have fallen. × ½.



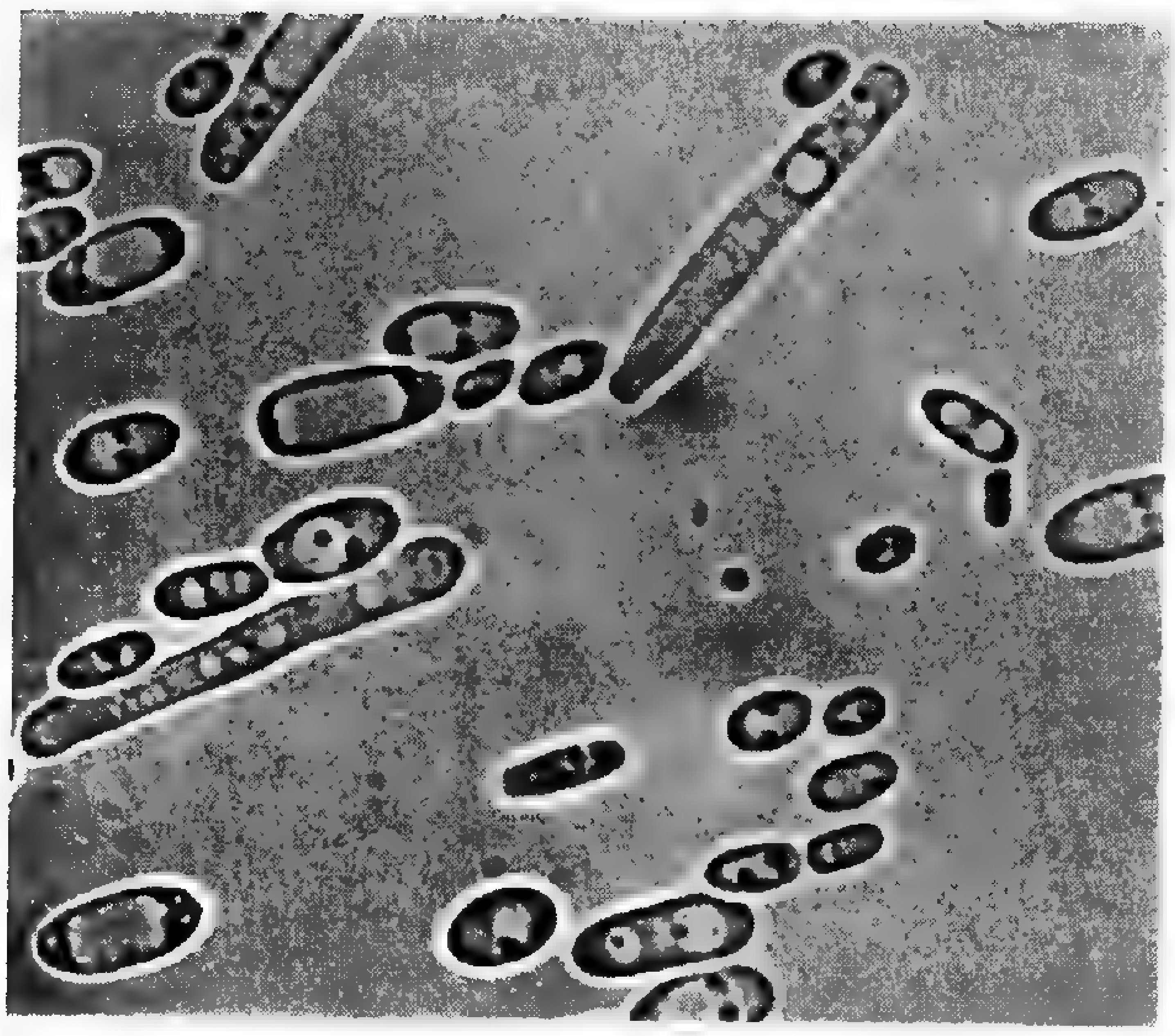
47. A smooth, membrane-type film forms on ethyl alcohol medium in 4 days. × ½.

Candida

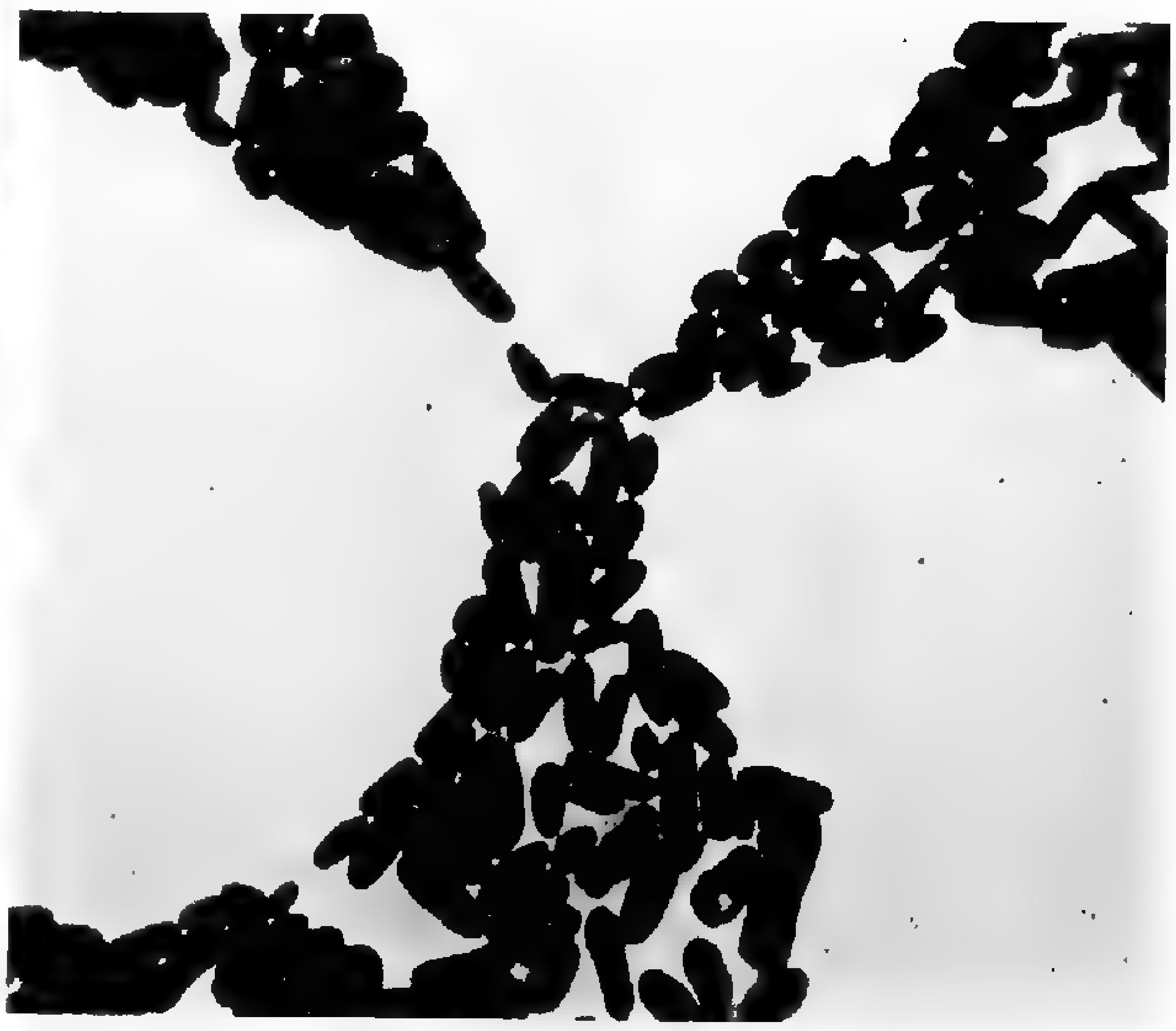


| | |
|---|---|
| Vegetable-juice agar | Synthetic agar-A |
| Glucose agar | Glucose-salt agar |

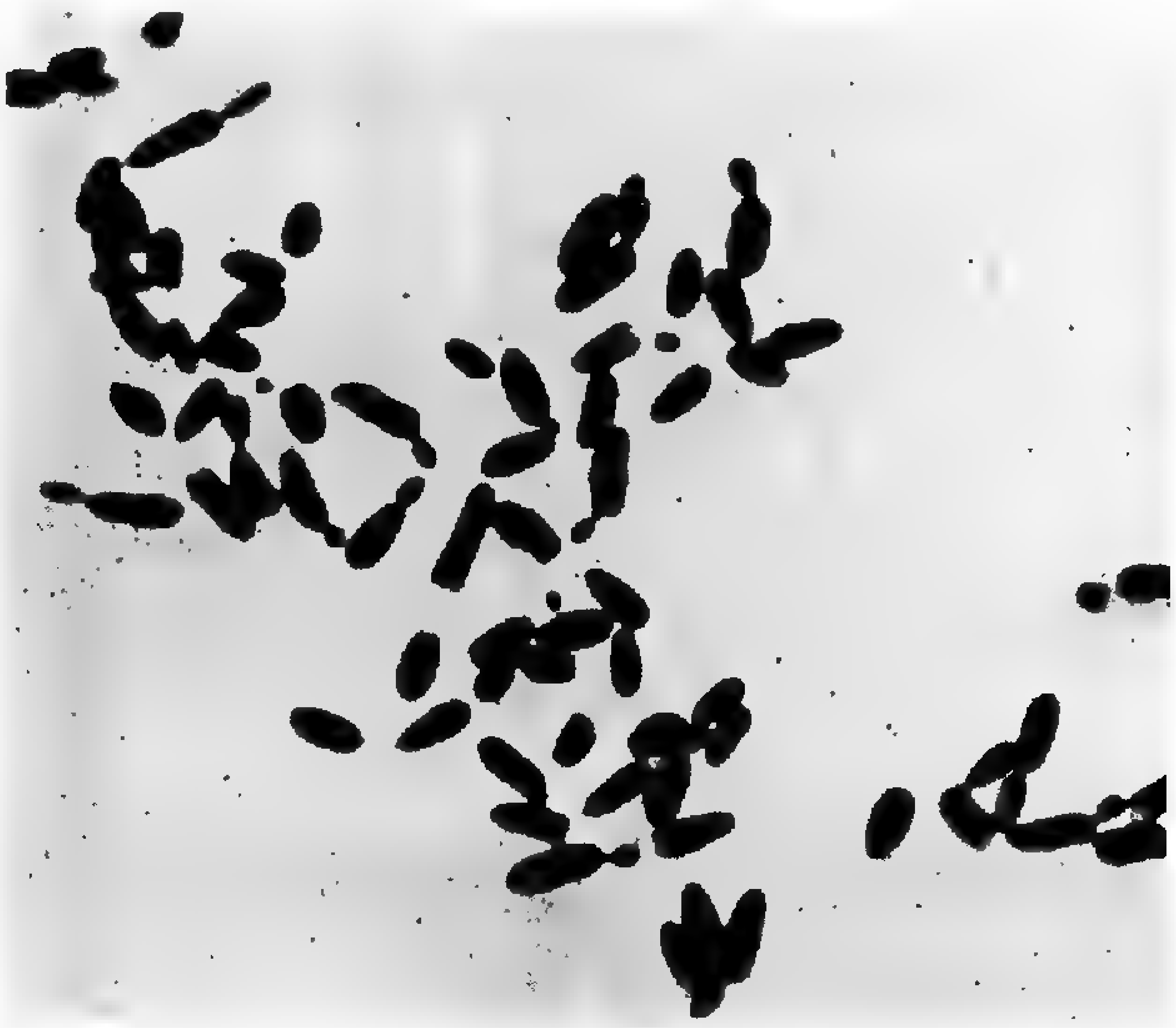
D. Comparative growth by *Candida krusei* (A. Cast.) Berkhout (FY-20) on different cultural media after 6 weeks' incubation at room temperature. Actual size. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.



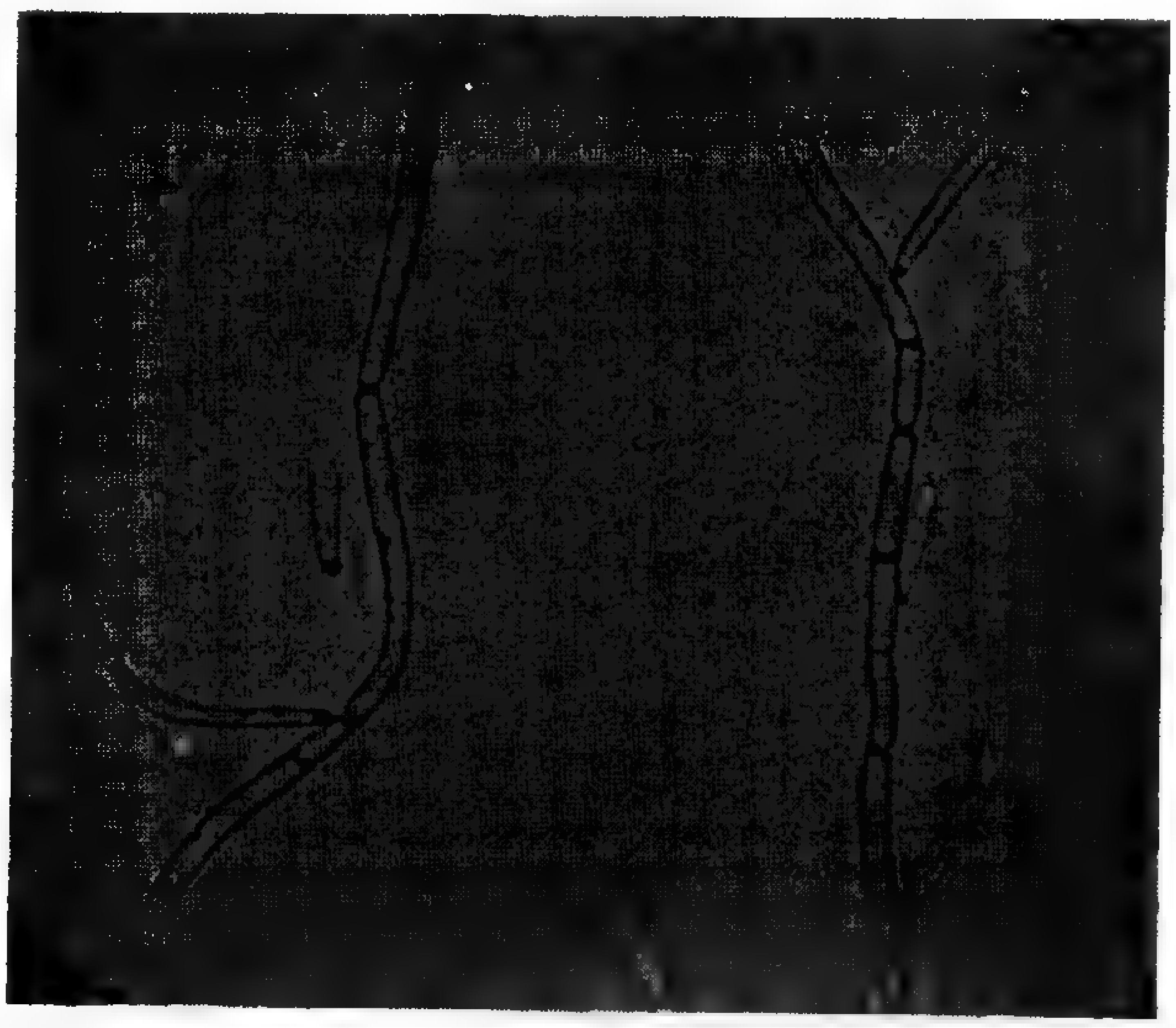
48. Typical cells from vegetable-juice agar at 3 weeks. Unstained, × 1500.



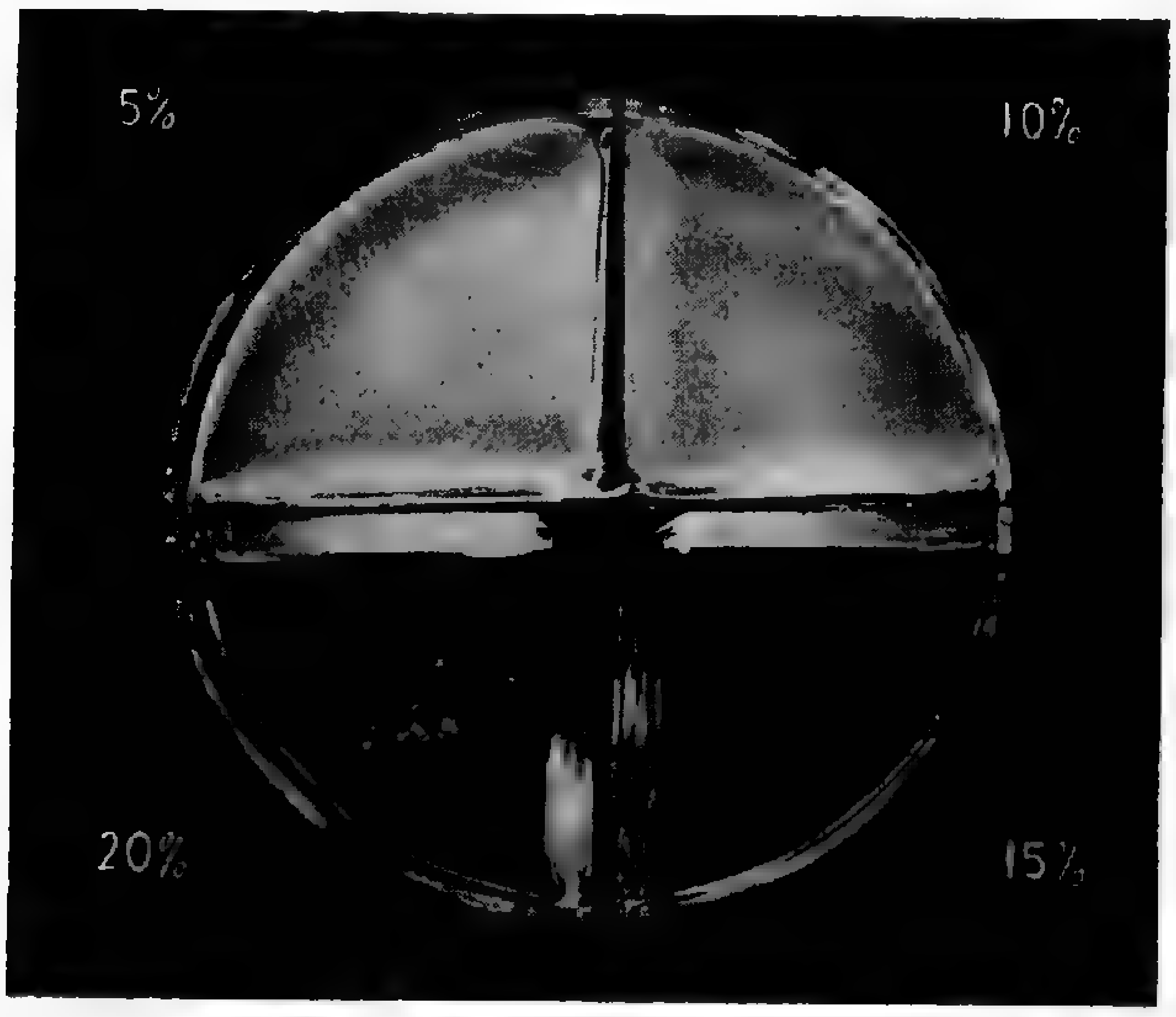
49. Cells from synthetic agar-A after 7 days. Gram stained, × 1500.



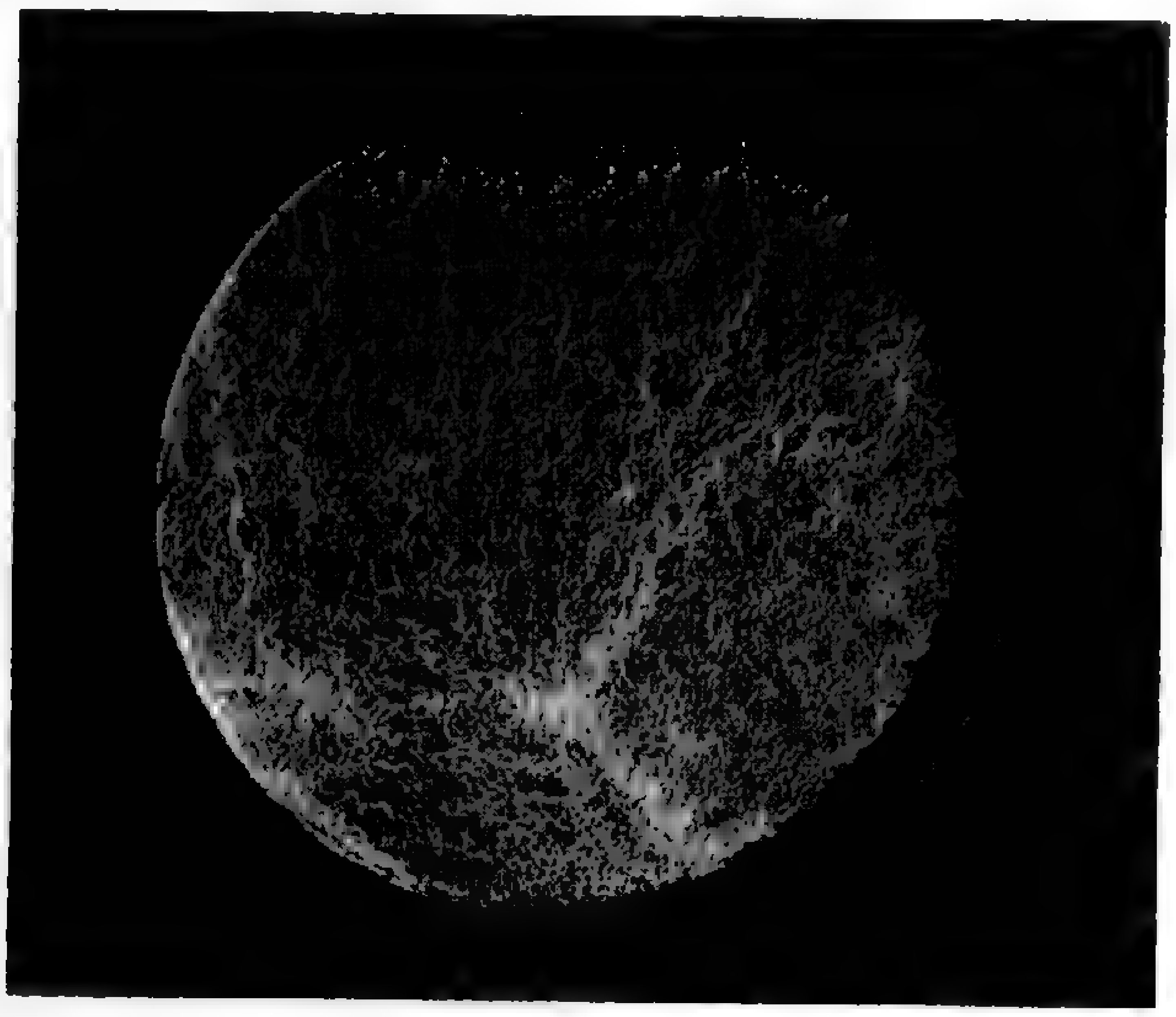
50. Cells from film on 10% salt brine after 5 days. Gram stained, × 1500.



51. Evidence of septated mycelium on cornmeal agar after 3 weeks. Unstained, × 650; enlarged, × 2.

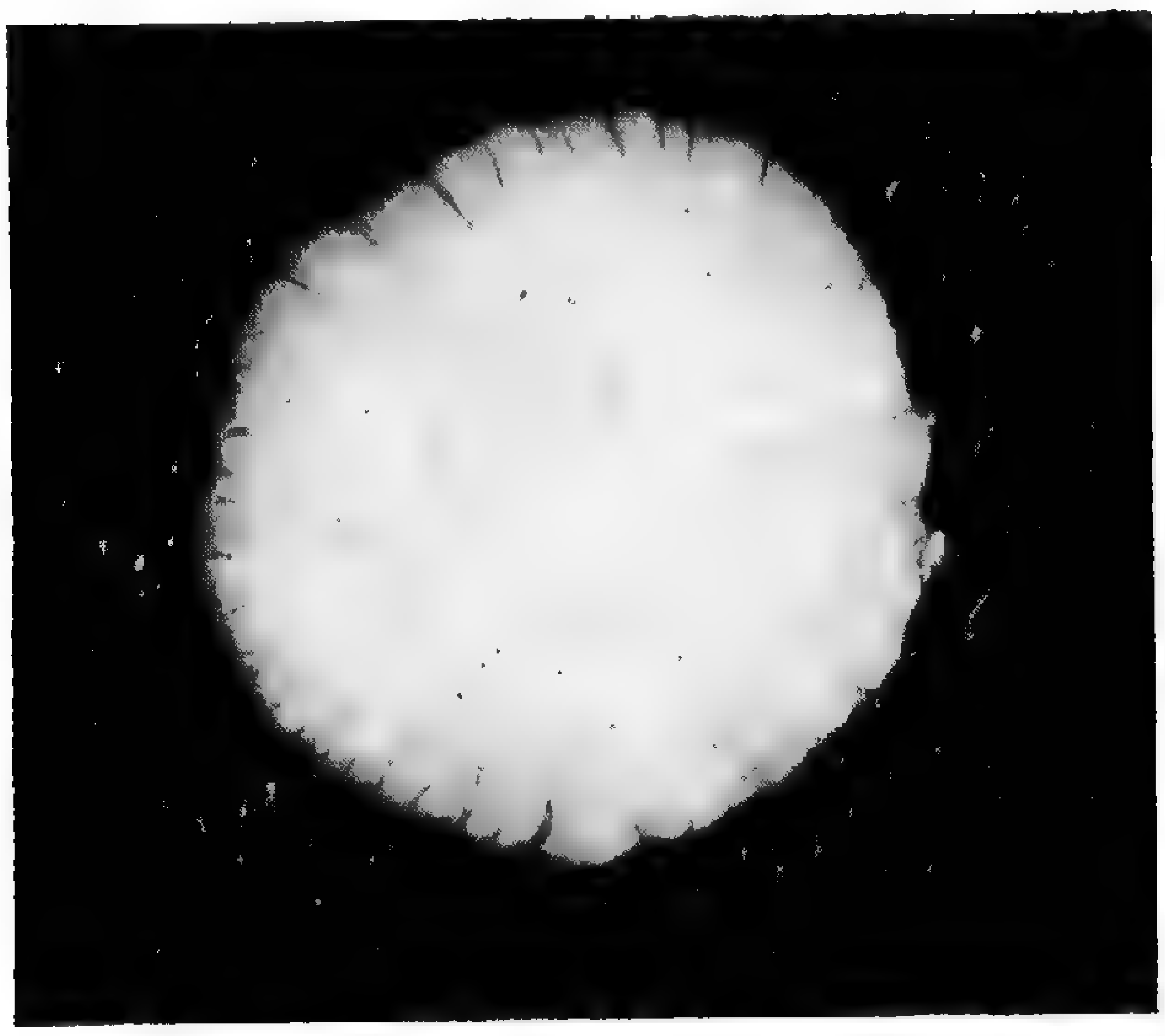


52. Salt-tolerance test shows no film growth above 10% brine strength after 7 days. × ½.

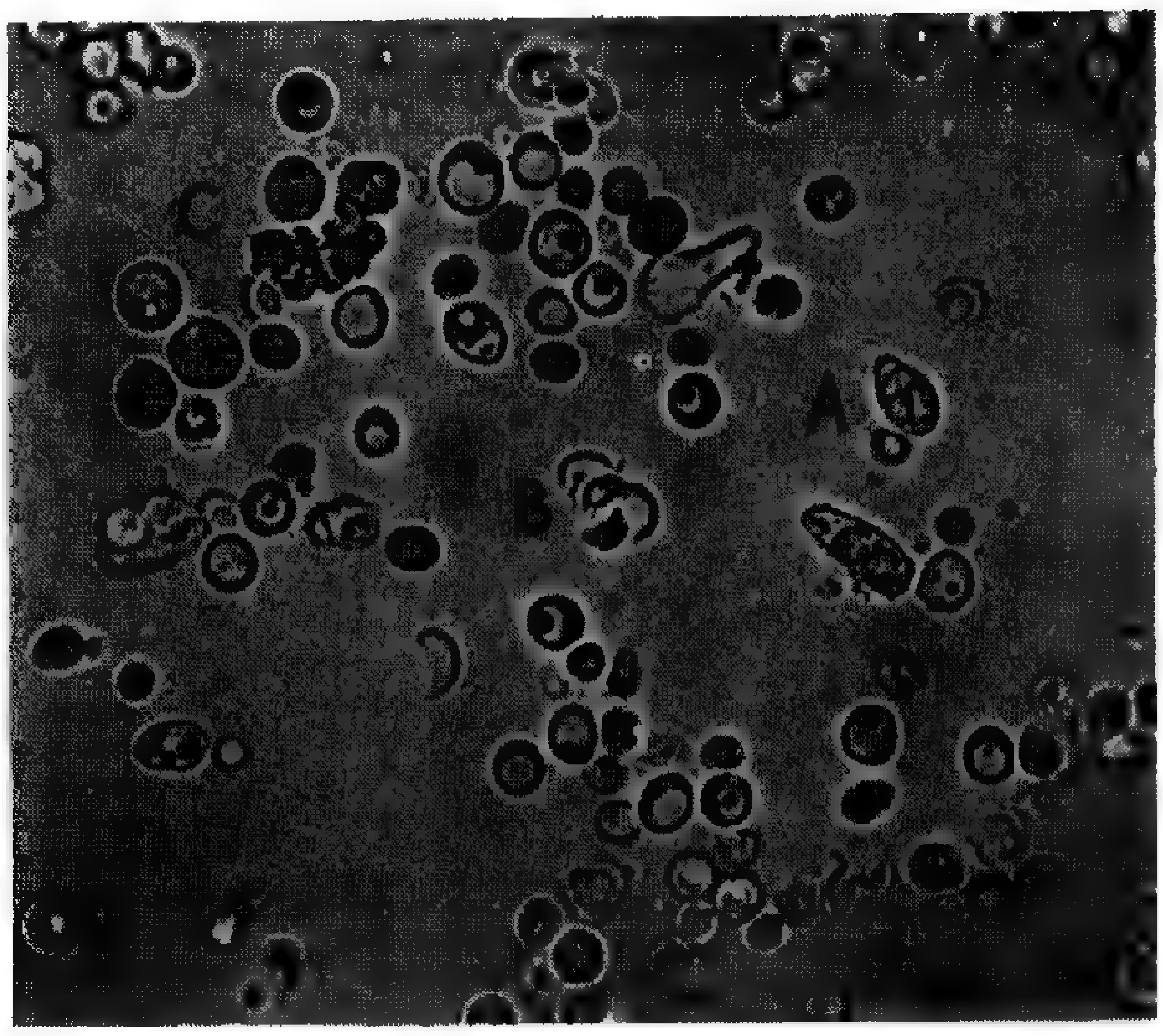


53. Heavy film formation on ethyl alcohol medium at 4 days. × ½.

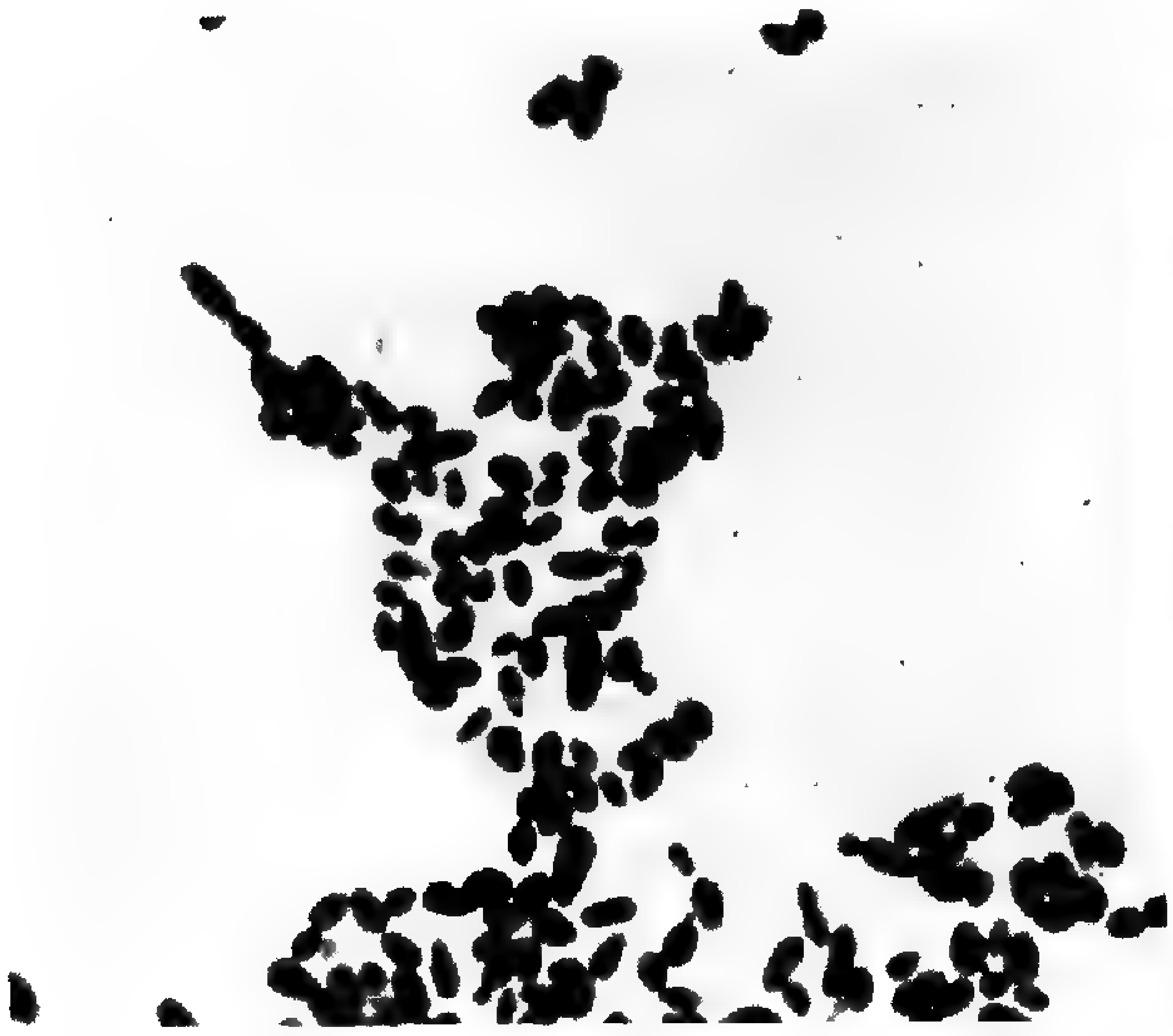
## *HANSENULA ANOMALA* (HANSEN) SYDOW (KS)



54. Giant colony grown on vegetable-juice agar, 6 weeks. × 2.

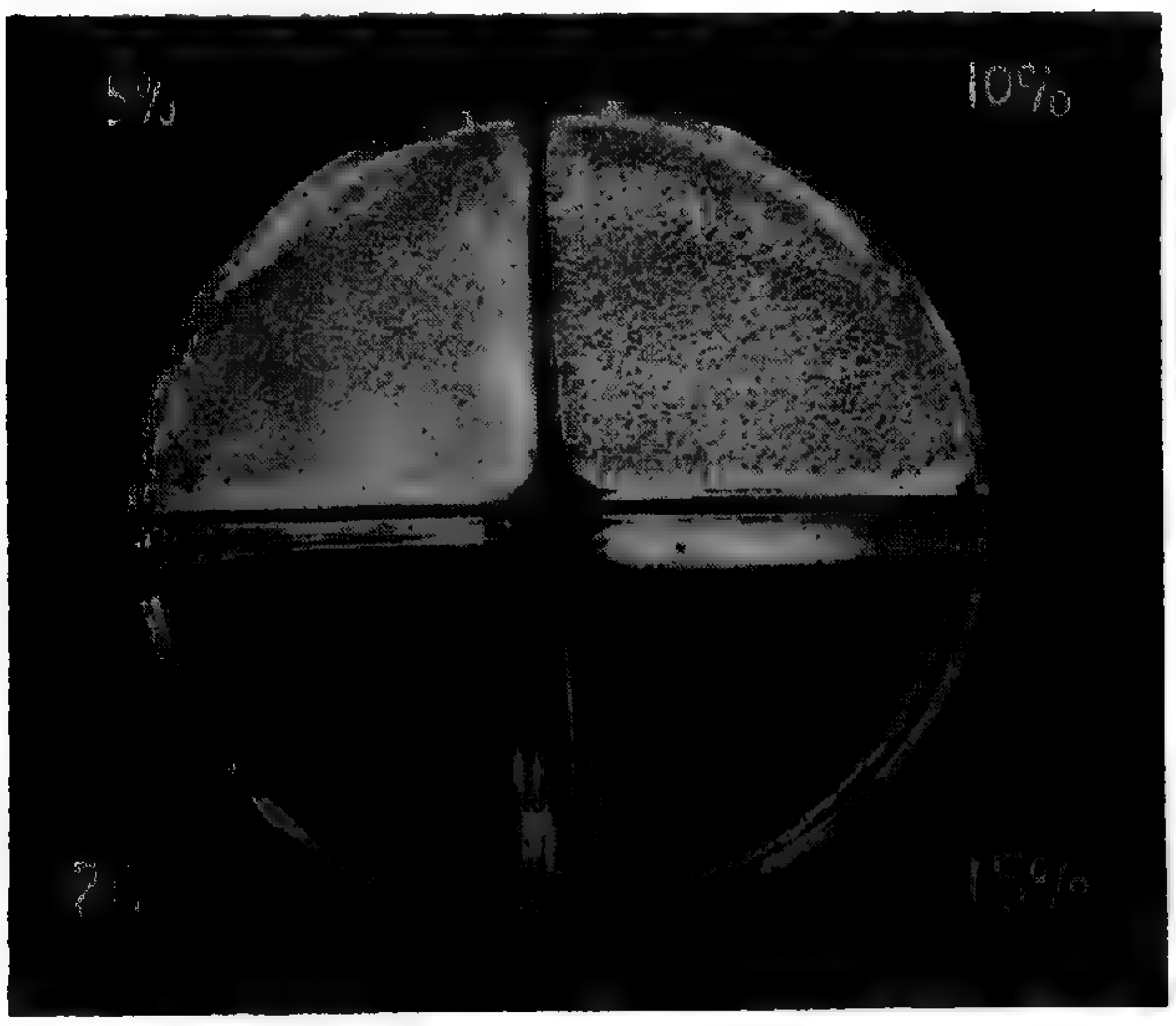


55. Sporulation at 2 months. *A*, hat-shaped spores in ascus; *B*, emerging spore; *C*, cluster of free spores. Unstained, × 1500.

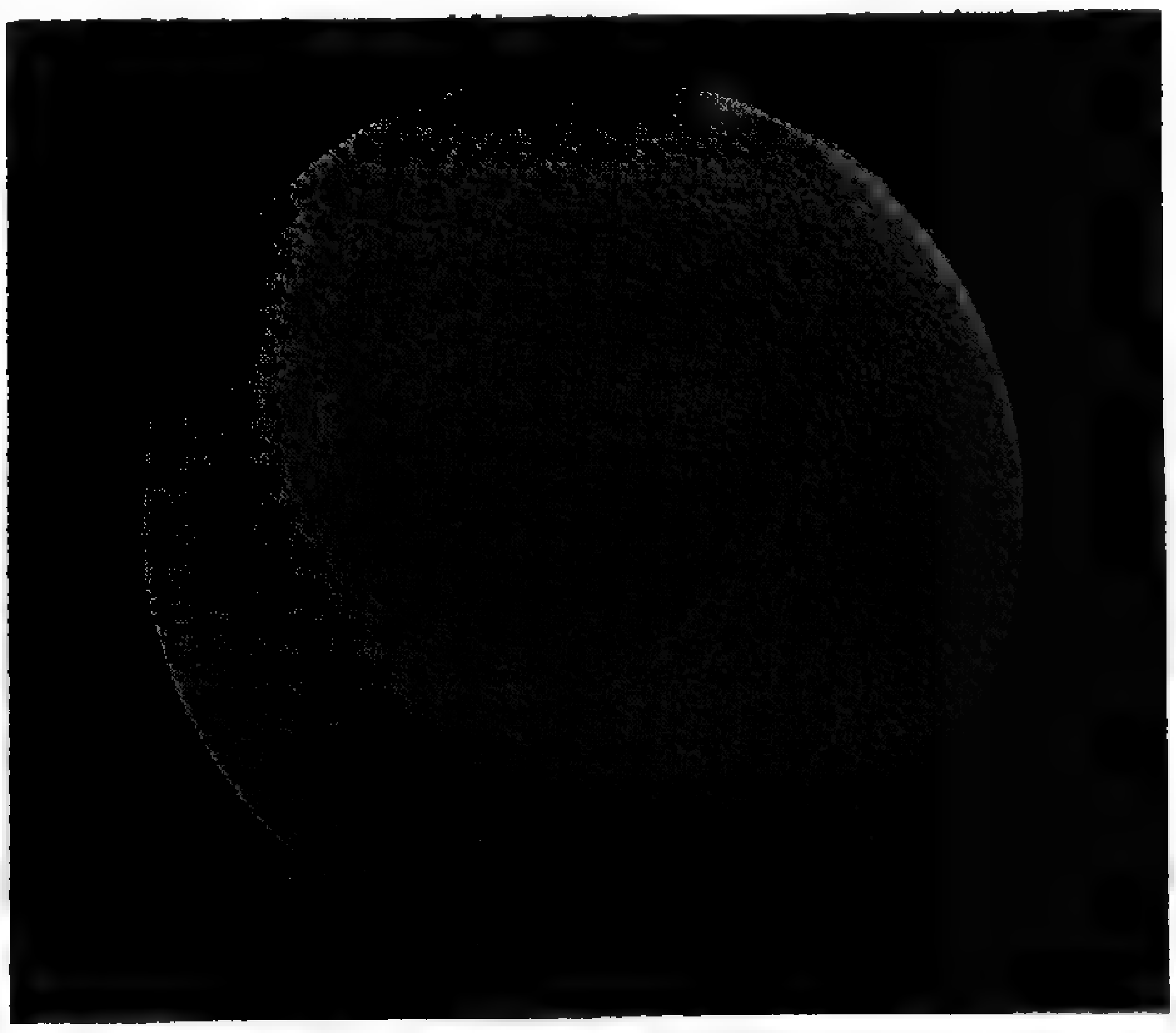


56. Cells from film on 5% salt brine after 48 hours. Gram stained, × 1500.

57. Mycelium formation on cornmeal agar after 3 weeks. Unstained, × 650.

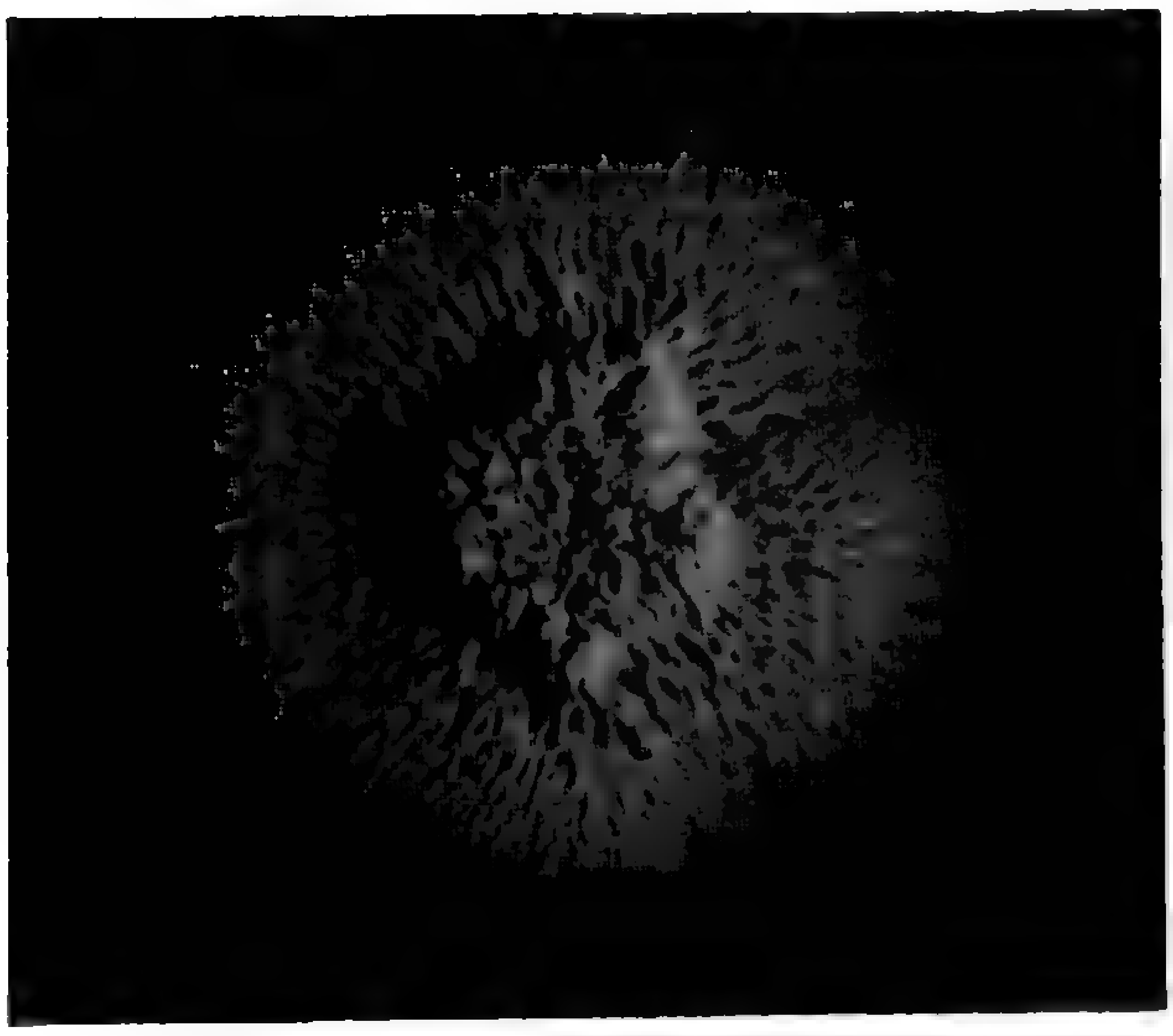


58. Salt-tolerance test shows heavy films at 5 and 10% brines, a very thin film on 15%, after 7 days. × ½.

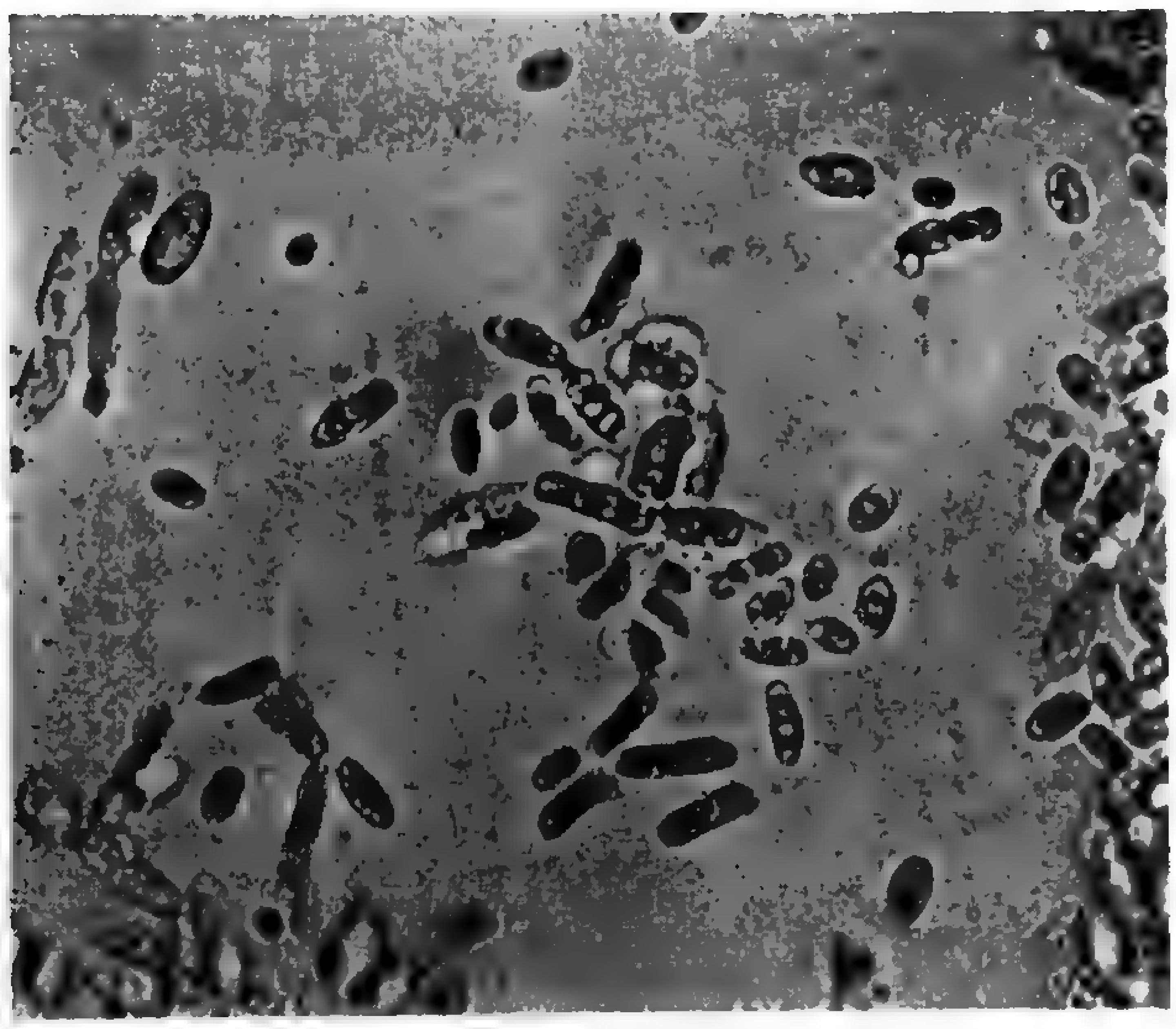


59. Heavy film formation on ethyl alcohol medium at 4 days. × ½.

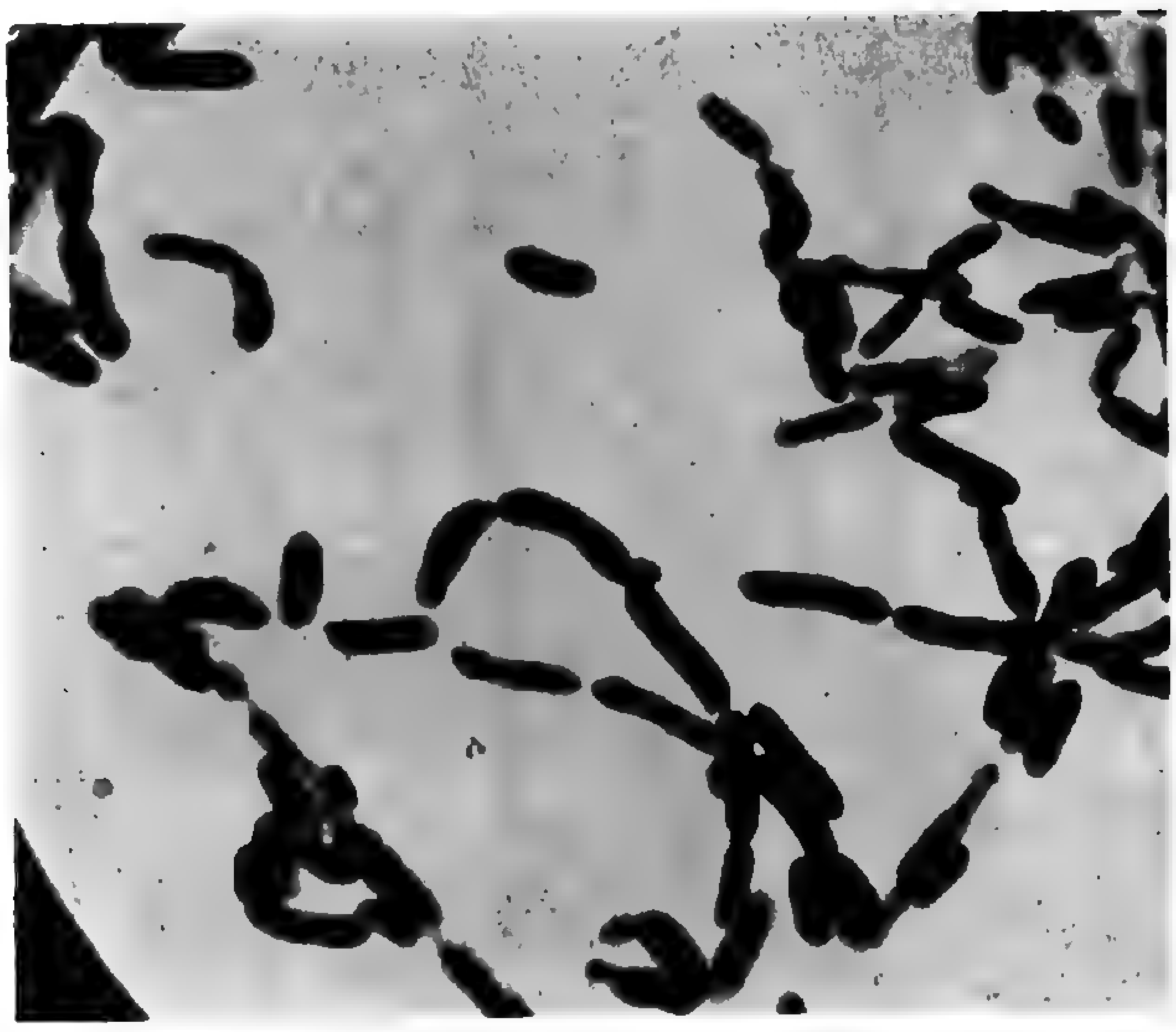
## *PICHIA ALCOHOLOPHILA* KLOCKER (FY-31)



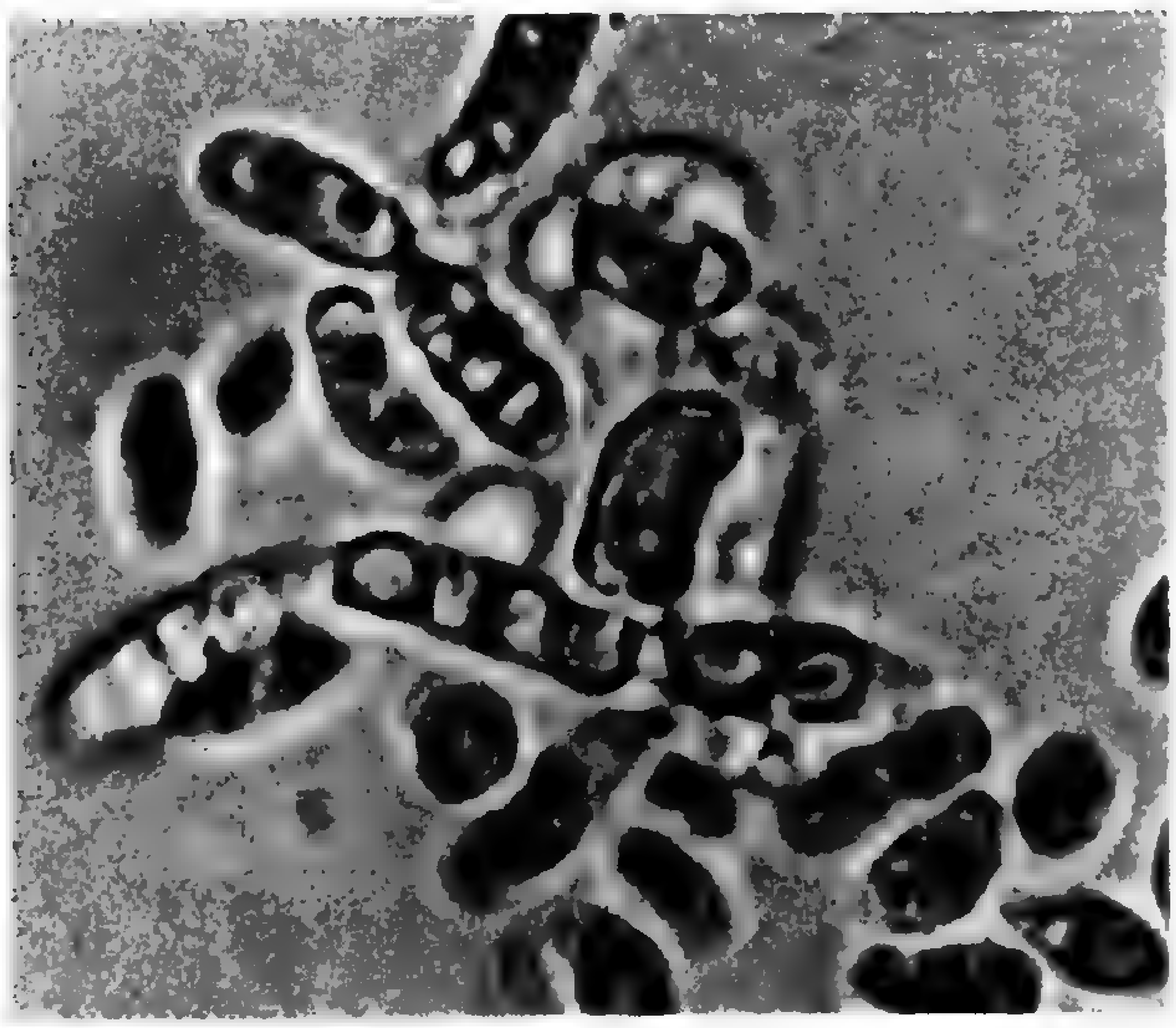
60. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2.



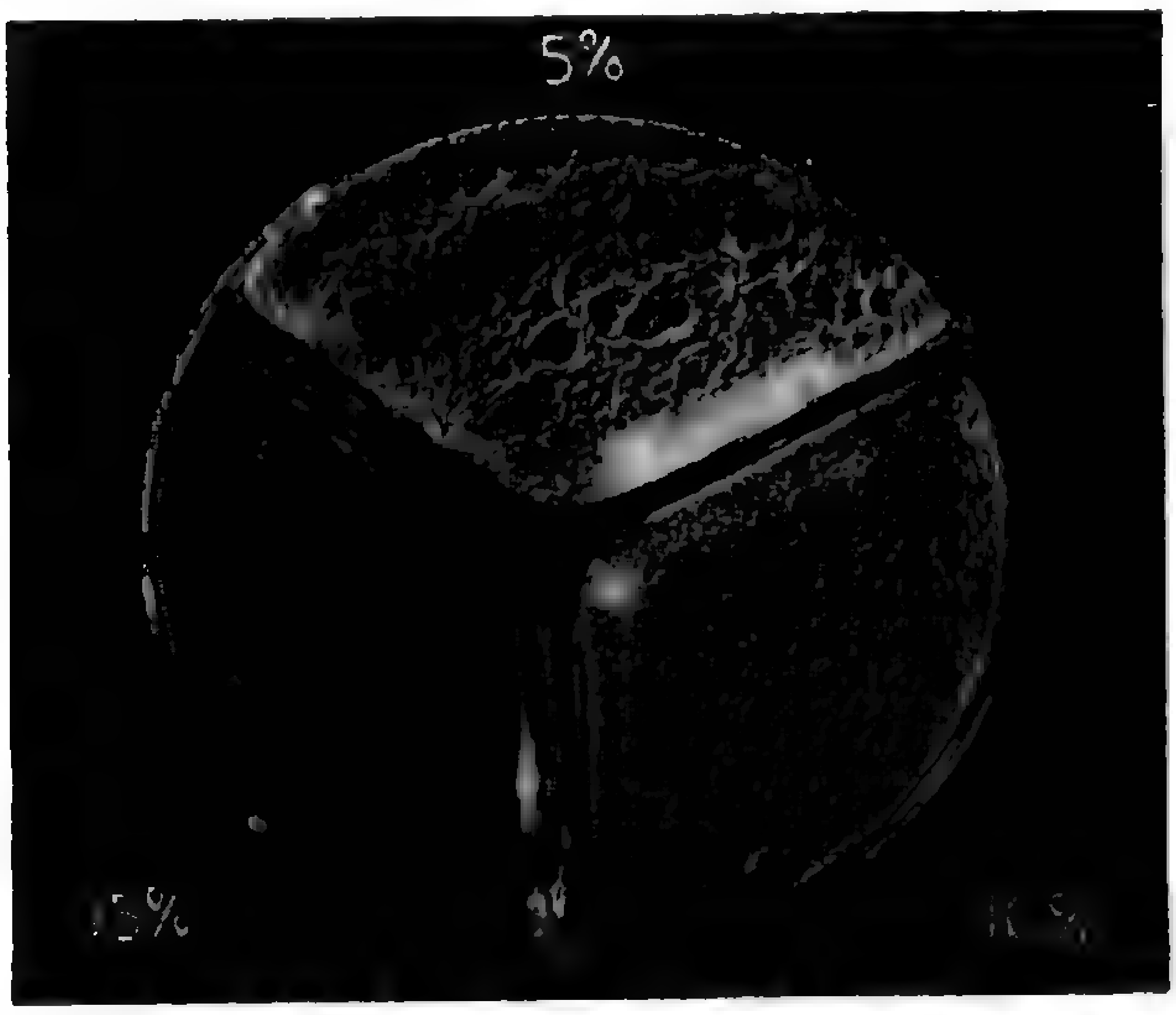
61. Sporulation on vegetable-juice agar at 2 months. Unstained, × 1500.



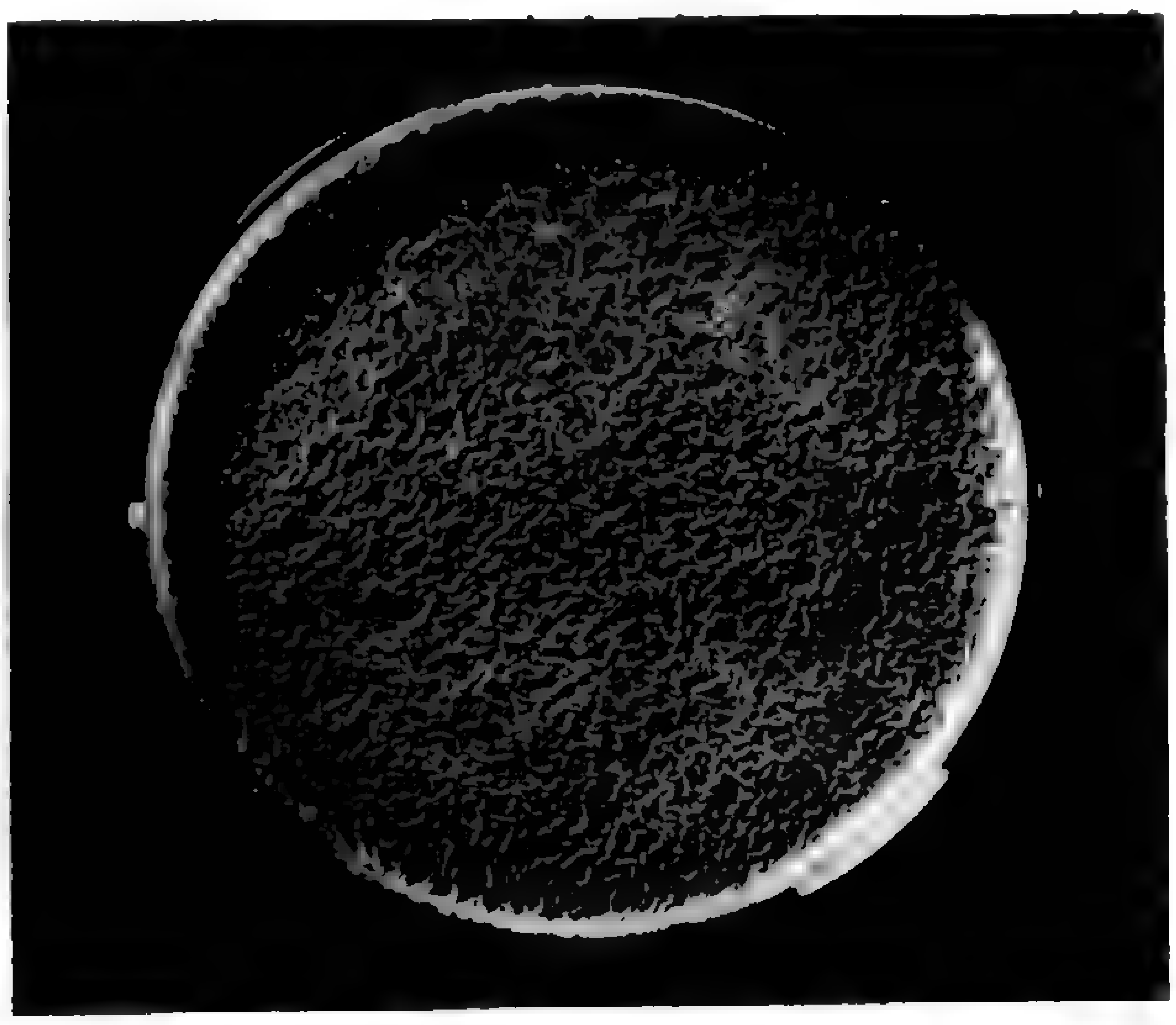
62. Sausage-shaped cells from film on 5% saltbrine after 48 hours. Gram stained, × 1500.



63. Enlarged section of above; fully developed asci with 2 and 4 helmet-shaped spores.



64. Salt-tolerance test shows film growth at 5 and 10% brines; no growth at 15% after 3 days. × ½.



65. Heavy film formation on ethyl alcohol medium at 4 days. × ½.

## SUBSURFACE BRINE YEASTS

Active growth by the fermentative subsurface yeasts in commercial cucumber brines was first reported in 1941 *(5)*. Since then, their growth activity has been reported in a variety of other brined and salted vegetables *(12)*. In contrast to film-forming types, the growth of subsurface species in brines is characterized by a gaseous fermentation which results in the evolution of rather large amounts of carbon dioxide.

Further, their growth covers a wide range with respect to brine concentration, the maximum salt-tolerance observed under commercial conditions being in the neighborhood of 20 to 22 percent by weight (saturation being 26.4). Usually, the salt content of the brine determines the time yeast growth starts as well as the duration of activity.

As a rule, fermentations in low salt content brines (about 5 percent) start earlier and are of shorter duration than those at higher concentrations (10 to 15 percent). The reason for more active yeast development in the stronger brines is that the lactic acid bacteria are inhibited as the brine strength increases and more food material remains for the yeasts which are much more salt-tolerant.

Studies on commercially brined cucumbers represent the principal source of information on the identity and sequence of individual yeast species in brine-fermented foods. Basic investigations of this type have been reported in detail *(6, 11)* for the two major cucumber brining areas in the country — northern and southern. A brief summary of these two studies, based on the identity of nearly 1,900 cultures, demonstrates that the pattern for the principal yeast species in brines from both areas is very similar. Seven of the nine species found were obtained from both northern and southern brines *(i.e. Brettanomyces versatilis, Torulopsis caroliniana, Torulopsis holmii, Torulaspora rosei, Hansenula subpelliculosa, Zygosaccharomyces halomembranis* and *Zygosaccharomyces globiformis)*. The presence of *Saccharomyces globosus* in northern brines was considered to be the principal floral difference.

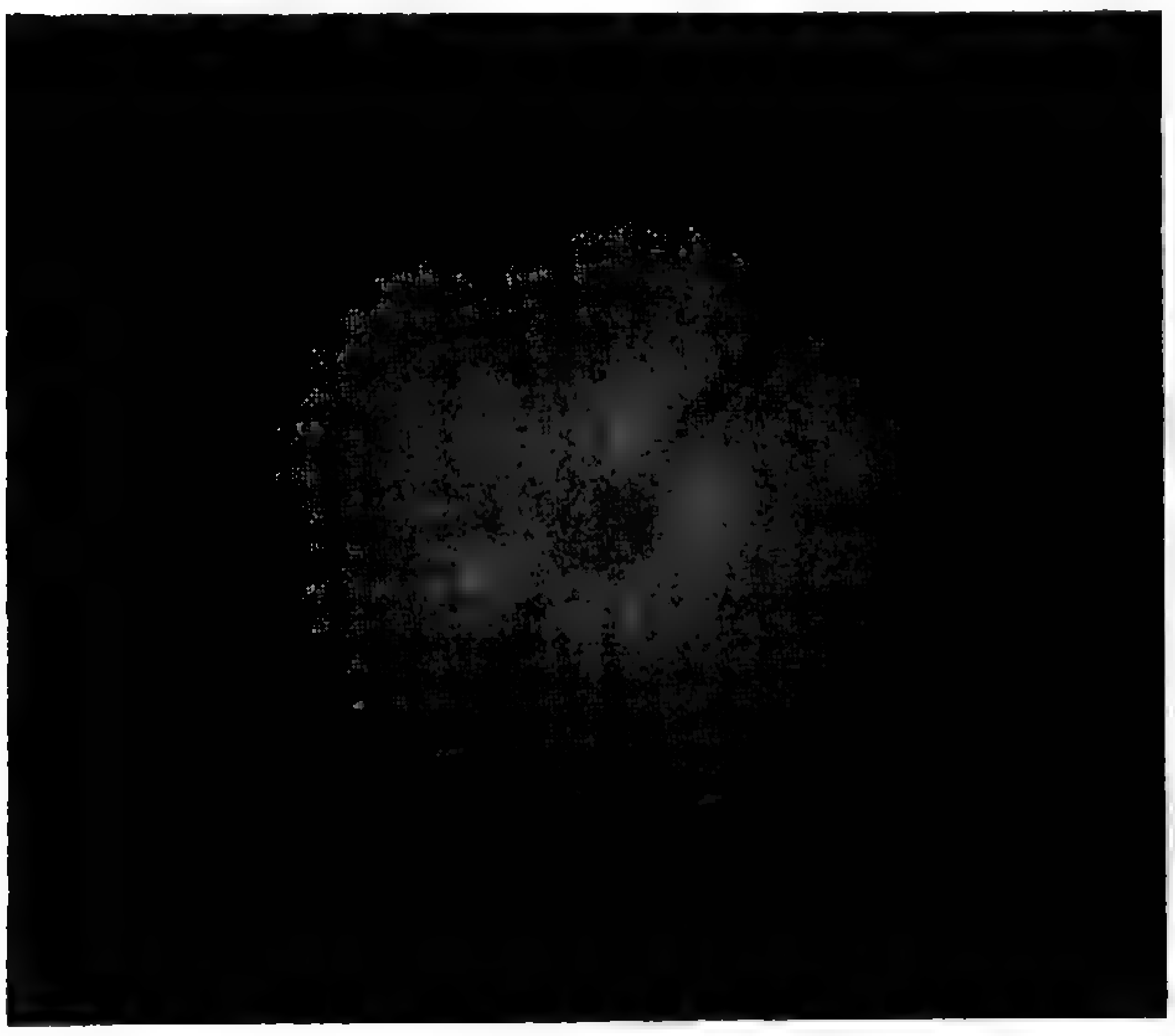
Because a gaseous fermentation by subsurface yeasts is associated with a type of spoilage known as "bloater" or hollow cucumber formation, yeast growth is of economic importance to the pickling industry. "Bloating" can be either in the form of lens-shaped gas pockets in the tissue, or the gas pressure can be sufficient to press the whole seed portion of the cucumber toward the skin, thus leaving a large gas-filled cavity.

Yeasts are also responsible for certain types of spoilage in manufactured pickle products. This is particularly true in cases of non-pasteurized products where the vinegar and sugar concentrations are insufficient to inhibit their growth, or, where they are allowed to develop high tolerance to vinegar and sugar through lack of plant sanitation. In a recent outbreak of spoilage of sweet pickles a number of very acid- and sugar-tolerant yeast cultures were obtained and identified as *Zygosaccharomyces globiformis* (*2*). It is recalled that this yeast was found in cucumber fermentations located in the principal brining areas of the country.

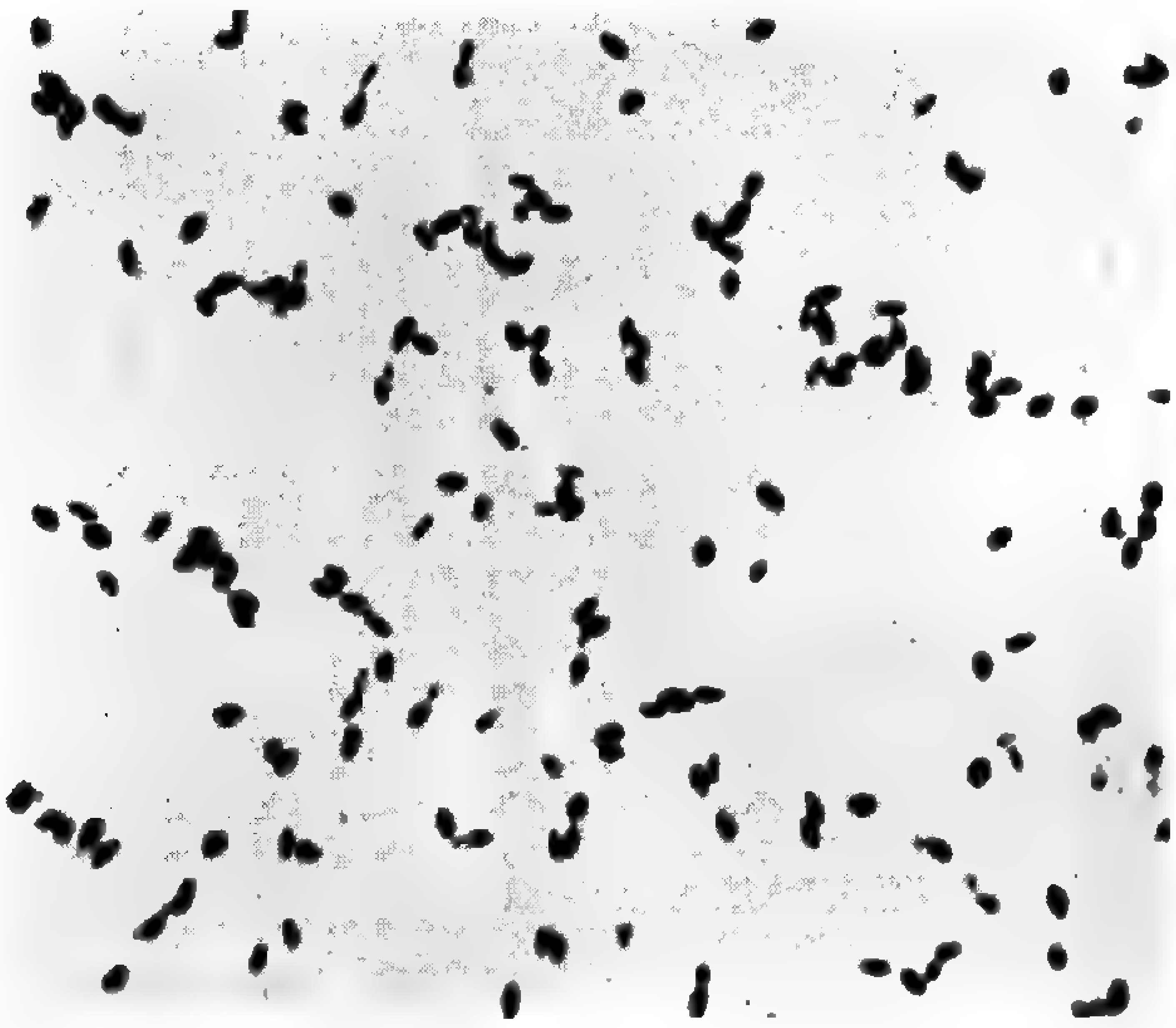
So far, the brine yeast species studied have not been incriminated as a potential source of the cucumber salt-stock softening enzyme pectinase *(8)*. However, a strain of *S. cerevisiae* isolated from soft dill pickles (YD-15, page 293) appears to be identical taxonomically with strains isolated from spoiled citrus concentrate (*13*) that do produce this enzyme (D-6, page 293).

## Torulopsis

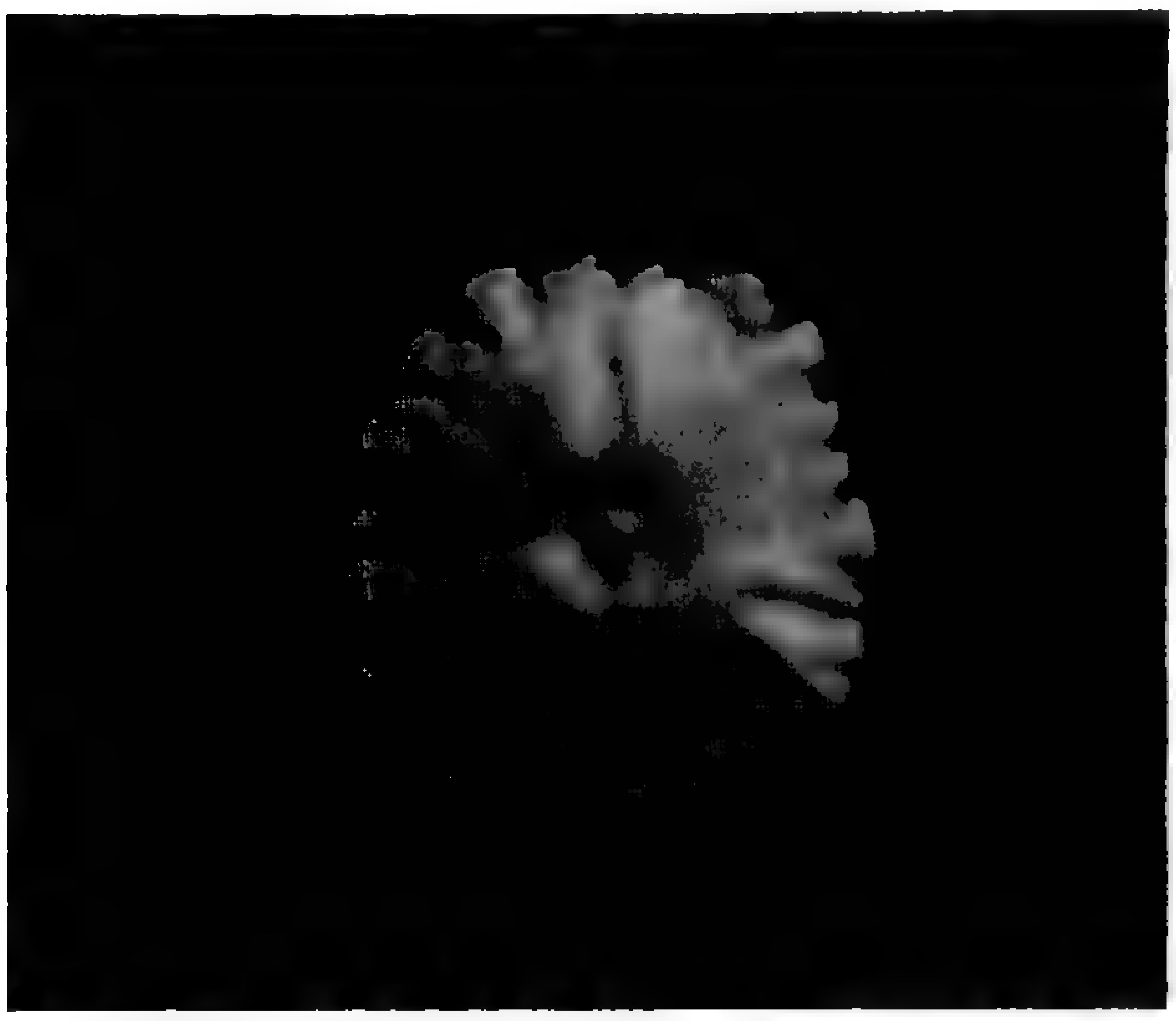
### *T. CAROLINIANA* ETCHELLS & BELL (RY-165)



66. Giant colony grown on vegetable-juice agar; at 6 weeks. × 3.



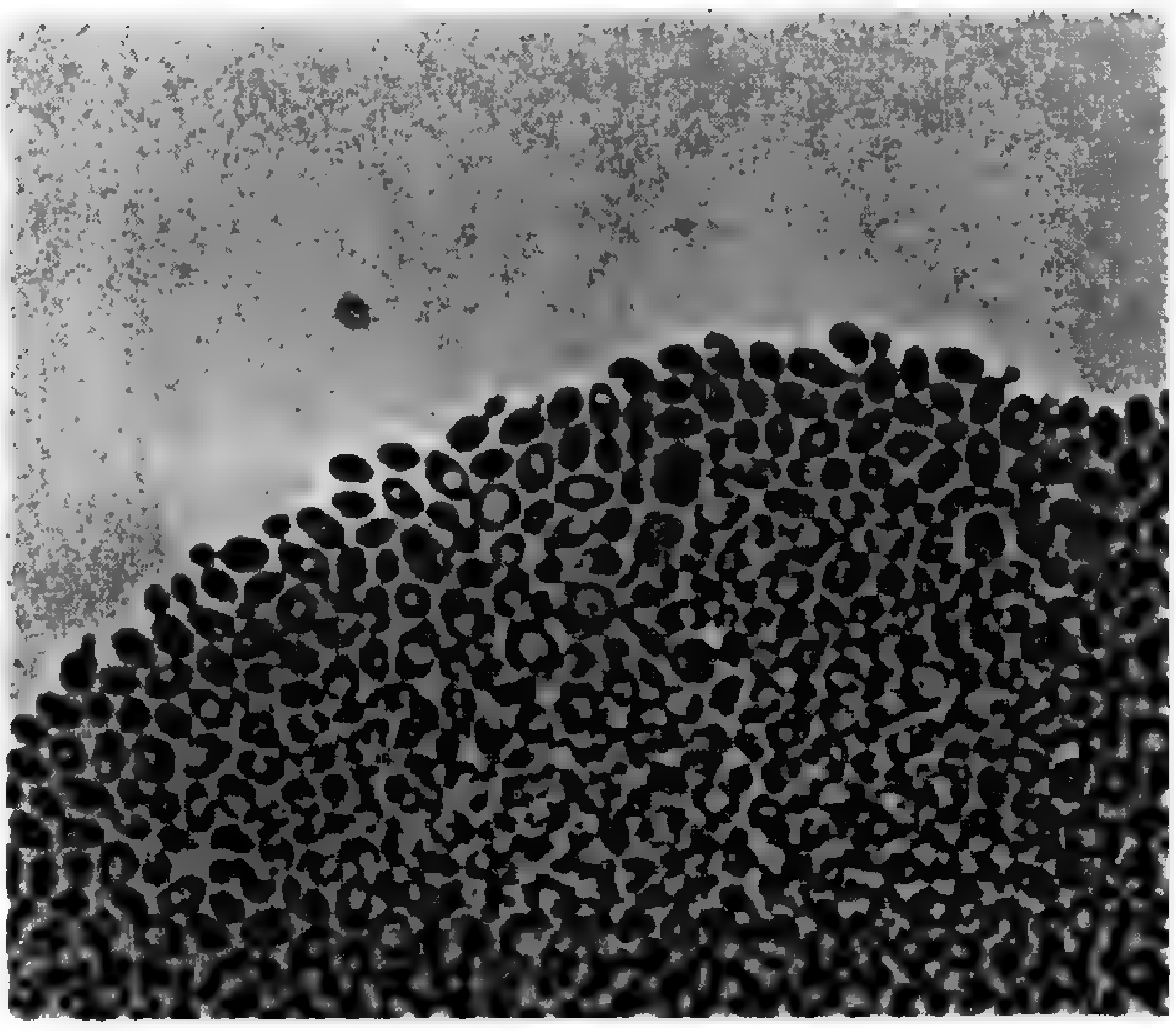
67. Cells from vegetable-juice agar at 1 month. These cells are among the smallest of known yeasts. Gram stained, × 1500.



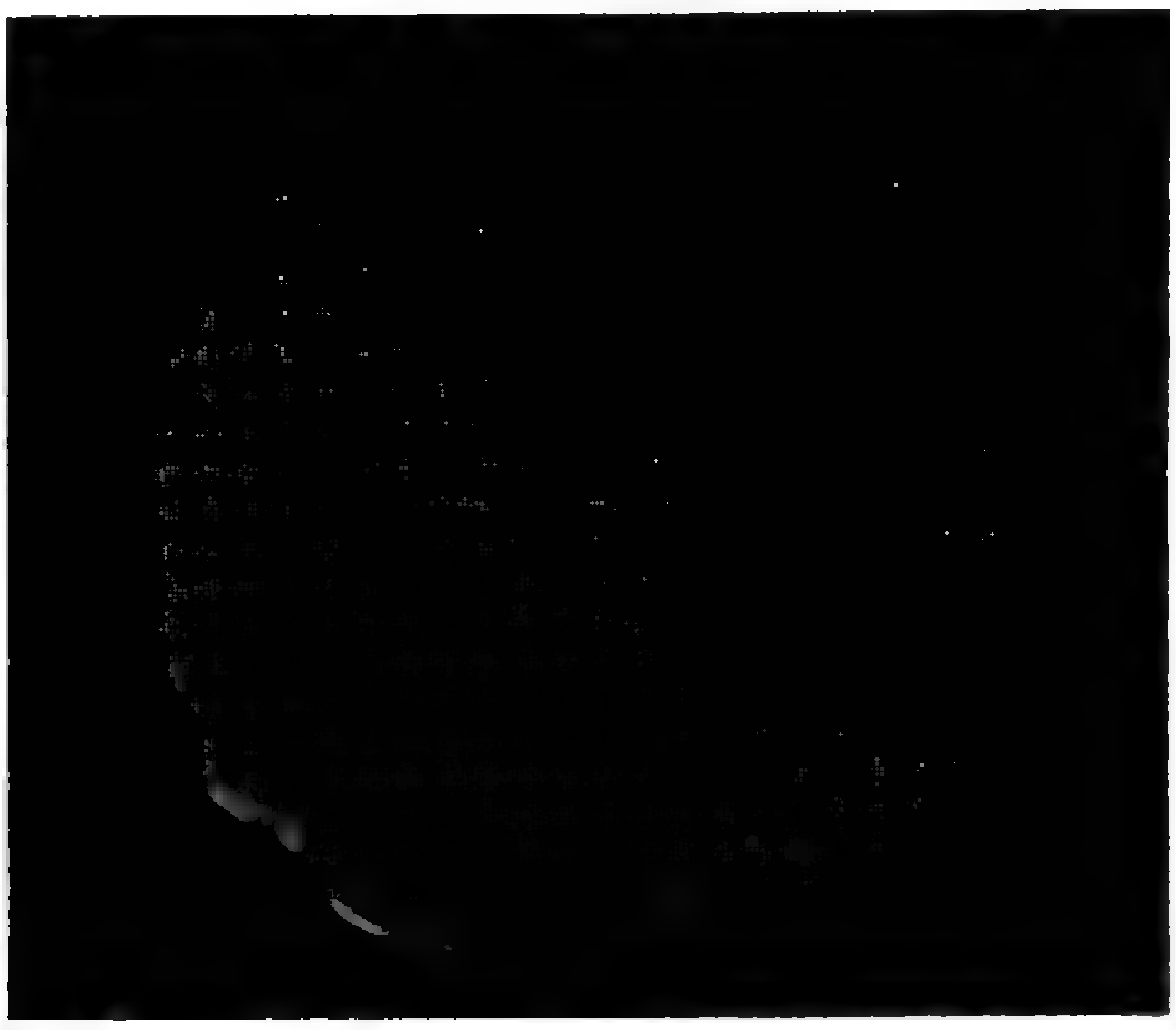
68. Giant colony grown on synthetic agar-A; at 6 weeks. × 4.

### *T. HOLMII* (JORGENSEN) LODDER (Y-600)

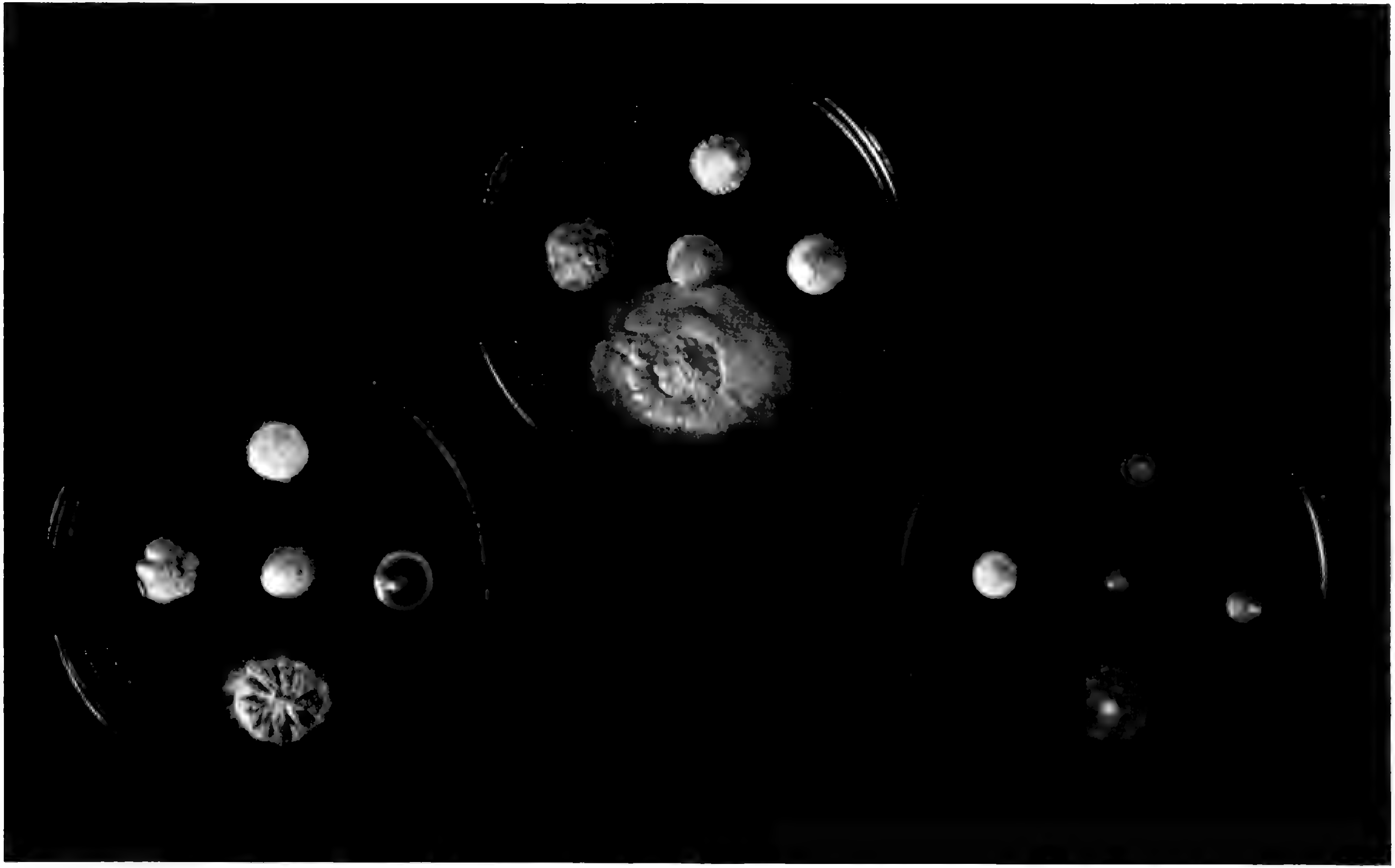
69. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2.



70. Cells from cornmeal agar are short-oval with no tendency to elongate. Unstained, × 950; enlarged, × 2.

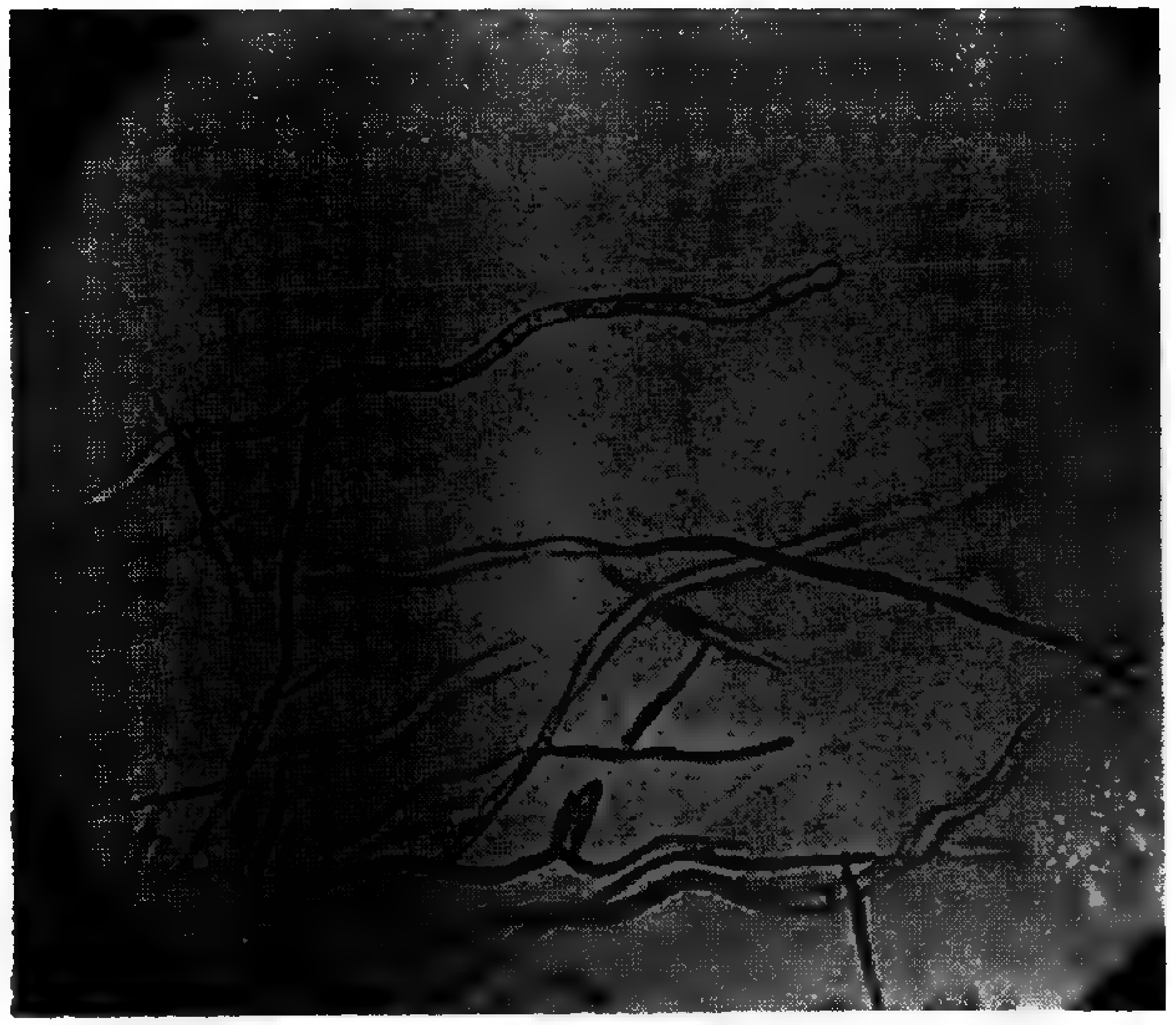


71. Giant colony grown on synthetic agar-A; at 6 weeks. × 3.



Glucose agar Vegetable-juice agar Synthetic agar-A

E. Comparative growth of 5 species of *Brettanomyces* on 3 cultural media after 6 weeks' incubation at room temperature. About ⅔ actual size.



75. *B. lambicus*

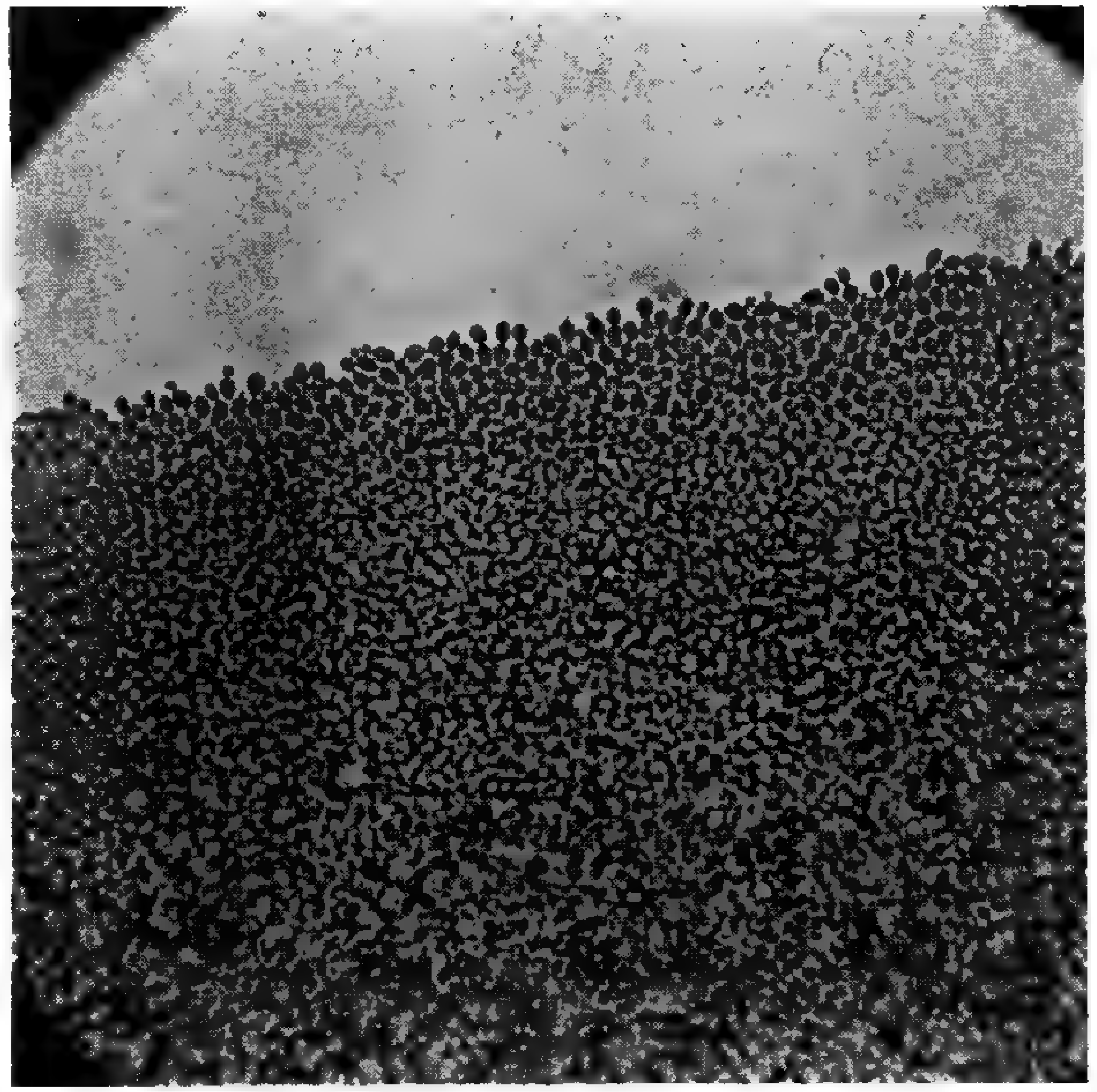
76. *B. anomalus*

↑

*B. bruxellensis*

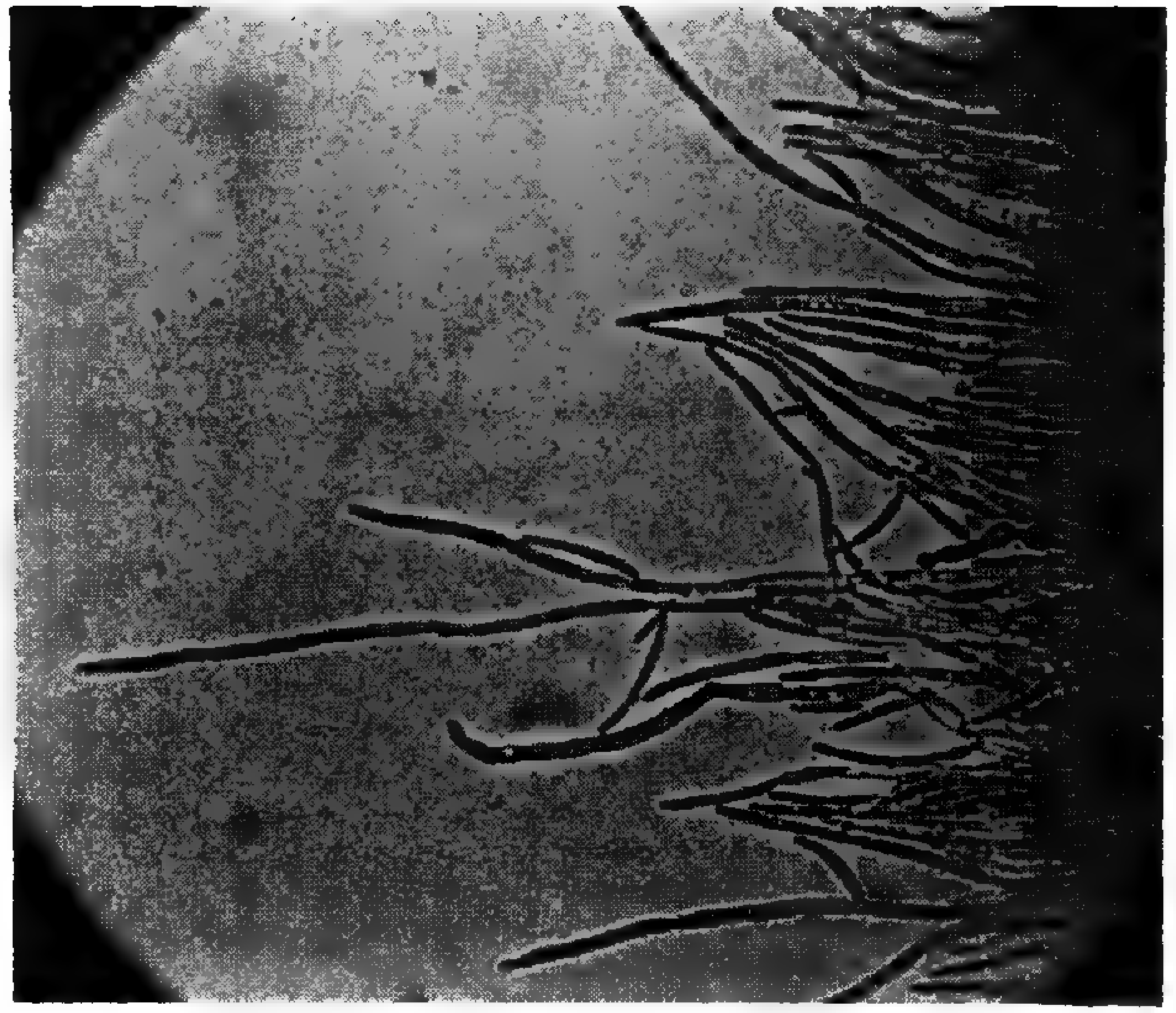
*B. lambicus* *B. versatilis* *B. claussenii*

*B. anomalus*

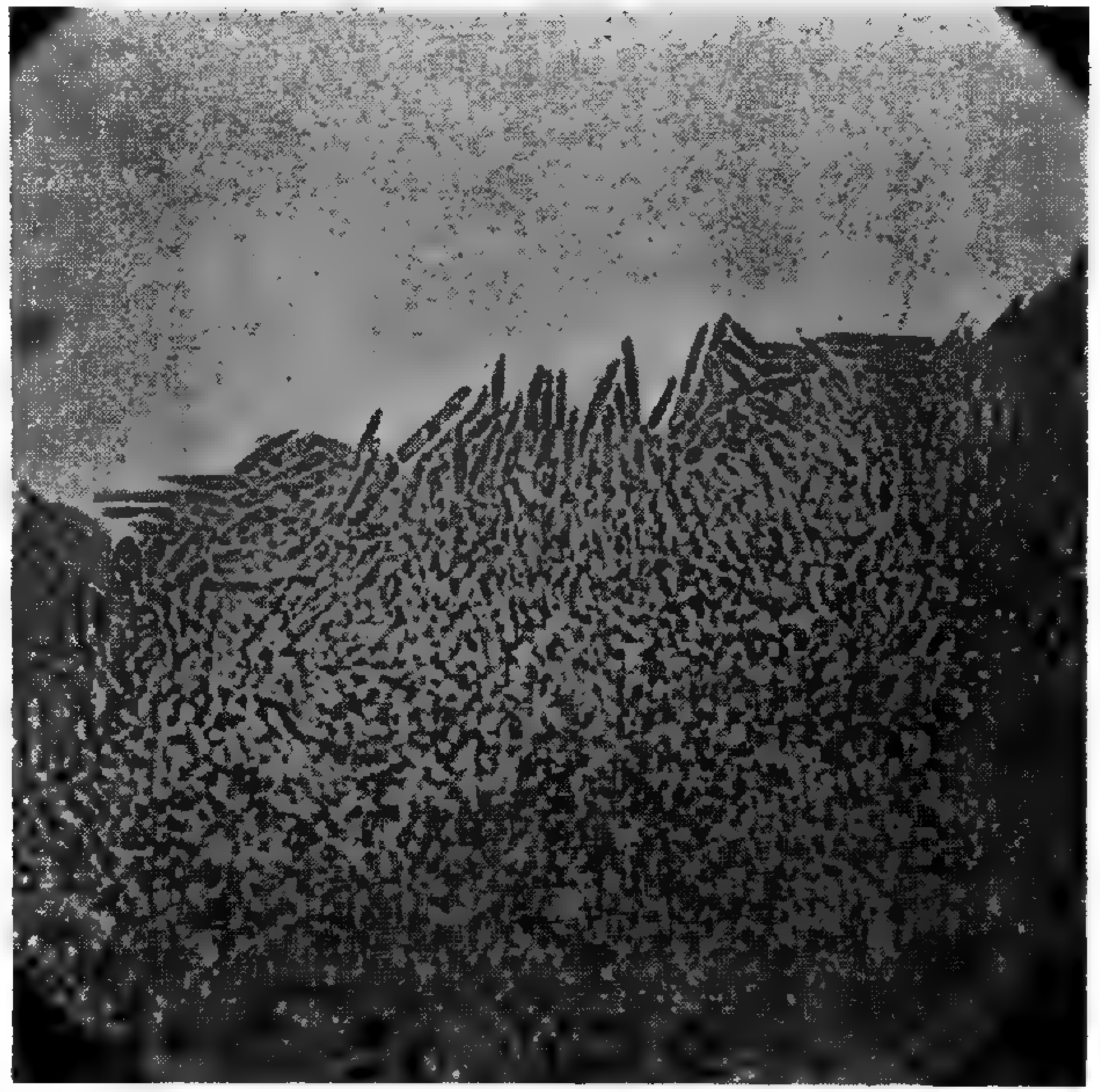


74. *B. versatilis*

Cornmeal agar mycelium tests at 3 weeks for five species of *Brettanomyces*. *B. versatilis* and *B. claussenii* show normal cells; other 3 species produce mycelium. Unstained, × 950.



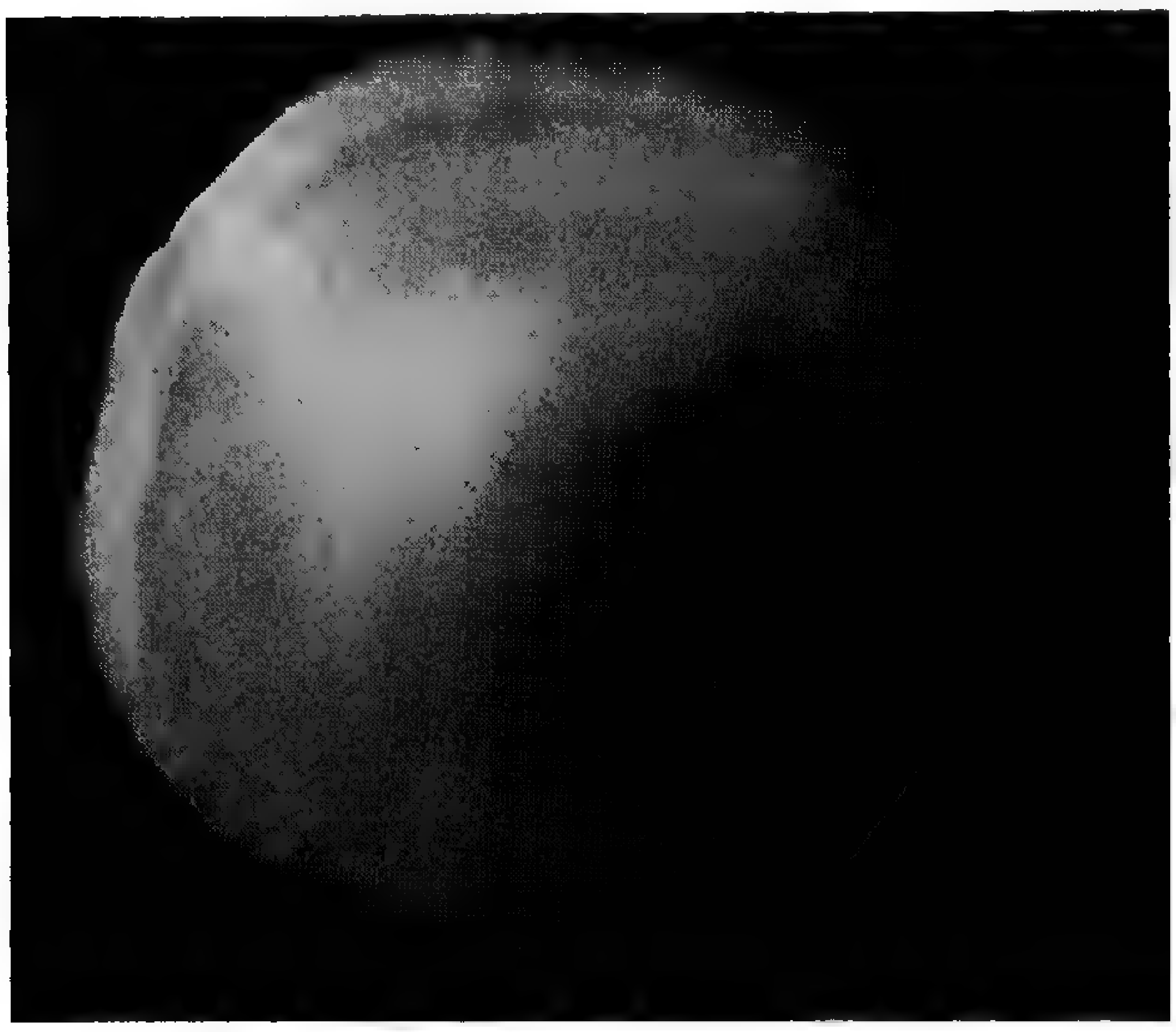
72. *B. bruxellensis*



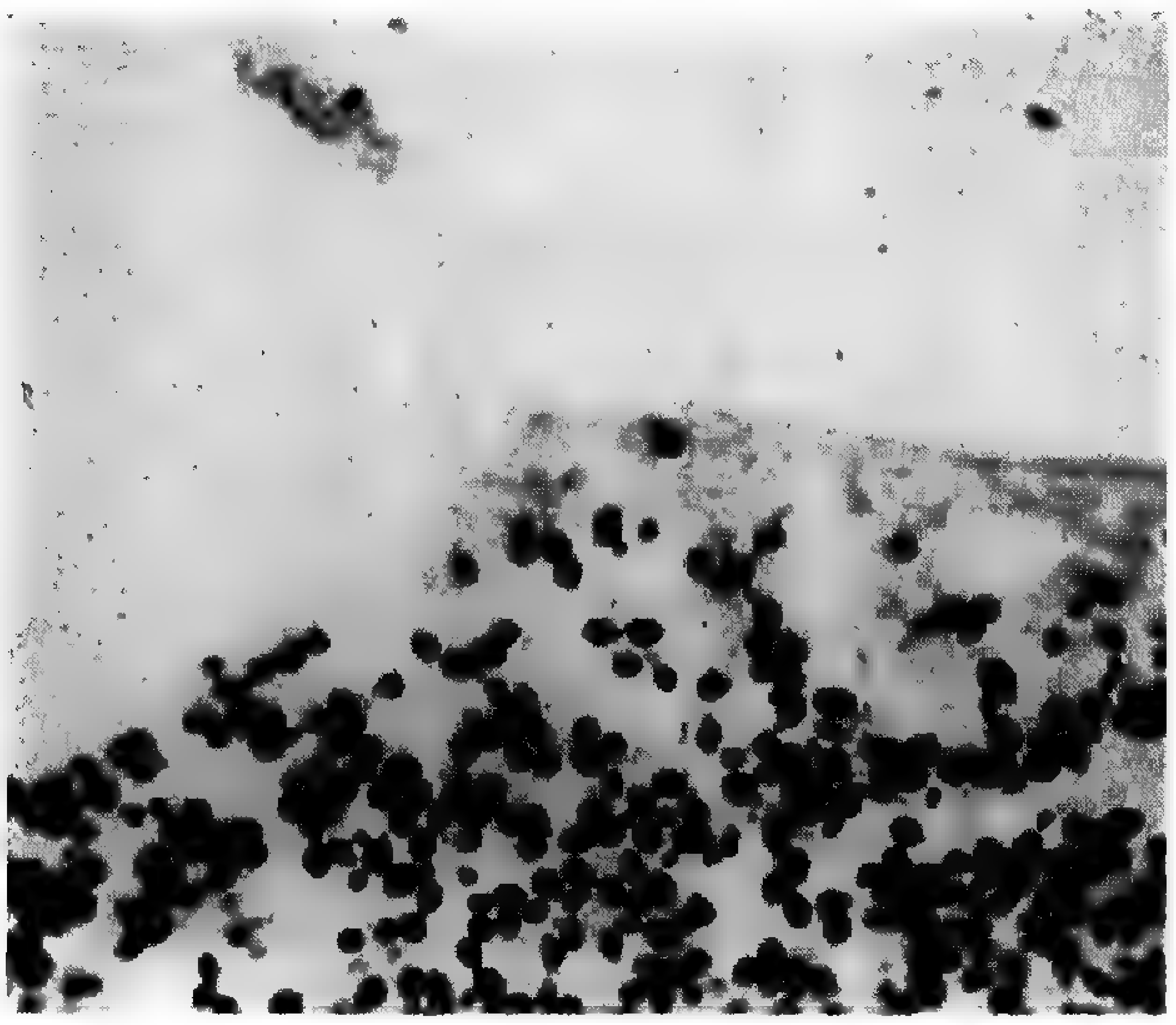
73. *B. claussenii*

Brettanomyces

*B. VERSATILIS* ETCHELLS & BELL (Y-1016)



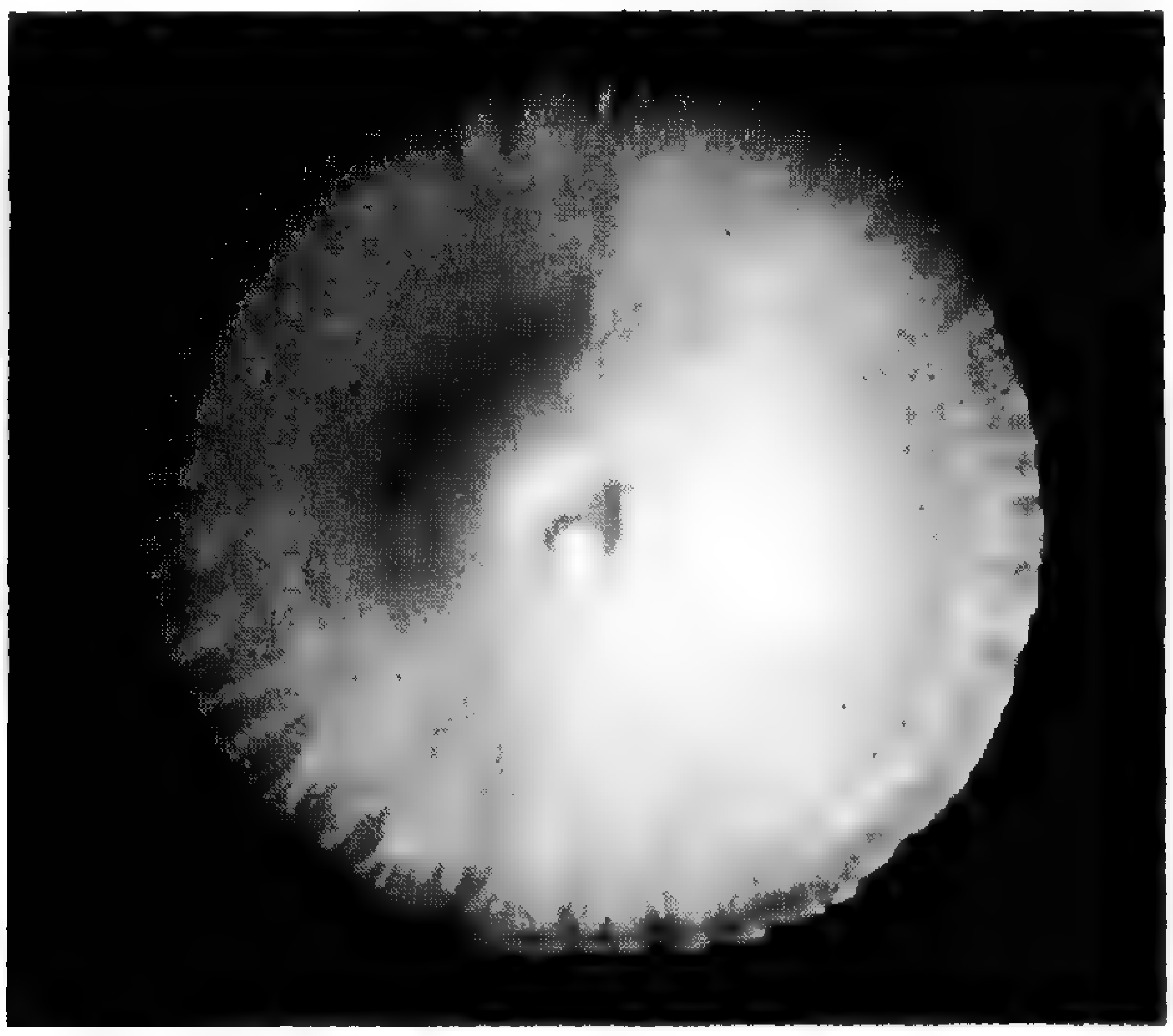
77. Giant colony grown on vegetable-juice agar; at 6 weeks. × 3.



78. Cells from vegetable-juice agar at 1 month. Note pointedness of some cells. Gram stained, × 1500.

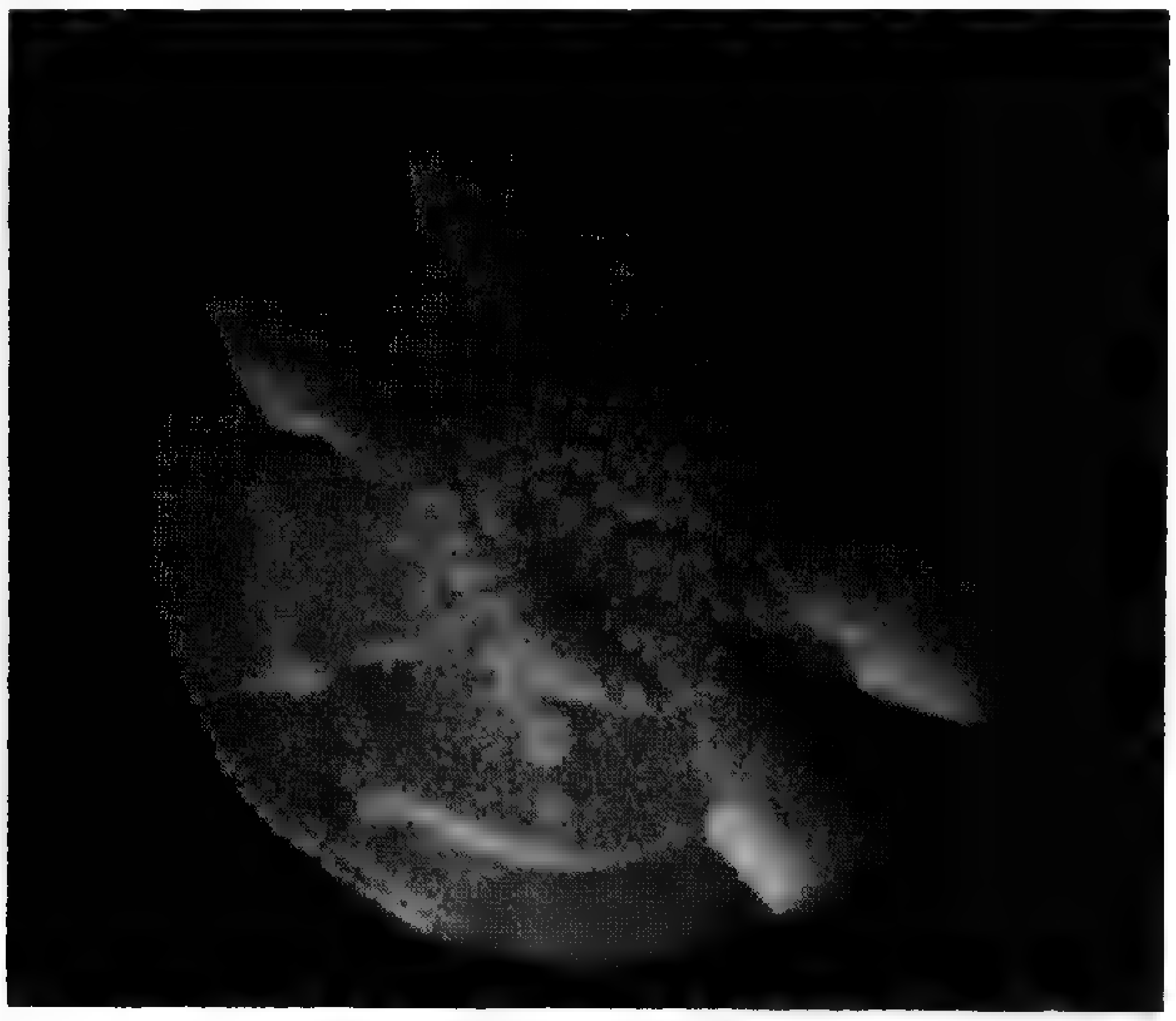
79. Giant colony grown on synthetic agar-A; at 6 weeks. × 4.

*B. SPHAERICUS* ETCHELLS & BELL (YS-606)



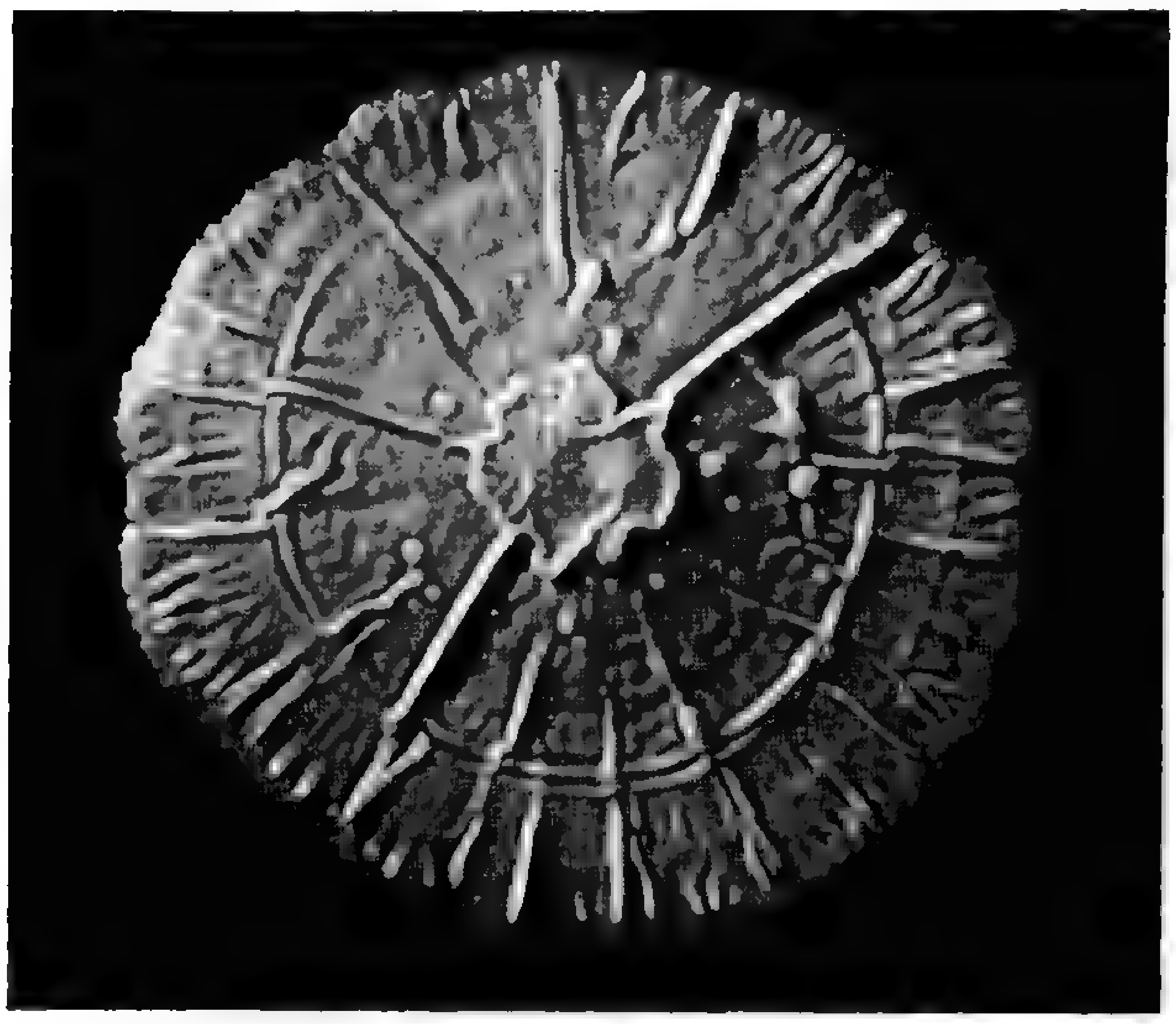
80. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2.

81. Cells from vegetable-juice agar at 1 month. Gram stained, × 1500.

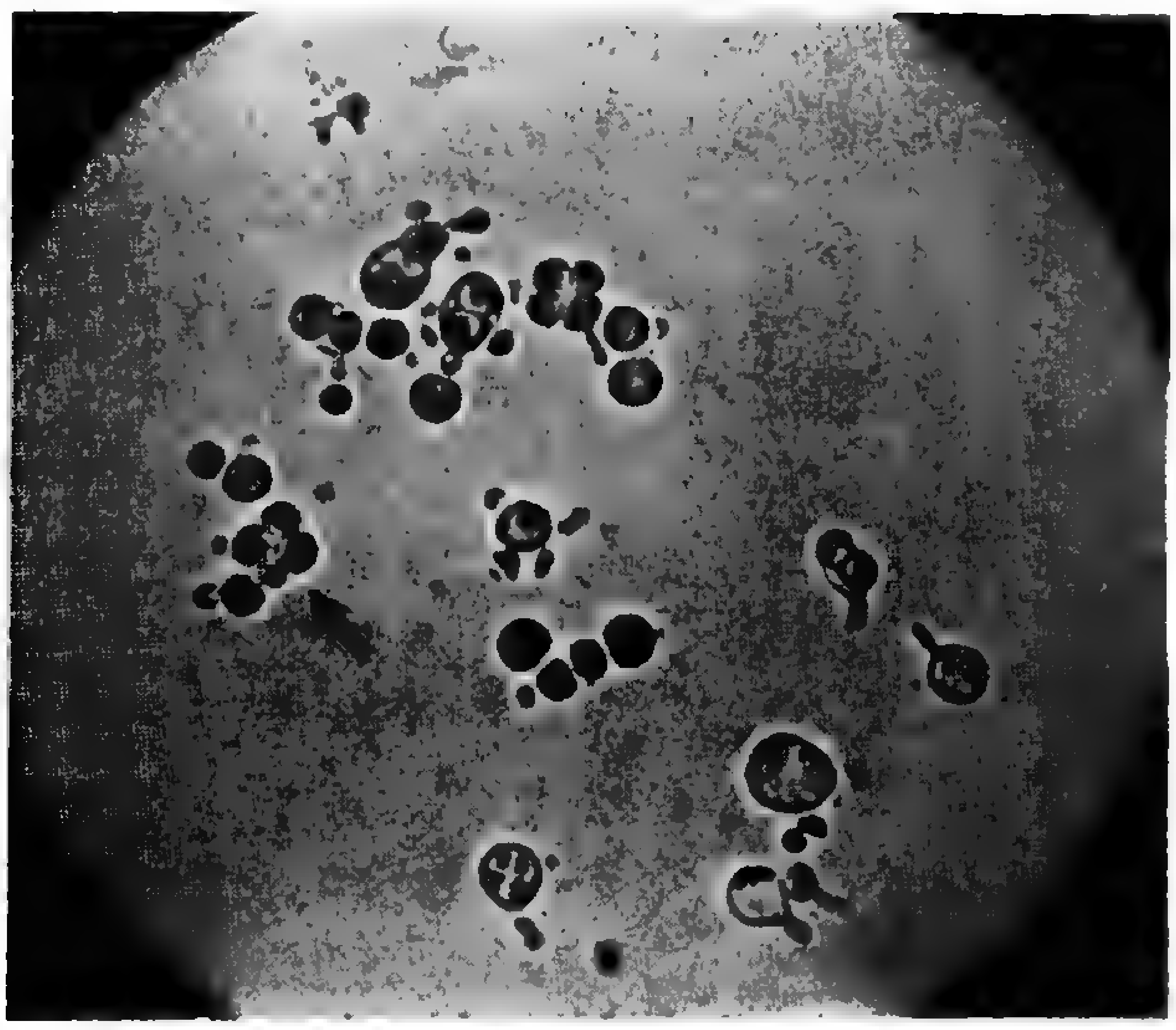


82. Giant colony grown on synthetic agar-A; at 6 weeks. × 4.

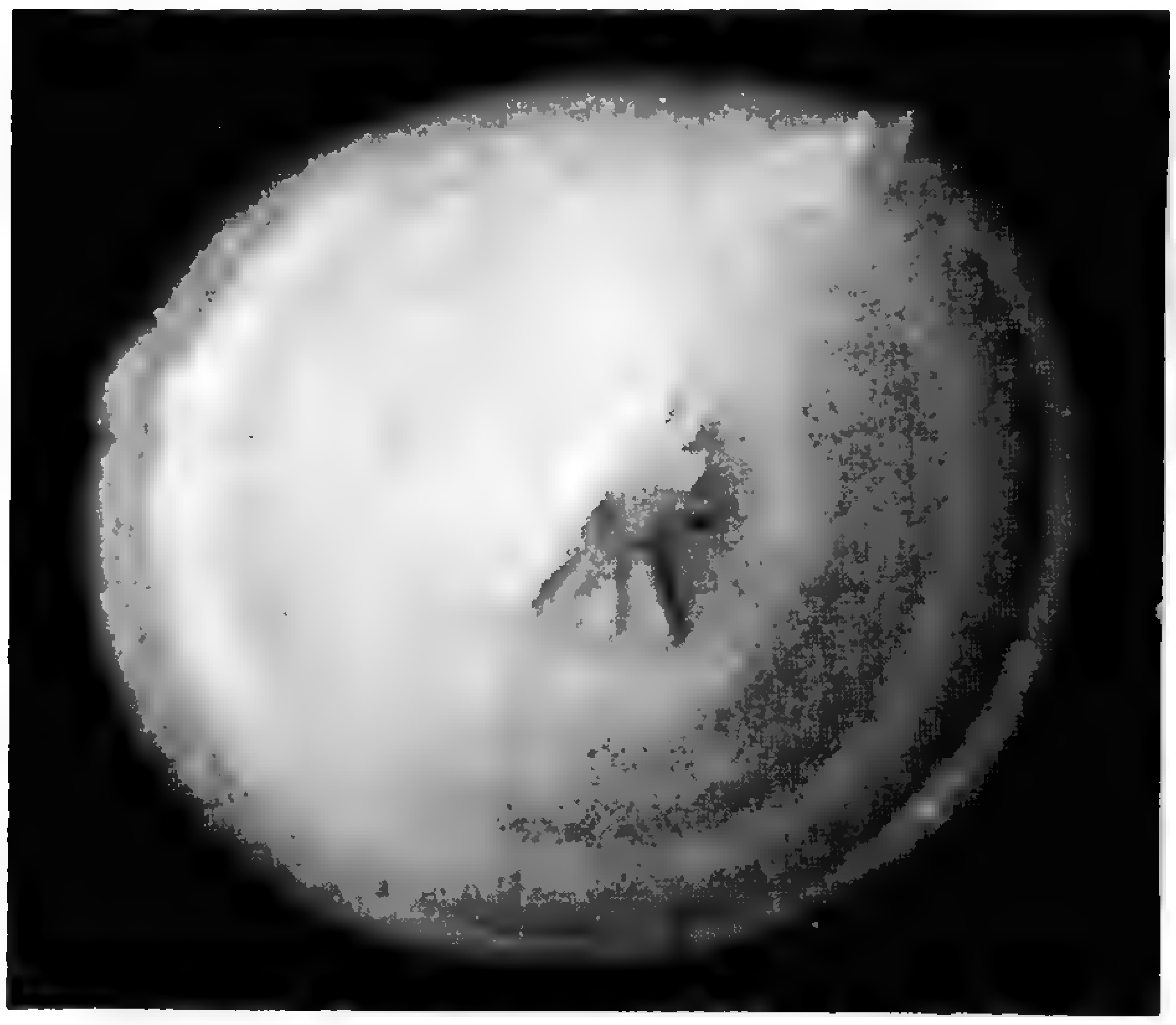
## *T. ROSEI* LINDNER (RY-20)



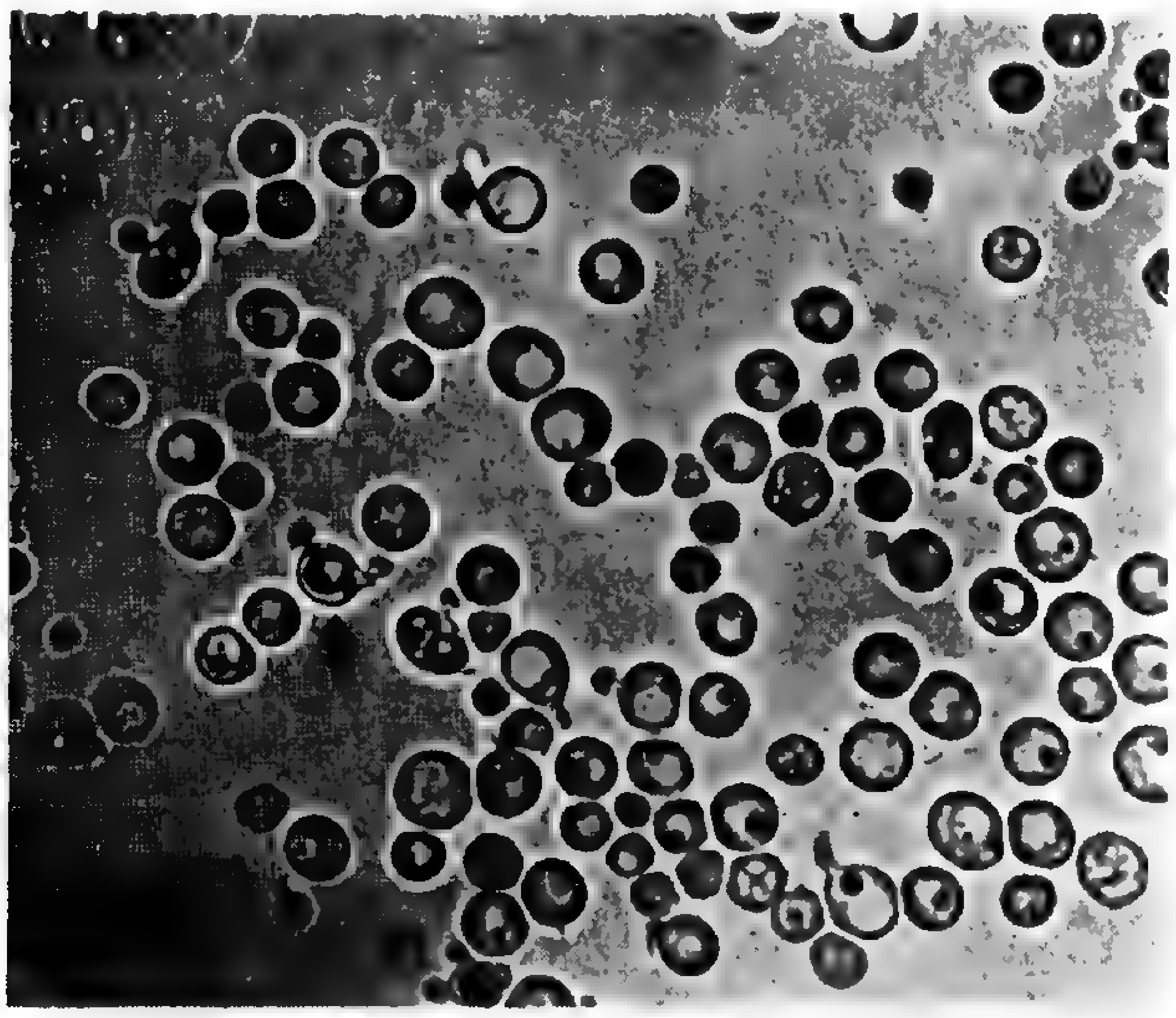
83. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2.



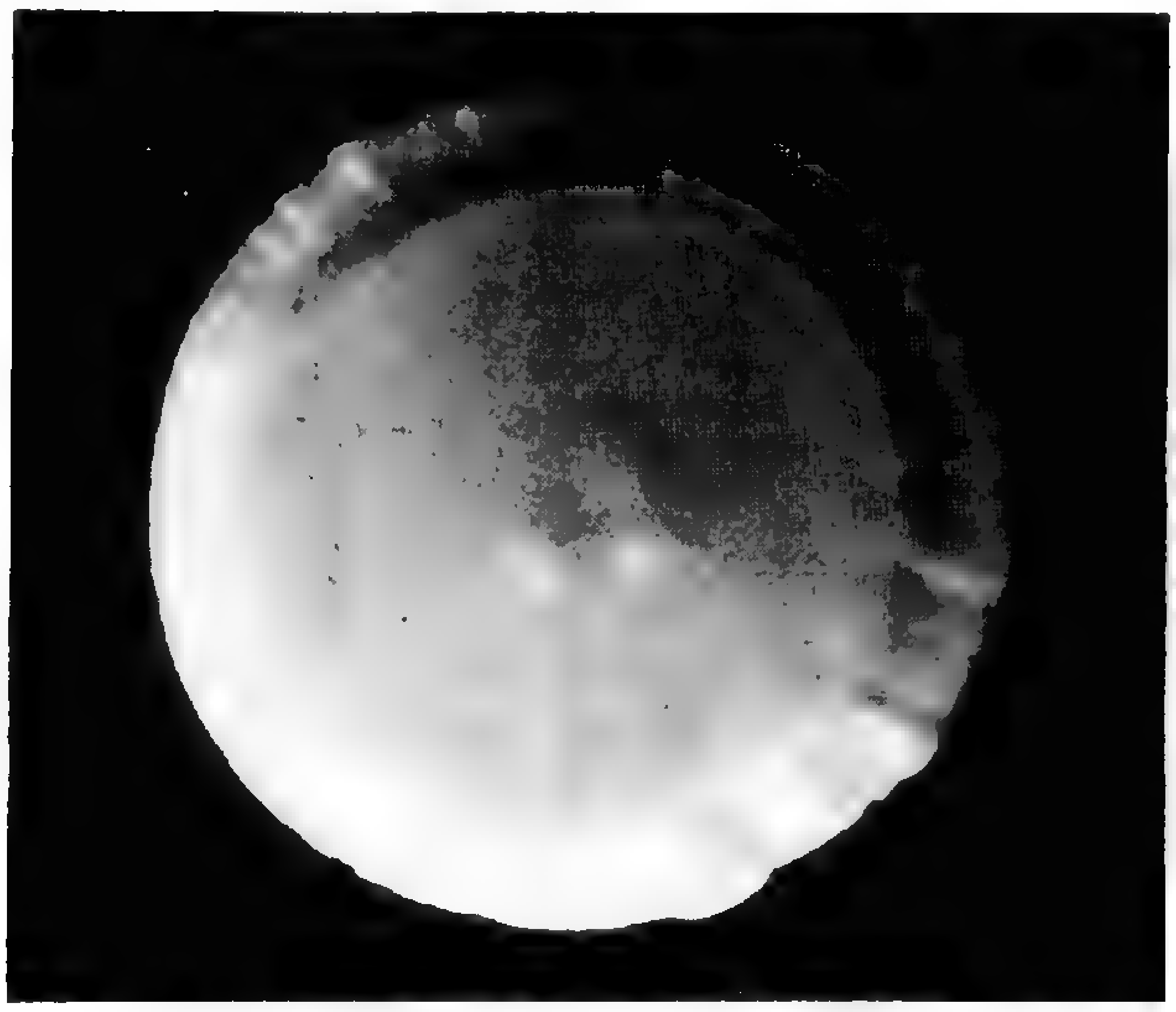
84. Sporulation on vegetable-juice agar at 1 month with 1, 2, and 4 (at arrow) round spores per ascus. Unstained, × 1500.



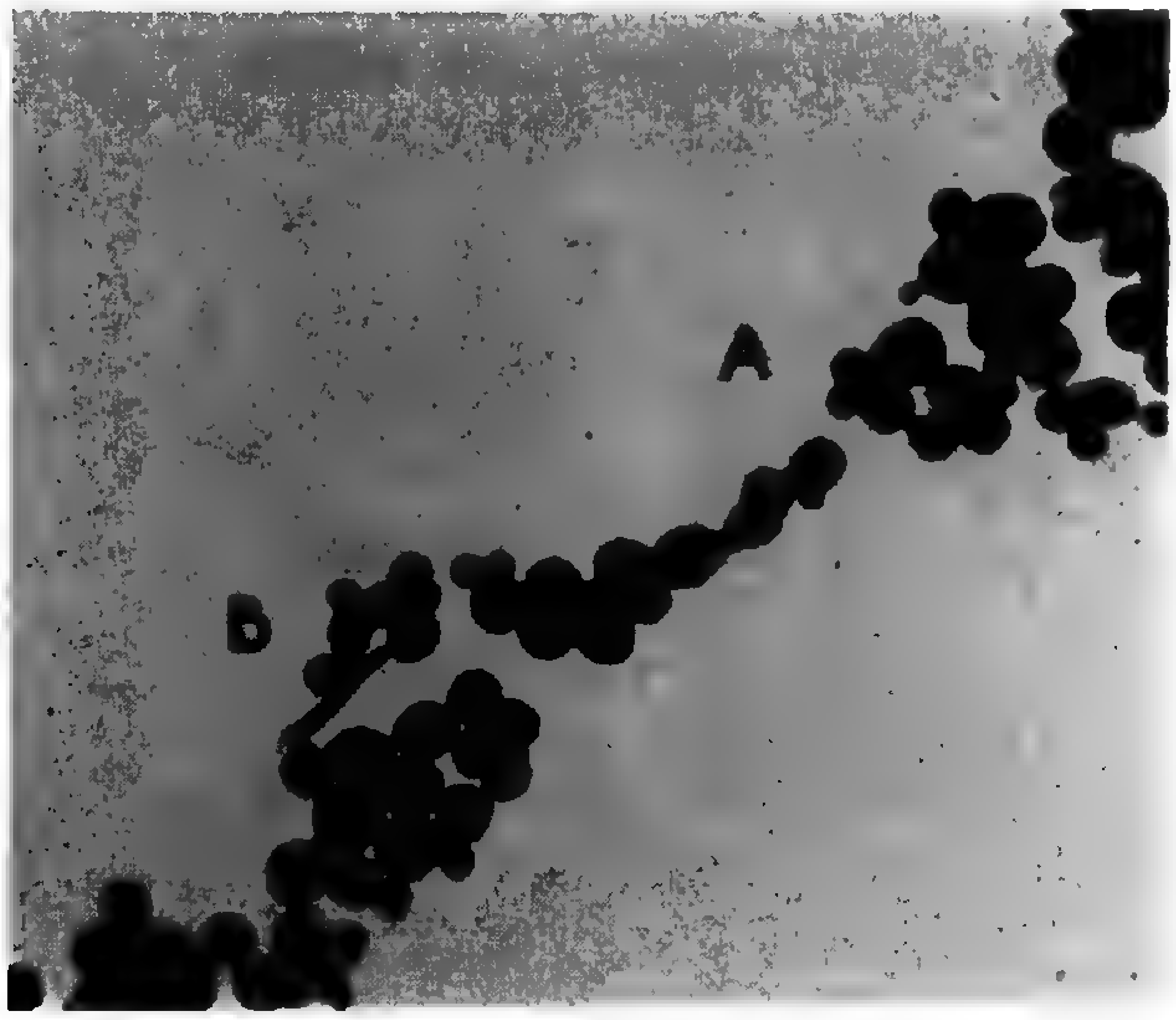
85. Giant colony grown on glucose agar; at 6 weeks. × 2.



86. Cells from a strain difficult to sporulate. Note single round spore at arrow. Grown on vegetable-juice agar; at 3 weeks. Unstained, × 1500.



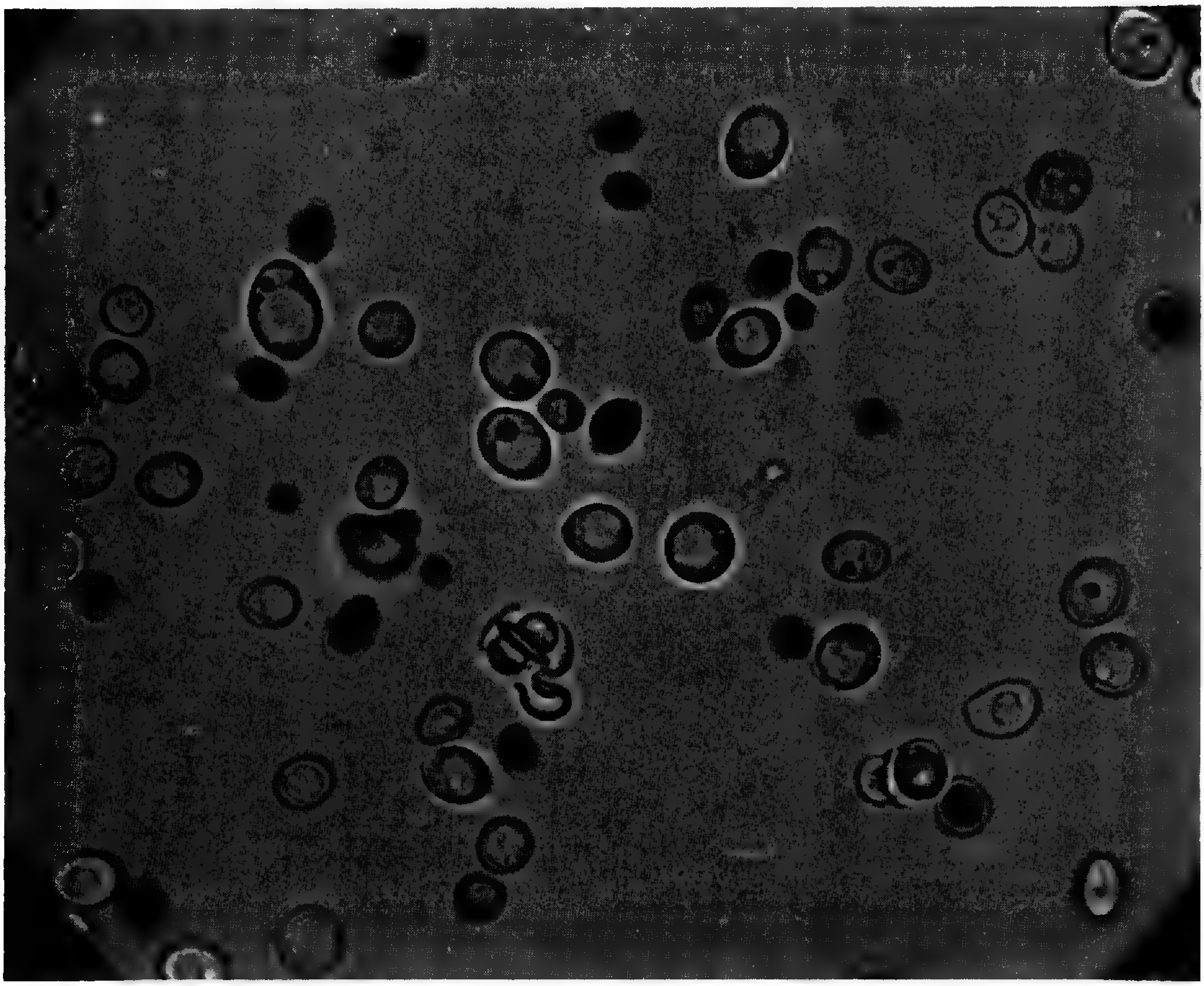
87. Giant colony grown on synthetic agar-A; at 6 weeks. × 3.



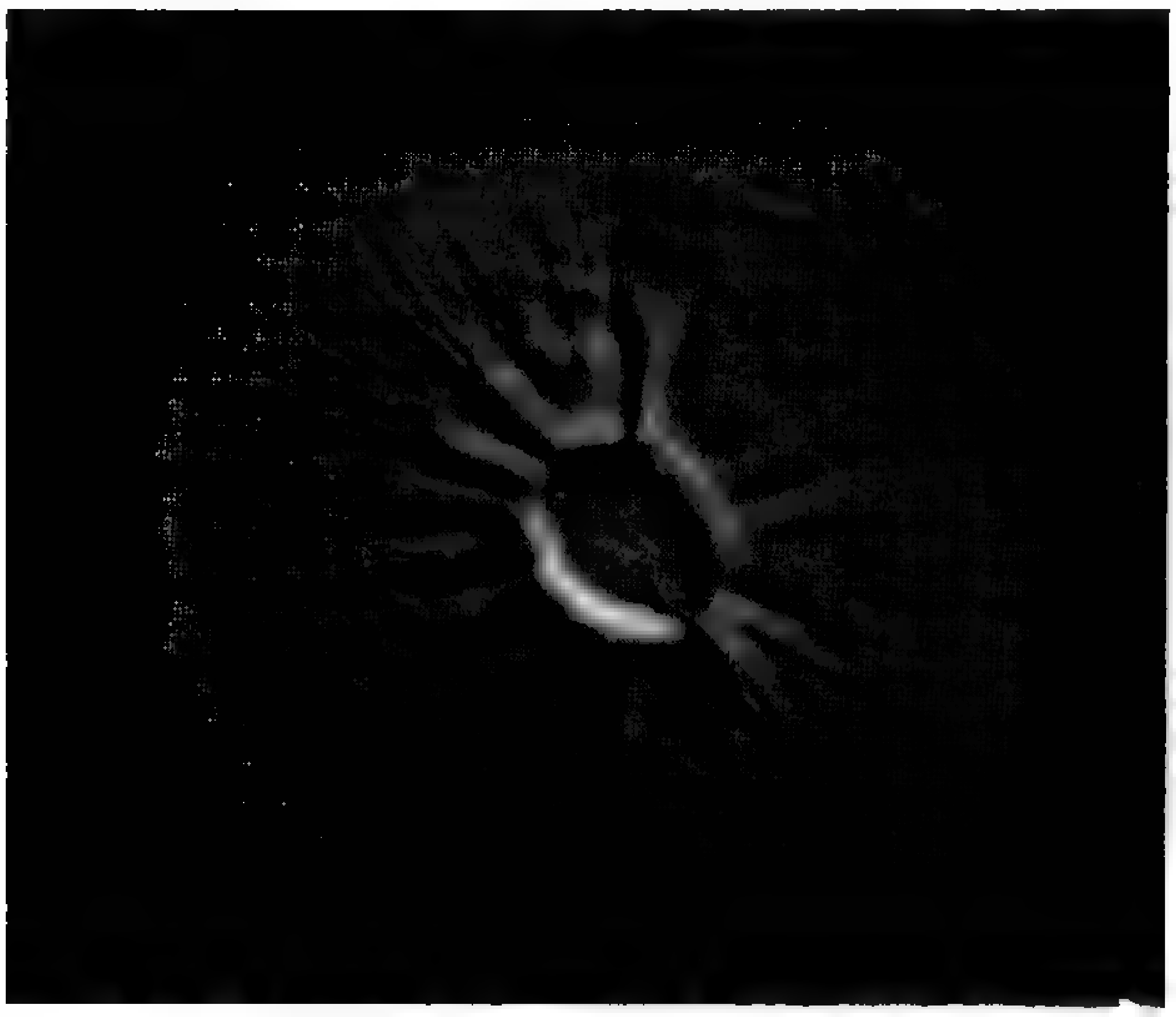
88. Cells from synthetic agar-A. Two unstained spores at *A*; long conjugation tube at *B*. Gram stained, × 1500.

## Hansenula

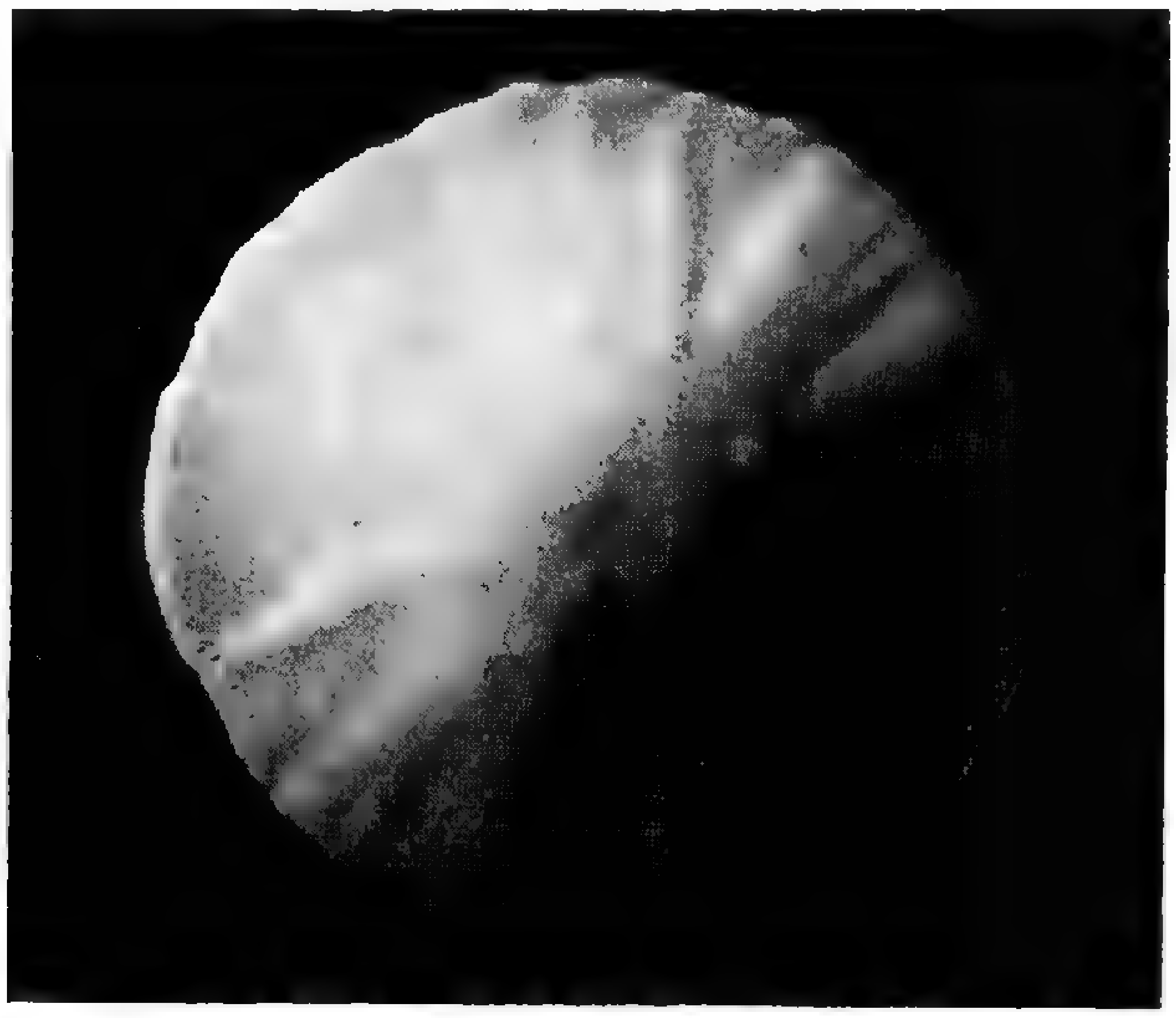
### *H. SUBPELLICULOSA* BEDFORD (RY-135)



89. Sporulation on vegetable-juice agar at 1 month. Note two hat-shaped spores (brim to brim) emerging from ascus. Unstained, × 1500; enlarged, × 2.

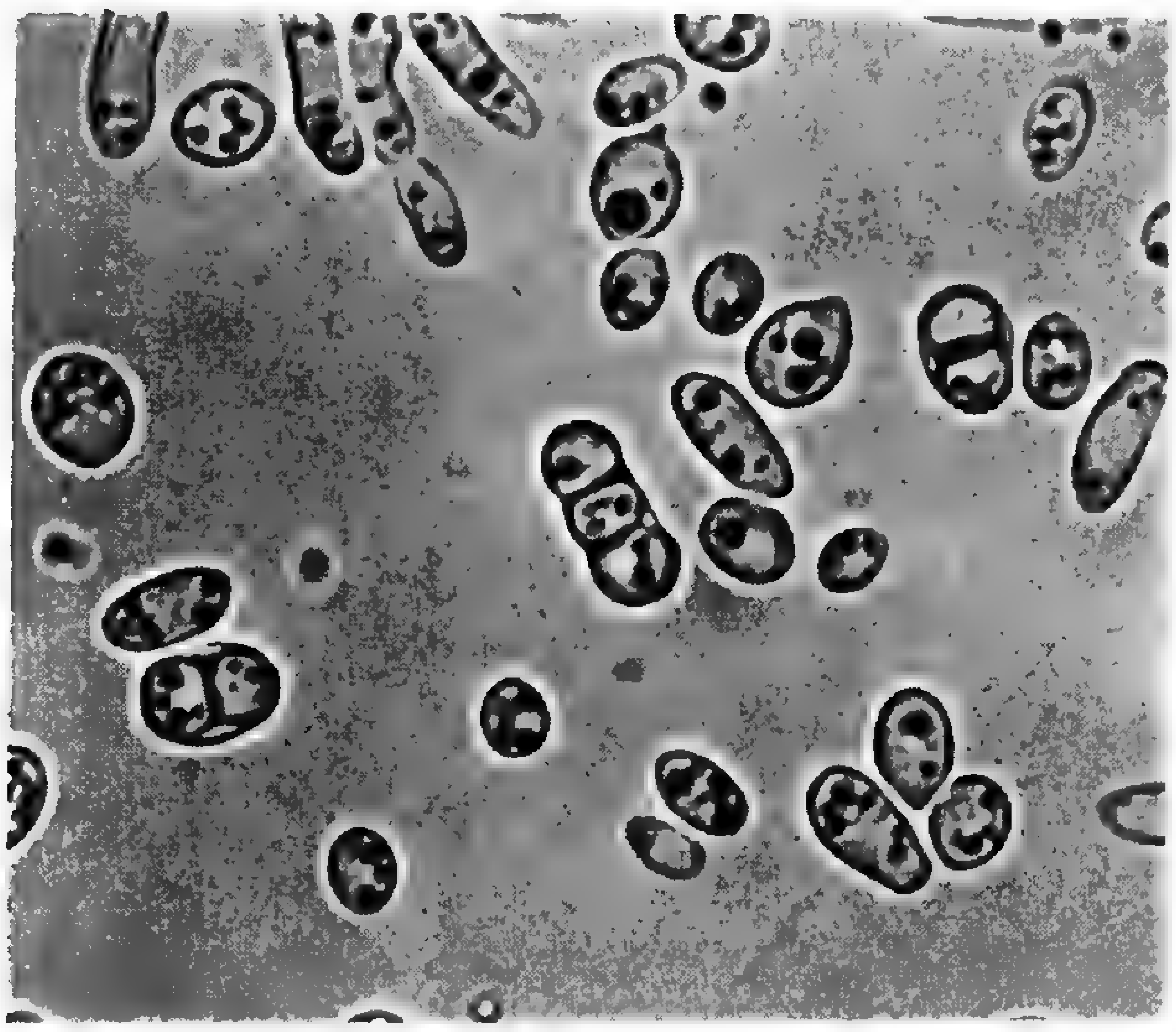


90. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2½.

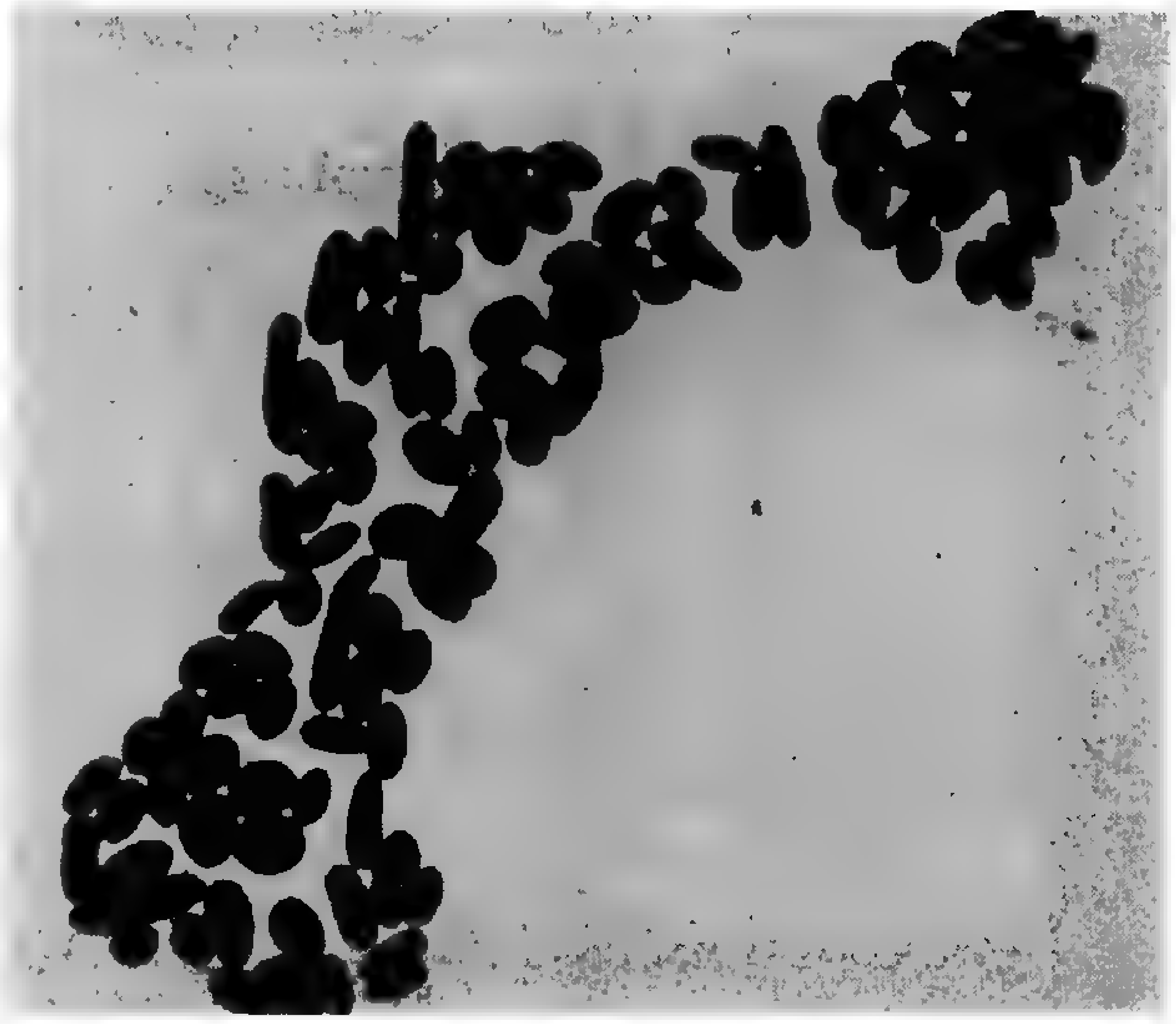


91. Giant colony grown on synthetic agar-A; at 6 weeks. × 3.

*S. CEREVISIAE* HANSEN (YD-15)

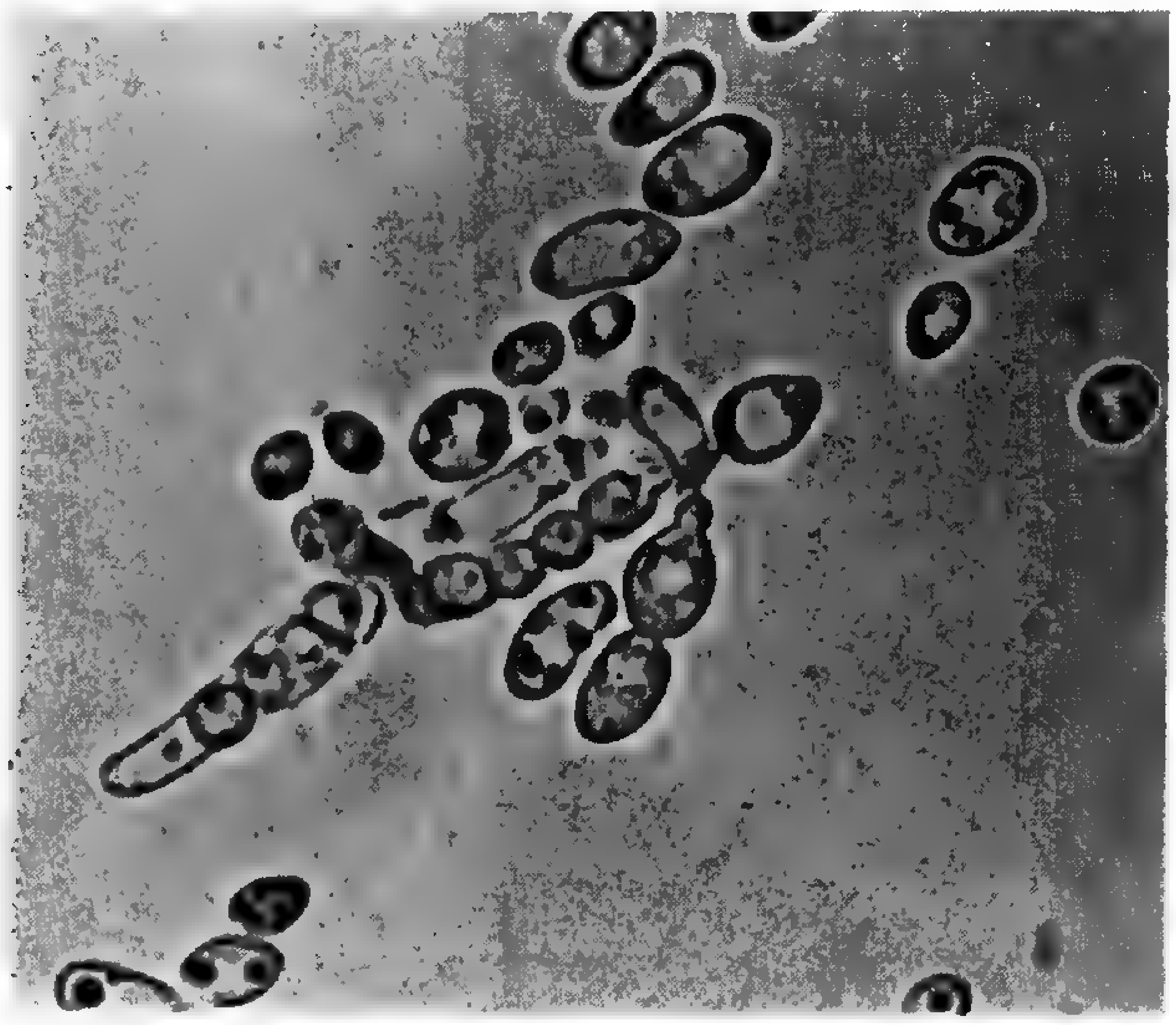


92. Two and 3 round to oval spores per ascus. From vegetable-juice agar at 2 months. Unstained, × 1500.

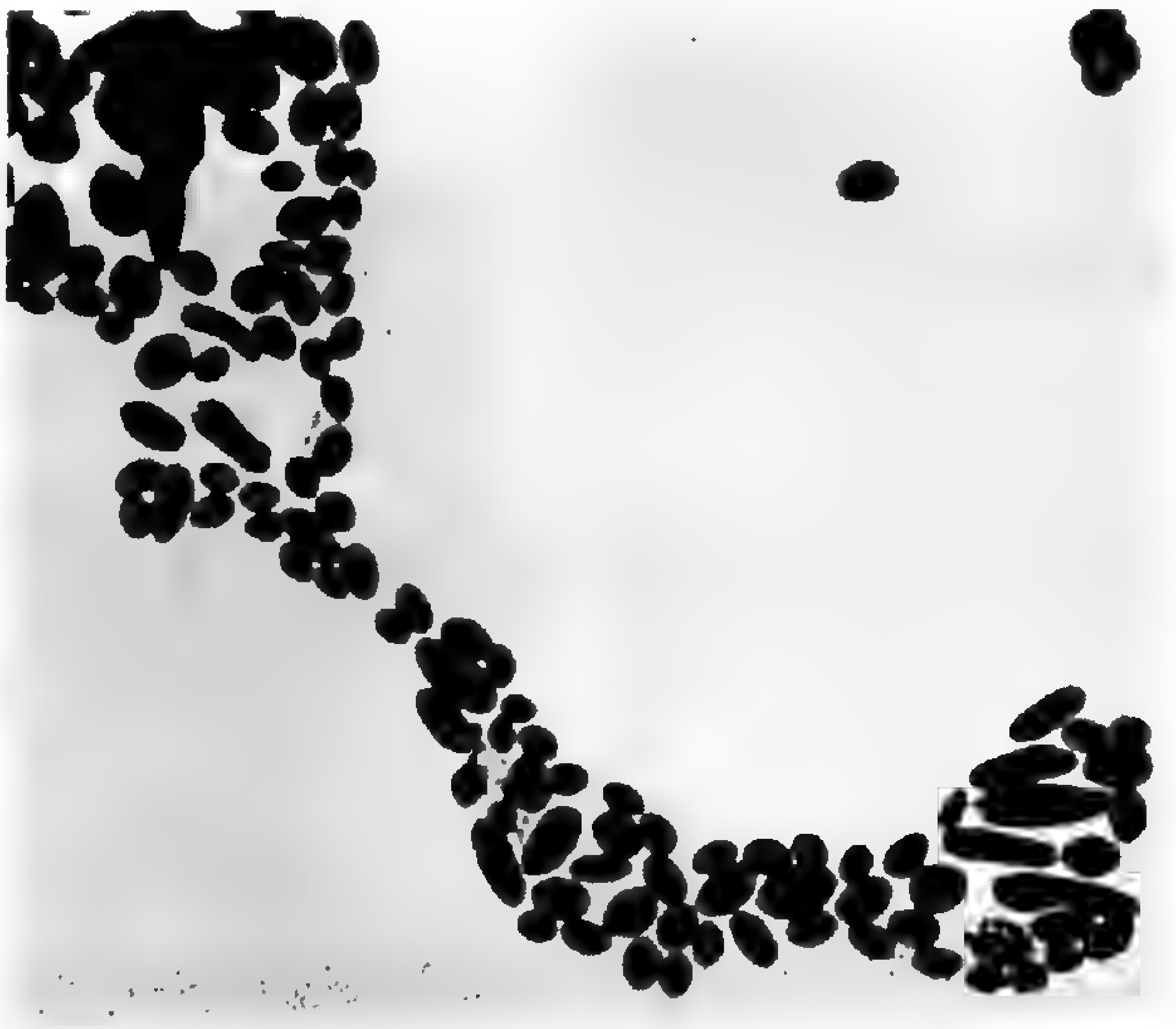


93. Cells from vegetable-juice agar; at 1 month. Gram stained, × 1500.

*S. CEREVISIAE* HANSEN (D-6)

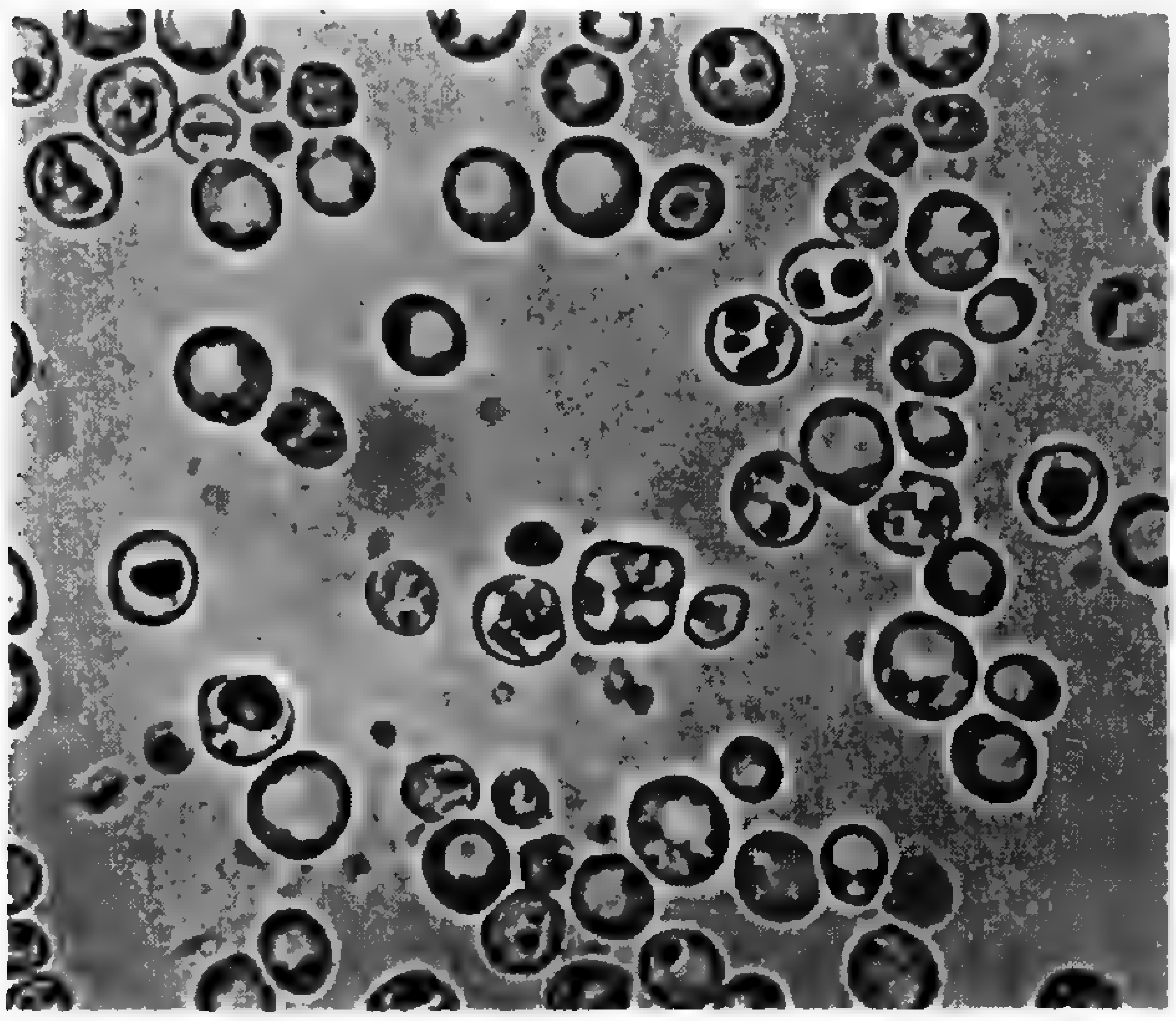


94. Asci with 4 round to oval spores each. From vegetable-juice agar at 1 month. Unstained, × 1500.

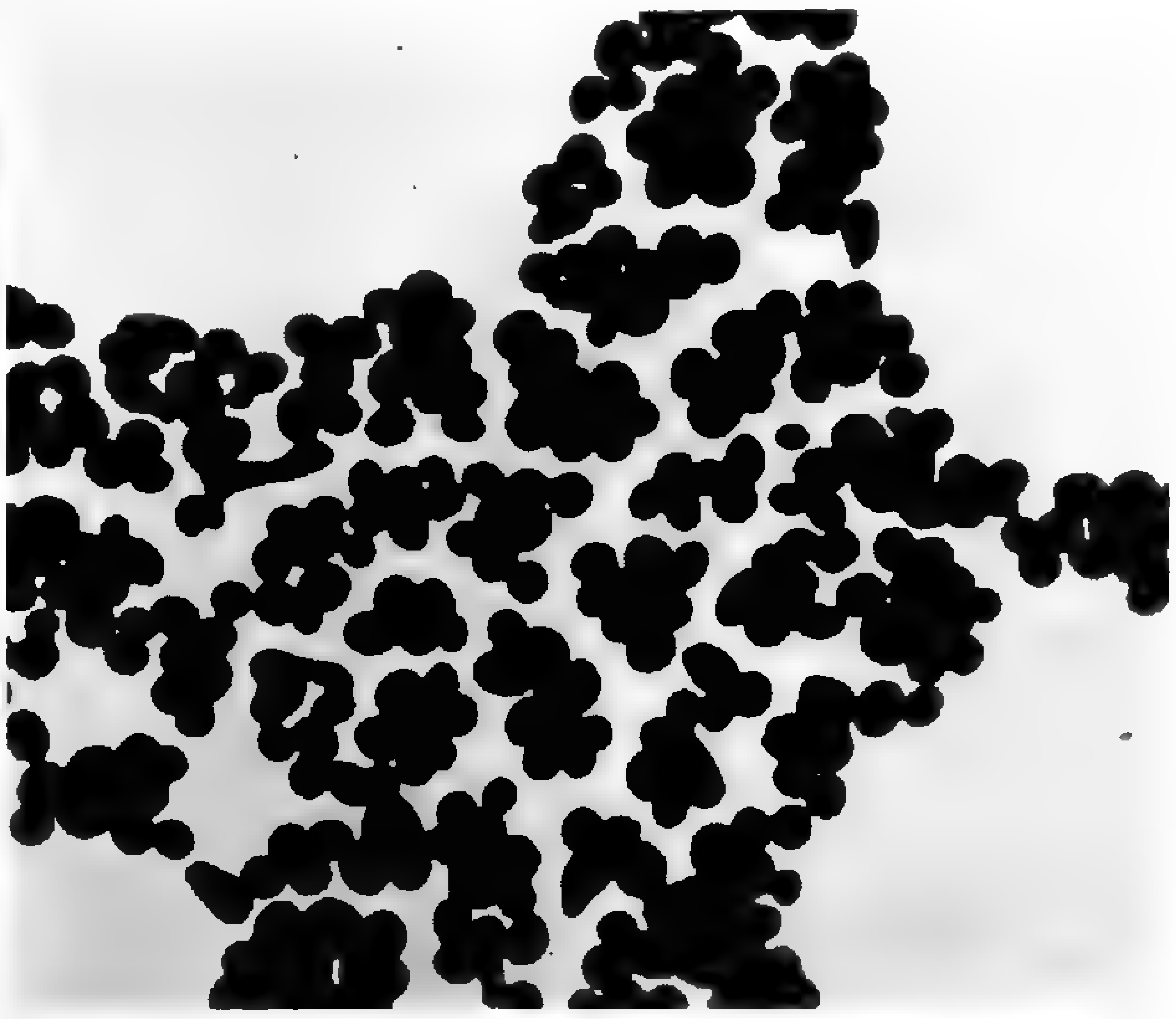


95. Cells from vegetable-juice agar at 1 month. Gram stained, × 1500.

*S. GLOBOSUS* OSTERW. (NY-114)



96. Typical round cells from vegetable-juice agar at 2 months. Four spores per ascus at lower center. Unstained, × 1500.



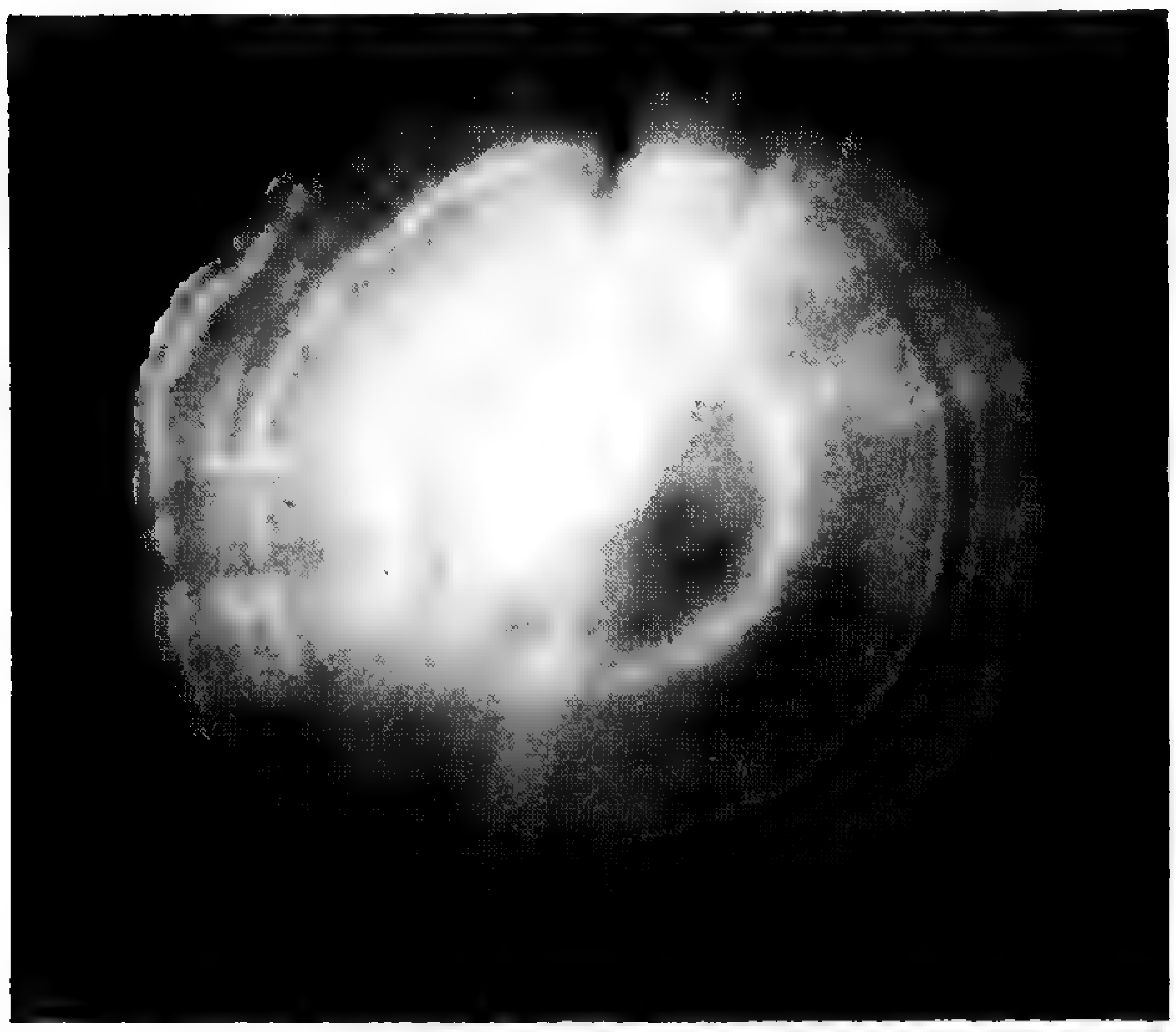
97. Young cells from synthetic agar-A at 7 days. Gram stained, × 1500.

Zygosaccharomyces s.g.

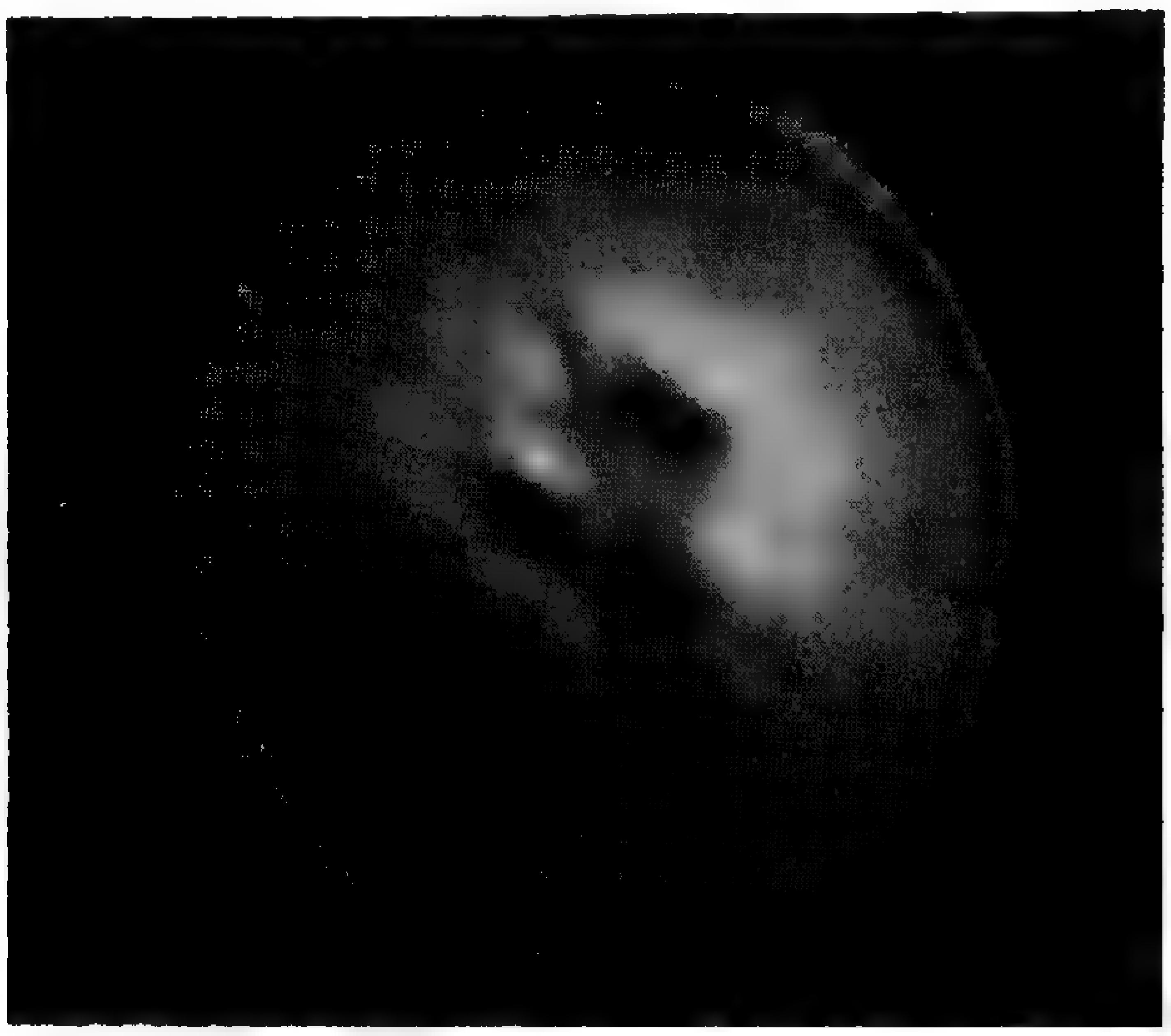
*Z. GLOBIFORMIS* KR. & KB.

Y-742 from brined cucumbers

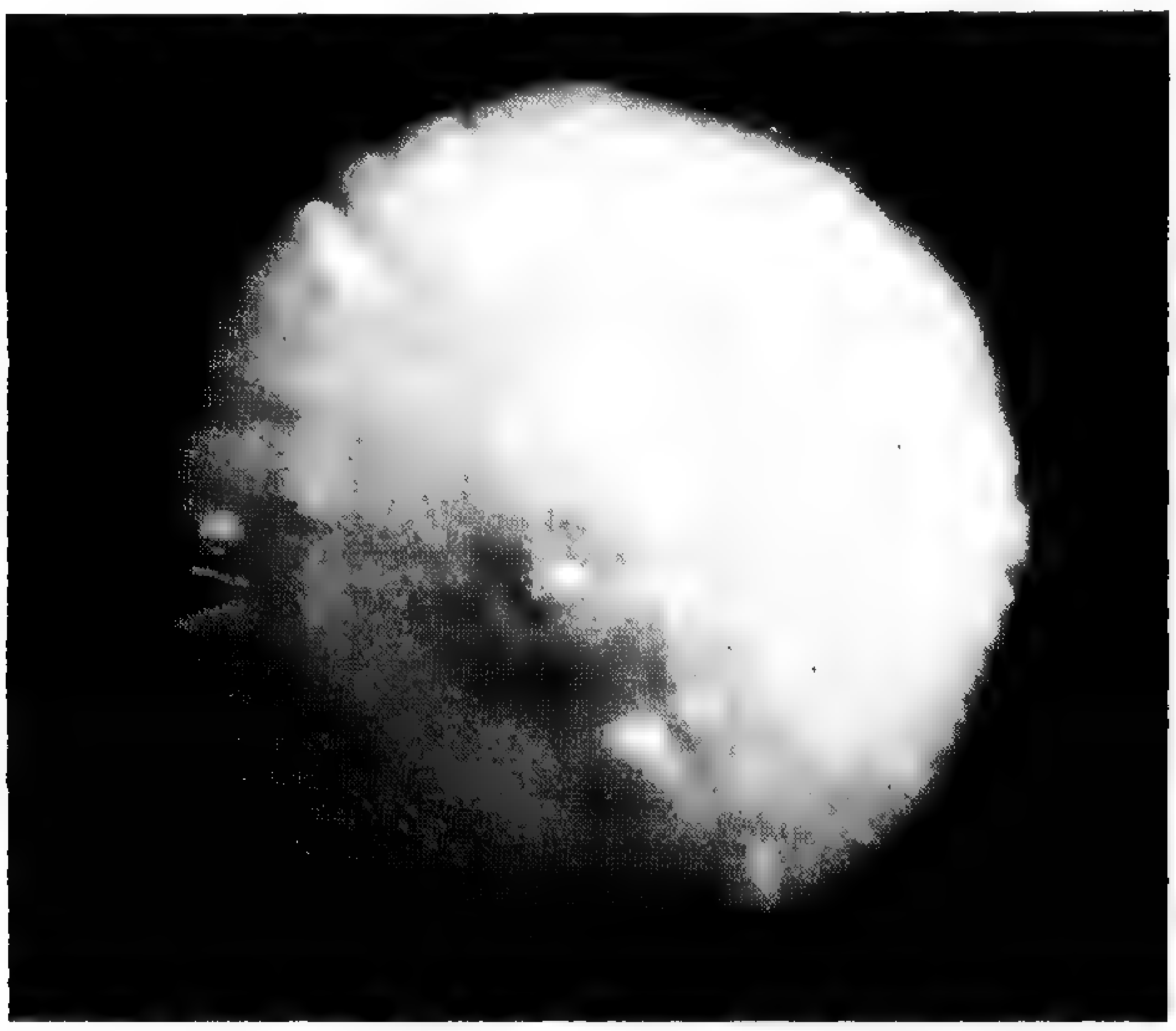
SPY-29 from spoiled sweet pickles



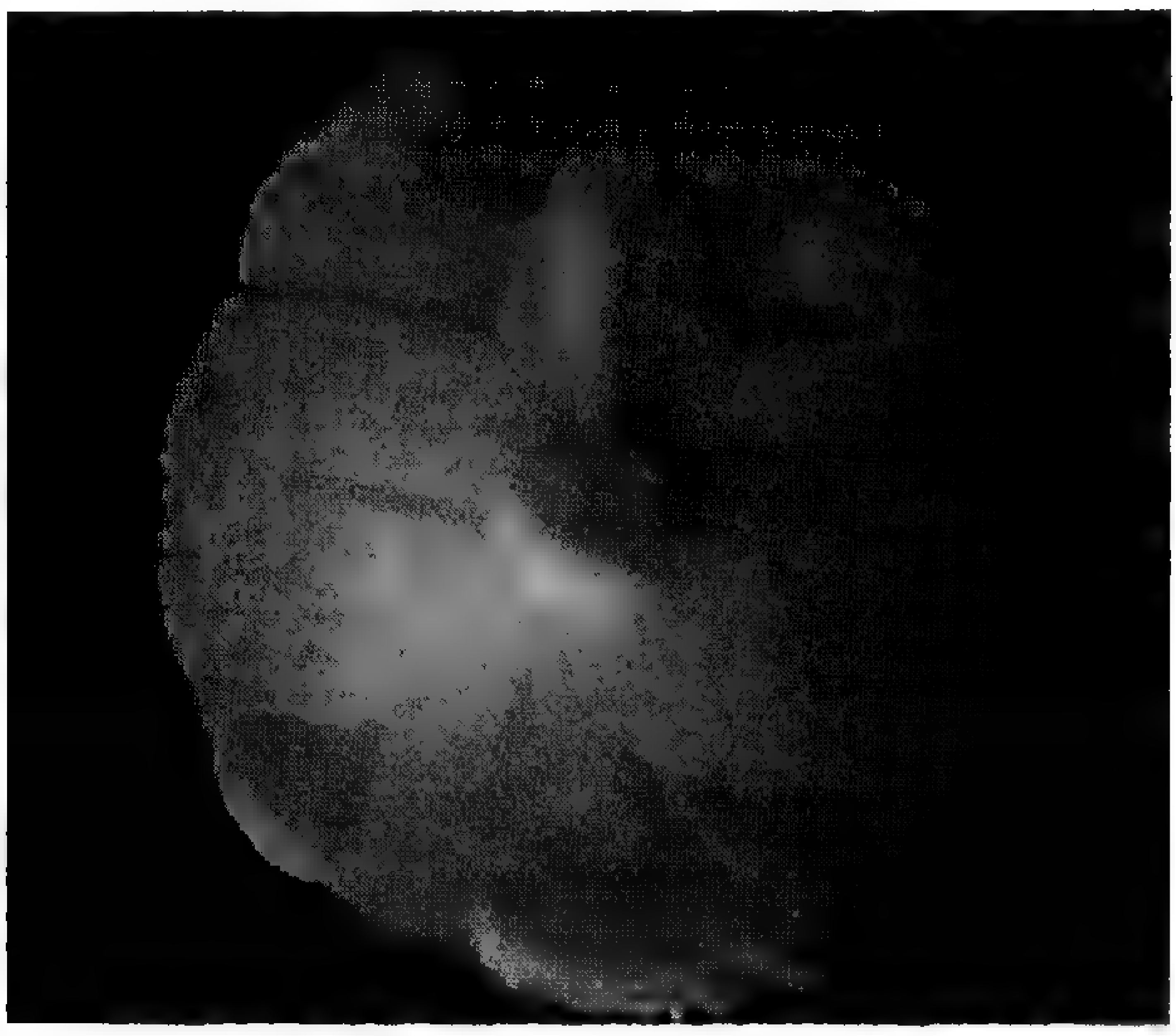
98. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2½.



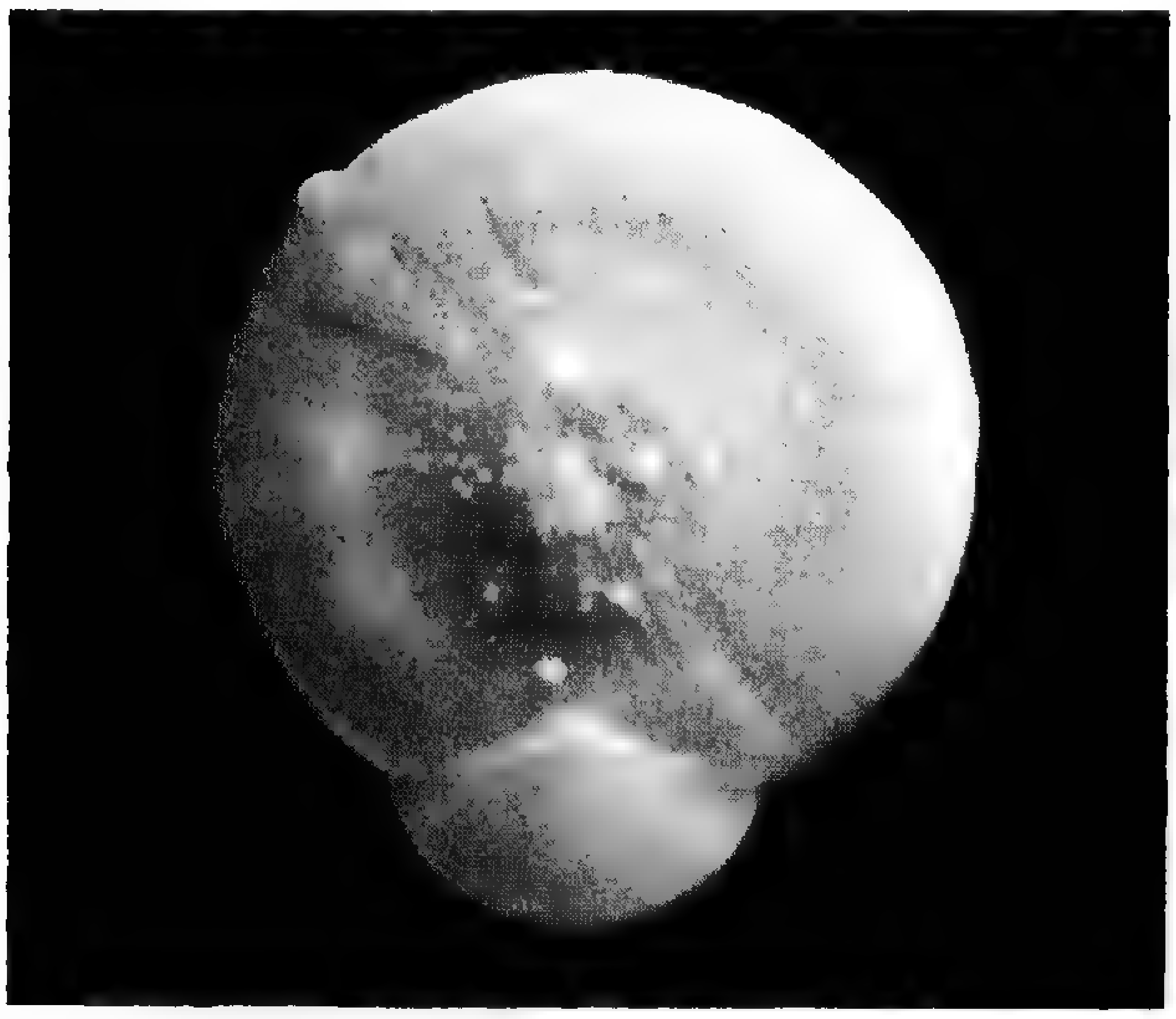
101. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2½.



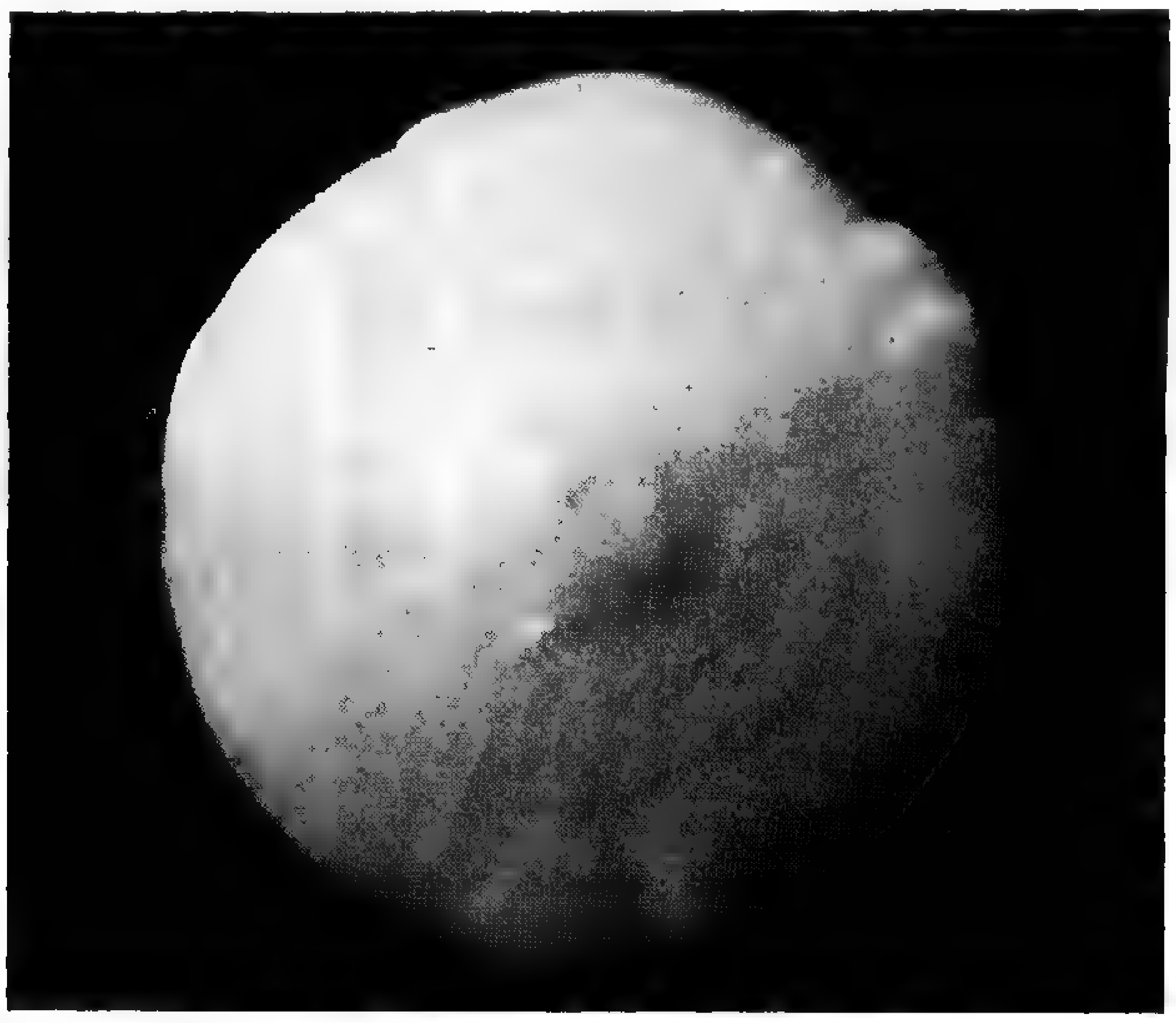
99. Giant colony grown on glucose agar; at 6 weeks. × 3½.



102. Giant colony grown on glucose agar; at 6 weeks. × 2½.



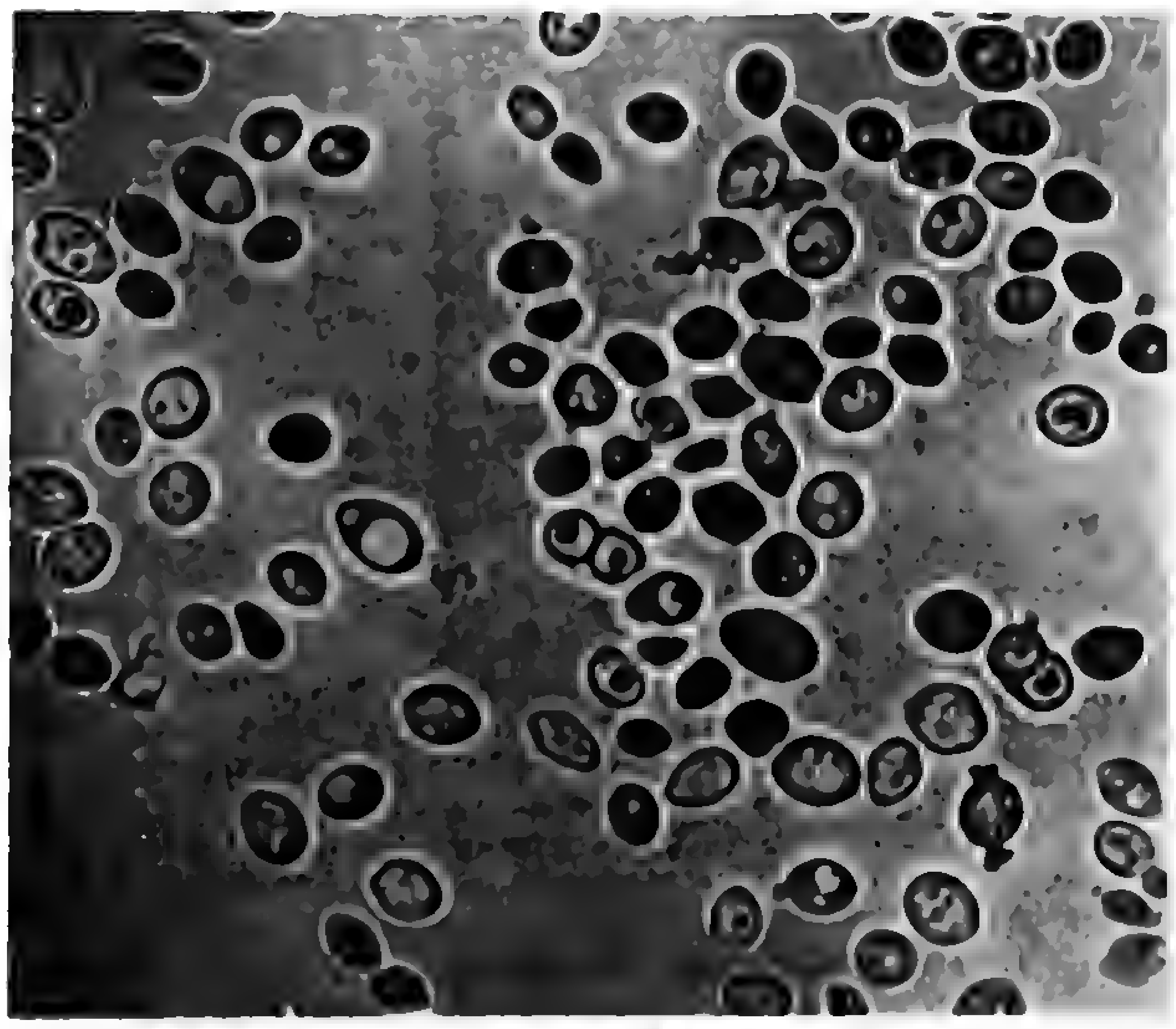
100. Giant colony grown on synthetic agar-A; at 6 weeks. × 3½.



103. Giant colony grown on synthetic agar-A; at 6 weeks. × 3.

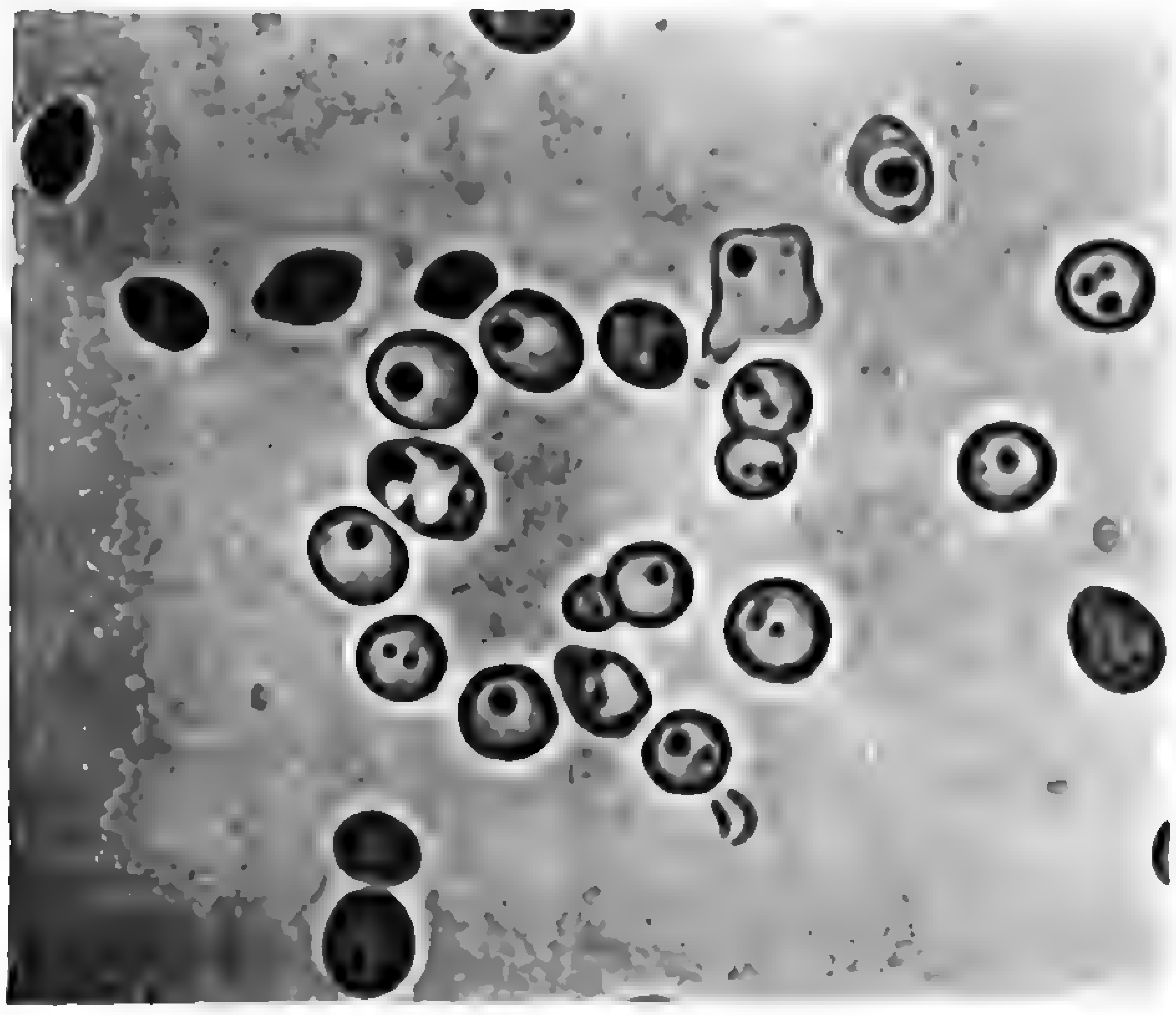
## *Z. GLOBIFORMIS* (Cont.)

Y-742



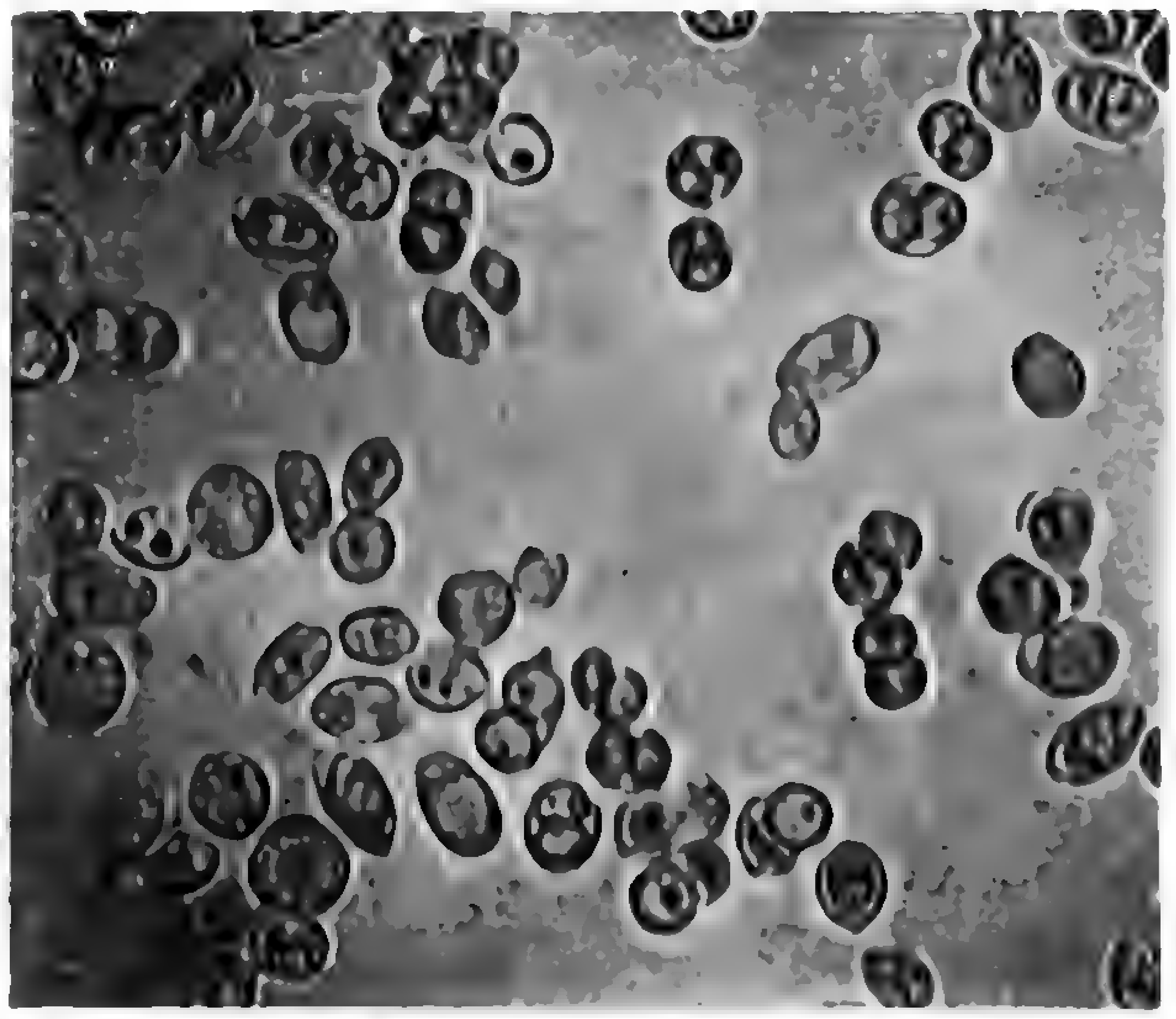
104. Cells from vegetable-juice agar at 1 month with a few spores. Unstained, × 1500.

105. Cells with conjugation tubes from vegetable-juice agar at 1 month. Unstained, × 1500; enlarged, × 2.

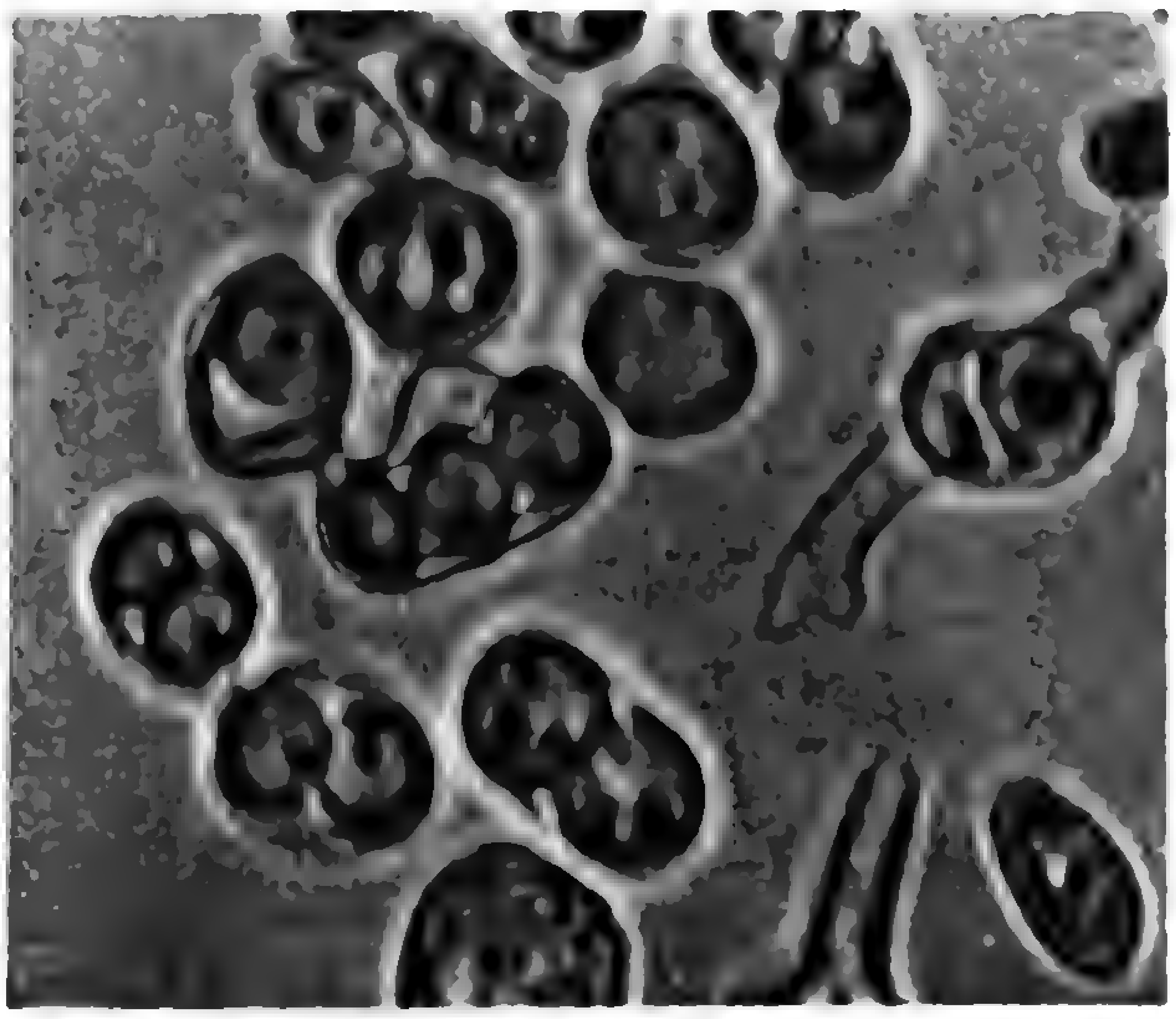


106. Free spores in center area, from vegetable-juice agar at 1 month. Unstained, × 1500; enlarged, × 2.

SPY-29

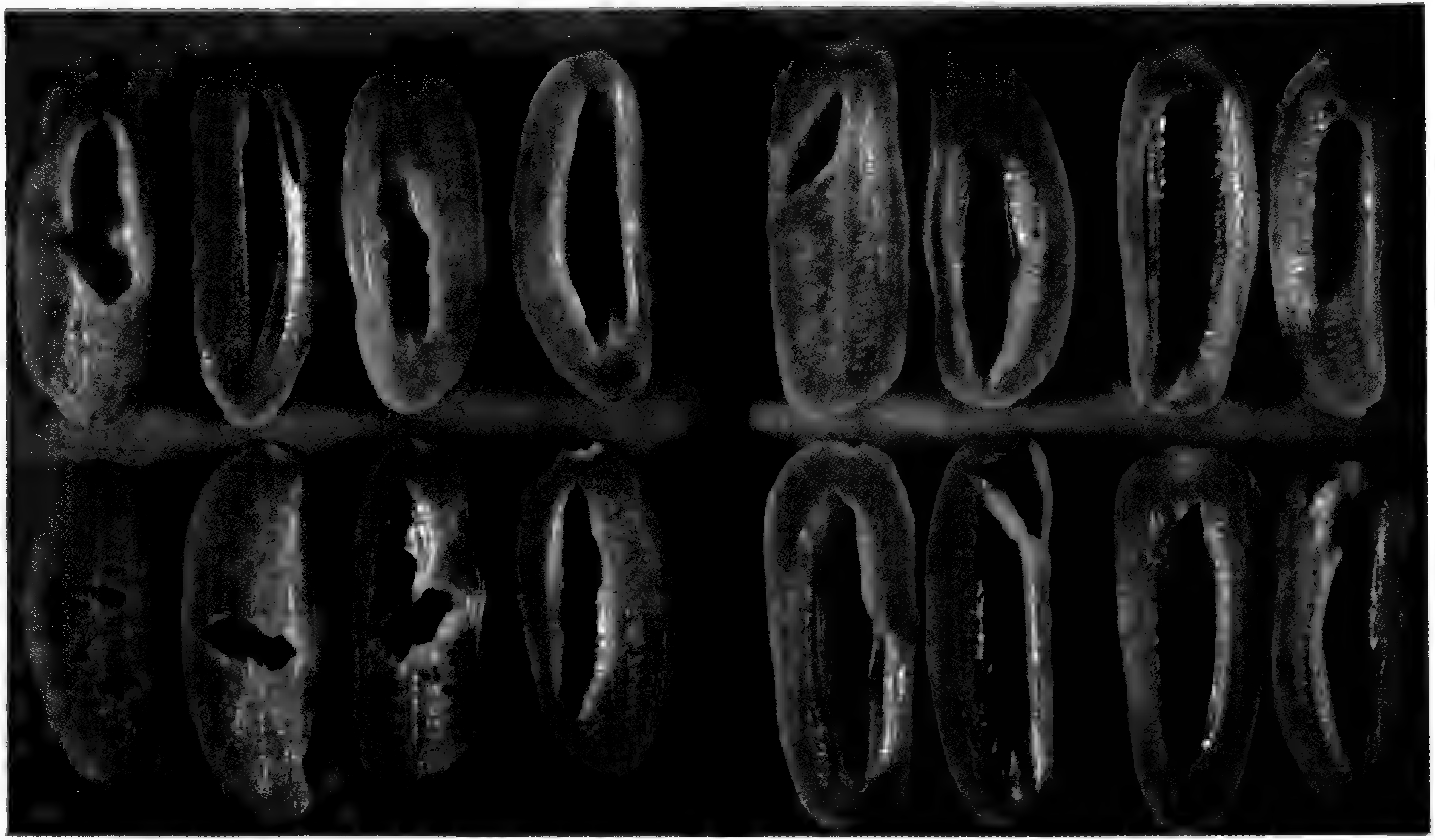


107. Sporulated culture from vegetable-juice agar at 1 month. Unstained, × 1500.



108. Asci with 4 spores. Center, 1 and 3 spores per side; lower left, 2 spores per side. Unstained, × 1500; enlarged, × 2.

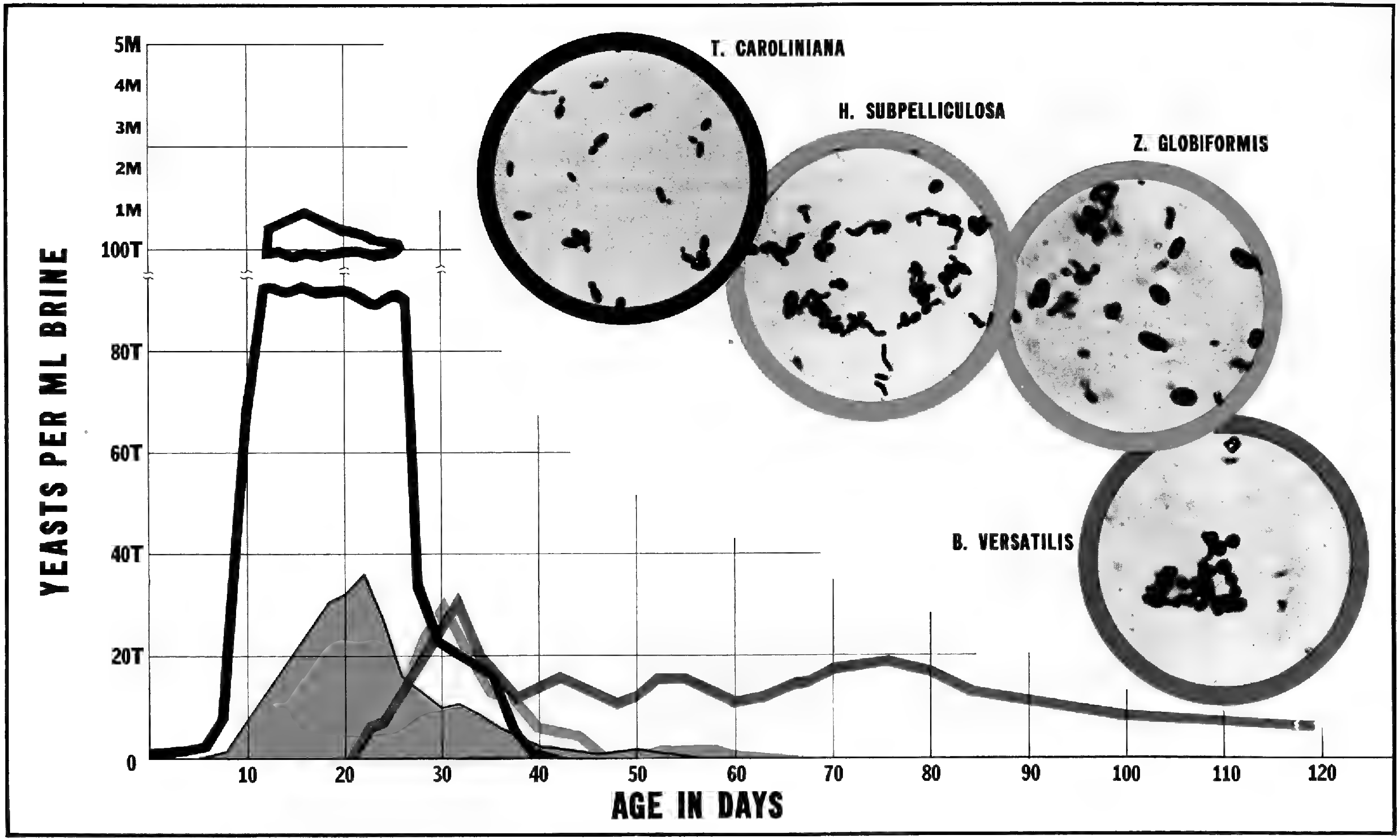
109. Ascus with two round spores per side. From vegetable-juice agar at 1 month. Unstained, × 1500; enlarged, × 2.



FROM NATURAL FERMENTATIONS FROM PURE CULTURE FERMENTATIONS

F. Examples of "bloater" formation by yeasts during the brine-fermentation of cucumbers. The four pairs of bloaters (at right) are typical of those produced by the 4 yeasts pictured below (p. 297).

110. BELOW. Yeast populations in commercial cucumber brines (T = thousands and M = millions) according to sequence of species (Cf. Etchells and Bell), (6). Inserts show 4 individual species as they occur naturally in brines during fermentation. Cells in brines Gram stained, × 1500.


5M
4M
3M
2M
1M
100T
80T
60T
40T
20T
0
YEASTS PER ML BRINE
10
20
30
40
50
60
70
80
90
100
110
120
AGE IN DAYS
T. CAROLINIANA
H. SUBPELLICULOSA
Z. GLOBIFORMIS
B. VERSATILIS

# YEASTS FROM THE CUCUMBER PLANT

During the 1951 growing season, work was started to determine the numbers and species of yeasts associated with different parts of the cucumber plant *(Cucumis sativus)*. In the course of these studies, 966 yeast isolates were obtained from 37 sets of staminate and pistillate flowers, and five samples of small, immature fruit. These samples came from two important cucumber production areas in Eastern North Carolina. The details of the above study will be published elsewhere when the taxonomic work is complete; however, for our purpose here, certain remarks are in order.

More than one-half of the yeast cultures obtained during the study were asporogenic, non-fermentative, carotenoid-producing types placed in the genus *Rhodotorula*. Other yeast genera represented were: *Candida*, *Torulopsis*, *Debaryomyces*, *Torulaspora*, *Kloeckera*, *Saccharomyces s.s.*, and *Zygosaccharomyces s.g.* A breakdown of *Rhodotorula* isolates showed three major groups; red cultures similar to *R. glutinis*, yellow cultures similar to *R. flava*, and yellow cultures apparently not related to *R. flava*. In the minor red group were five rough strains with red-orange color; these produced rather well-developed mycelia. Several minor types were found among the yellow pigmented yeasts, including one that developed a latent black pigment.

In order to meet the accepted requirements of the genus *Rhodotorula* the presence of carotenoid pigments must be demonstrated. Further, with a large collection of isolates, the use of culture media that will aid in visual screening of potential pigmented species is of importance, particularly for the yellow types. A large number of the latter yeasts would have been missed had they not first been cultured on SYNTHETIC AGAR-B. Finally, the need for improved cultural and chemical techniques to clearly demonstrate carotenoid production in pigmented species cannot be minimized. The use of strong acids and alkalis has been found inadequate for liberating the pigments from yeast cells grown on liquid or solid media of conventional type. However, excellent results were obtained for pigment extraction with acetone only, providing the yeasts were grown in SYNTHETIC BROTH-B for 72 hours on a rotary shaker. The pigments were then transferred to petroleum ether for characterization by chromatography and determinations of absorption spectra.

Based on current work, which will be reported in detail elsewhere, it seems clearly evident that carotenoid production covers a wider range of yeast types than previously suspected. In the pages to follow, absorption maxima for total carotenoid pigments in petroleum ether accompany the illustrations of giant colonies of certain of the *Rhodotorula* isolated. Also, chromatographs on magnesium oxide-supercel columns with petroleum ether were made on cell extracts from four yeast types. The spectral analyses of the carotenoid zones, in terms of visually observed absorption maxima in mμ are given below.

YEAST SY-85 (p. 300 LEFT), four pigments, Zone I, deep red, 485; II, red, 482 and 512; III, yellow, 460 and 488; IV, yellow (β-carotene), 450 and 475. YEAST SY-810 (p. 300 RIGHT), three pigments, Zone I, trace of pink; II, yellow orange, 450; III, yellow (β-carotene), 450 and 475. YEAST SY-875 (p. 301 RIGHT), four pigments, Zone I, deep red (sample lost); II, red, 435; III, yellow, 425 and 450; IV, yellow (β-carotene), 450 and 476. YEAST SY-836 (NOT SHOWN), one pigment, yellow (β-carotene), 450 and 474. B-carotene was identified as the pigment common to all four *Rhodotorula* species studied.

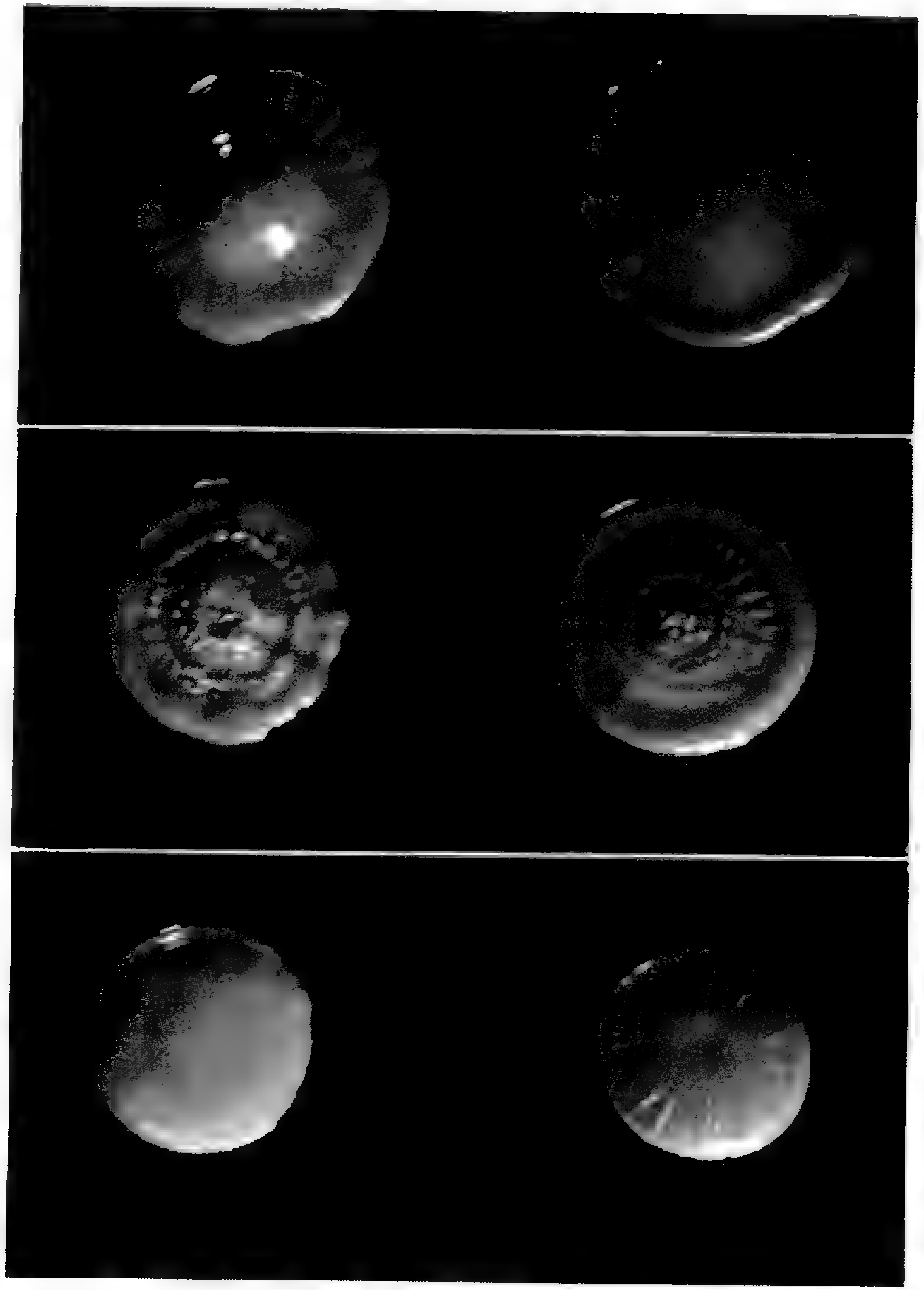
STAMINATE FLOWER AND BUDS

PISTILLATE FLOWER UNOPENED

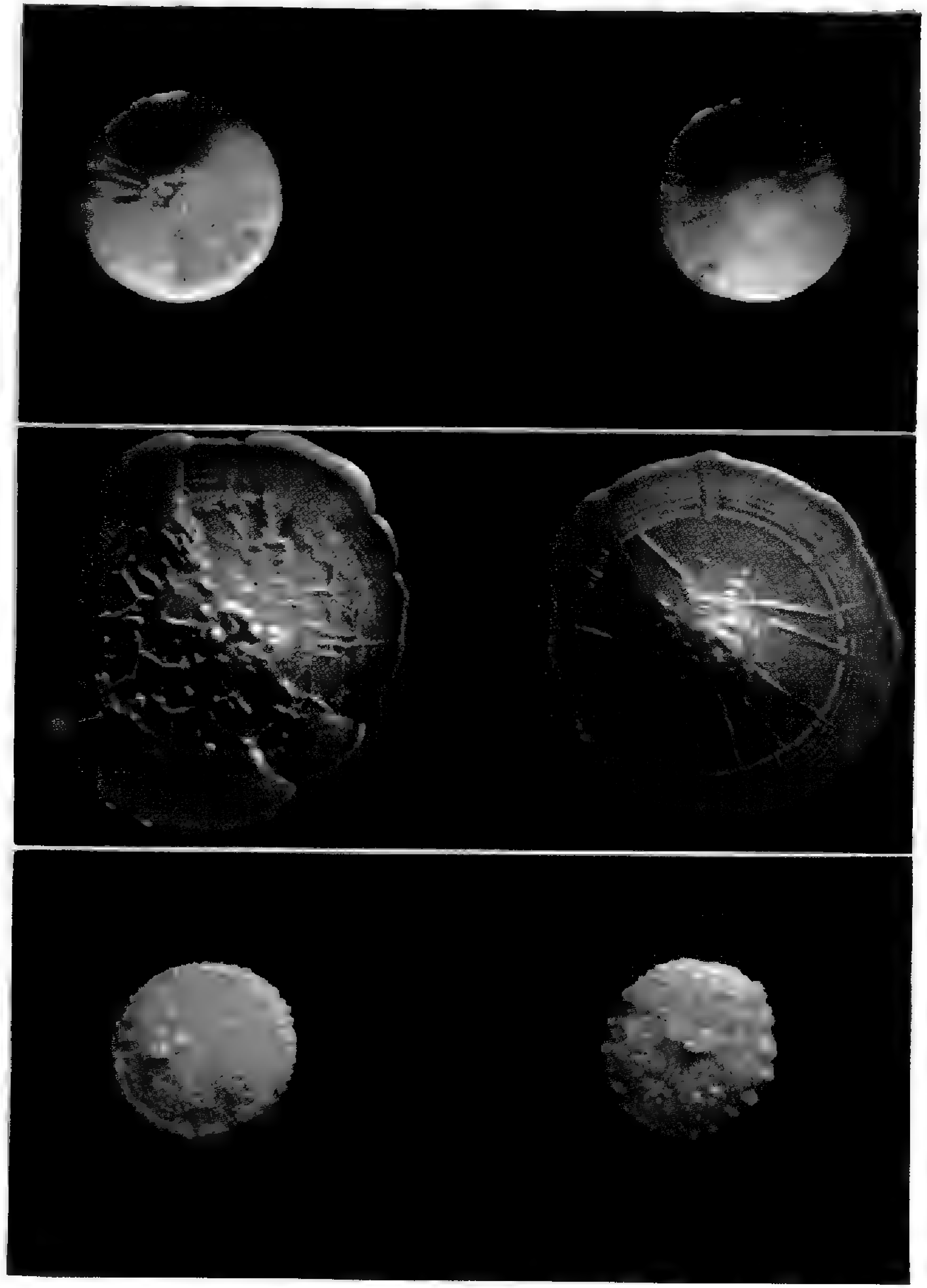
PISTILLATE FLOWER OPENED

IMMATURE FRUIT WITH DRIED FLOWER

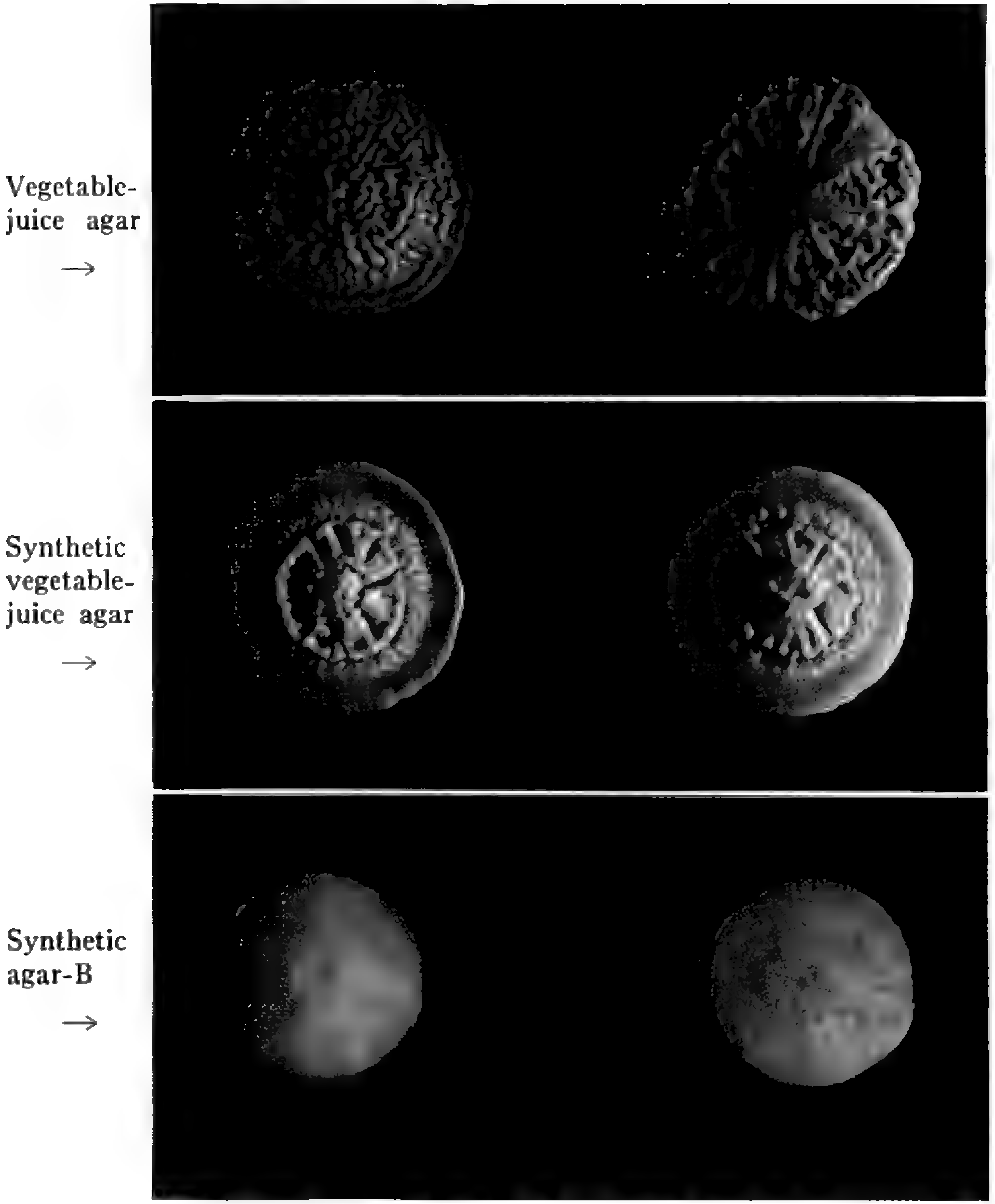
G. Flowers and immature fruit of the cucumber plant (*Cucumis sativus*). White spine variety; about actual size.



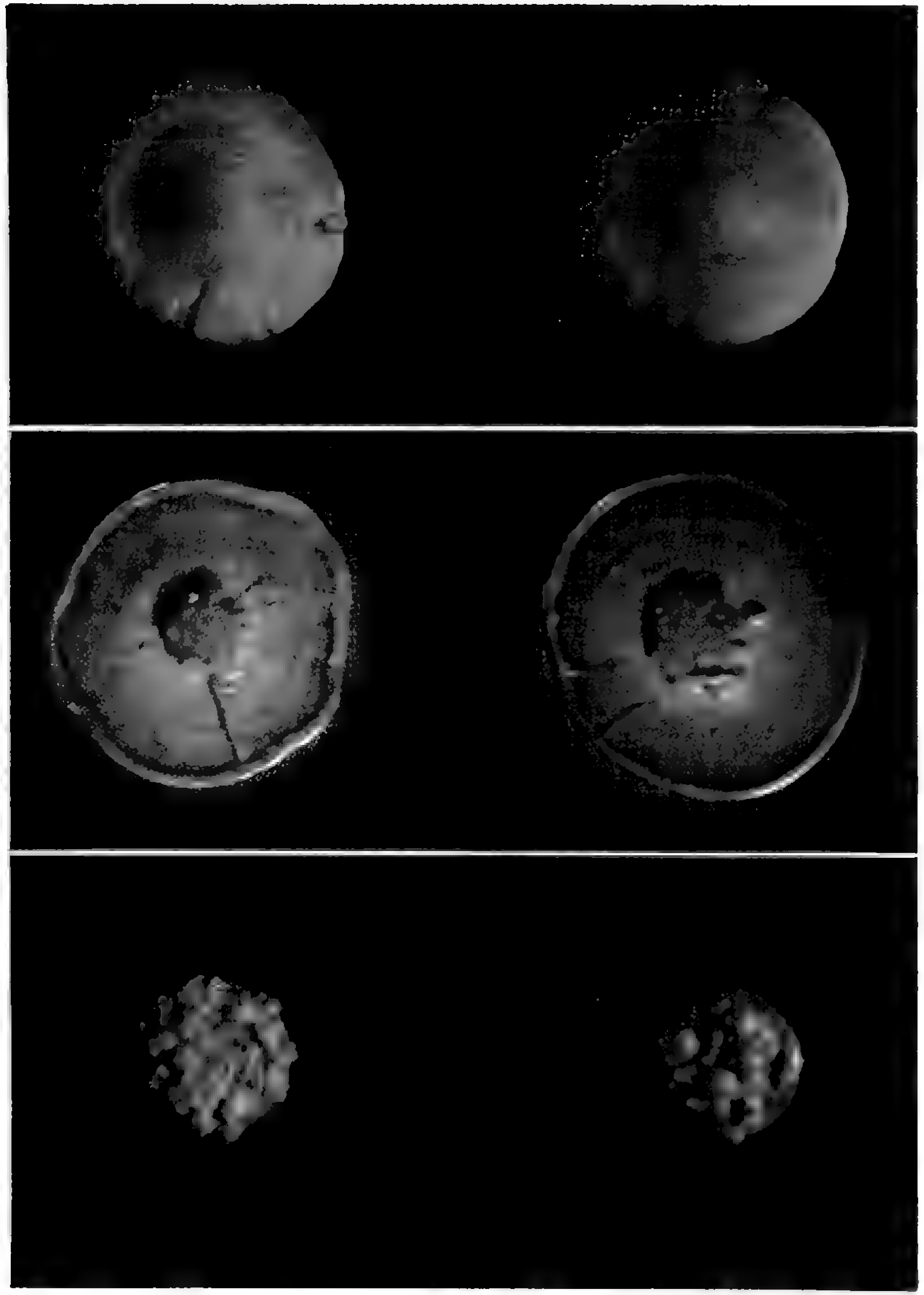
H. Comparative growth of 2 cultures of *Rhodotorula glutinis* group on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Absorption max. for culture SY-761 (left), 447 m$\mu$; SY-85 (right), 480 m$\mu$.



I. Comparative growth of 2 cultures of *Rhodotorula flava* group on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Absorption max. for both cultures, SY-873 (left) and SY-810 (right), 450 m$\mu$.



J. Comparative growth of 2 cultures of rough, yellow *Rhodotorula* species on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Absorption max. for both cultures, SY-629 (left) and SY-665 (right), 445 mμ.



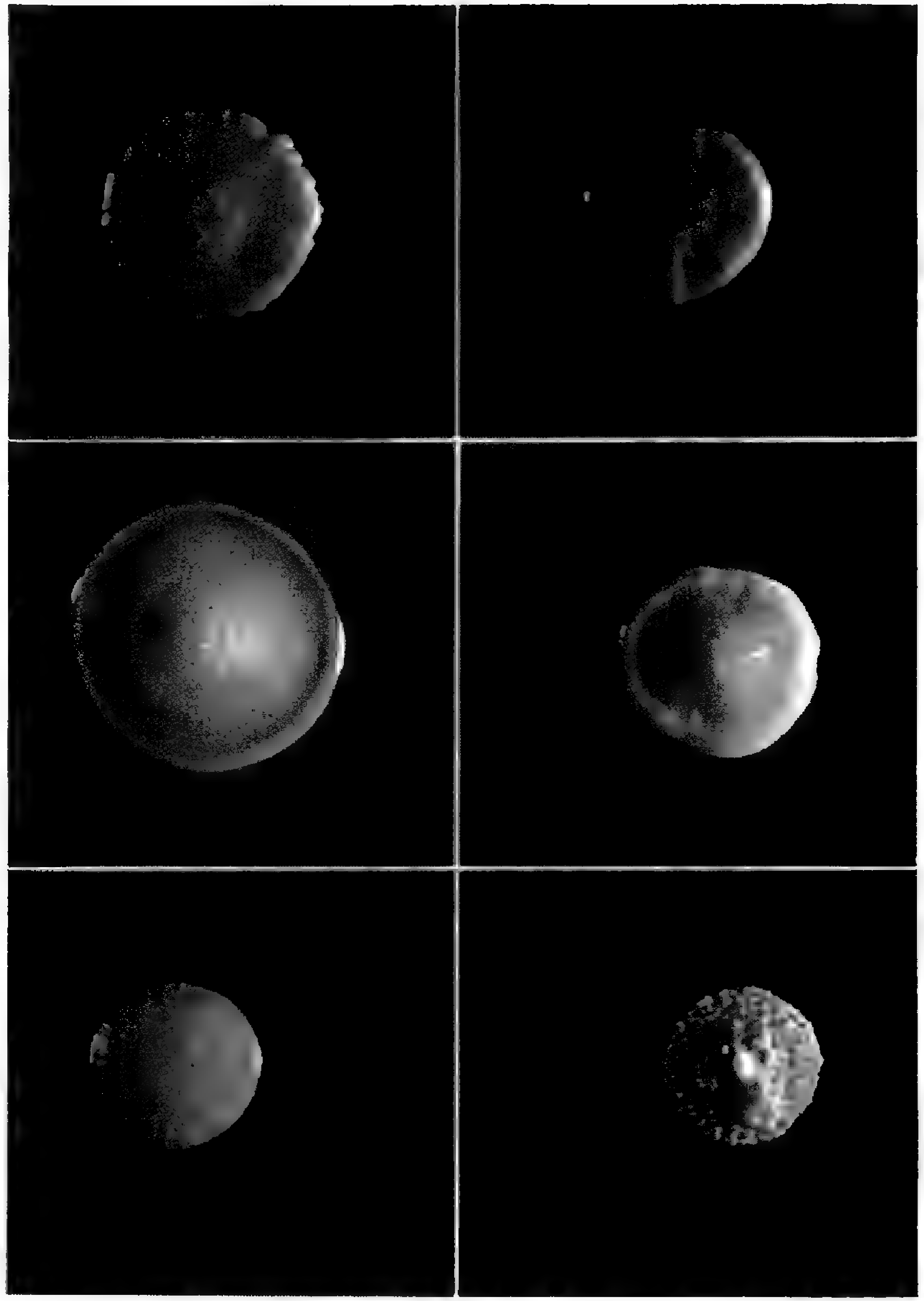
K. Comparative growth of 2 cultures of rough, mycelia-producing *Rhodotorula* species on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Absorption max. for both cultures, SY-1070 (left) and SY-875 (right), 450 mμ.

CULTURAL
MEDIA

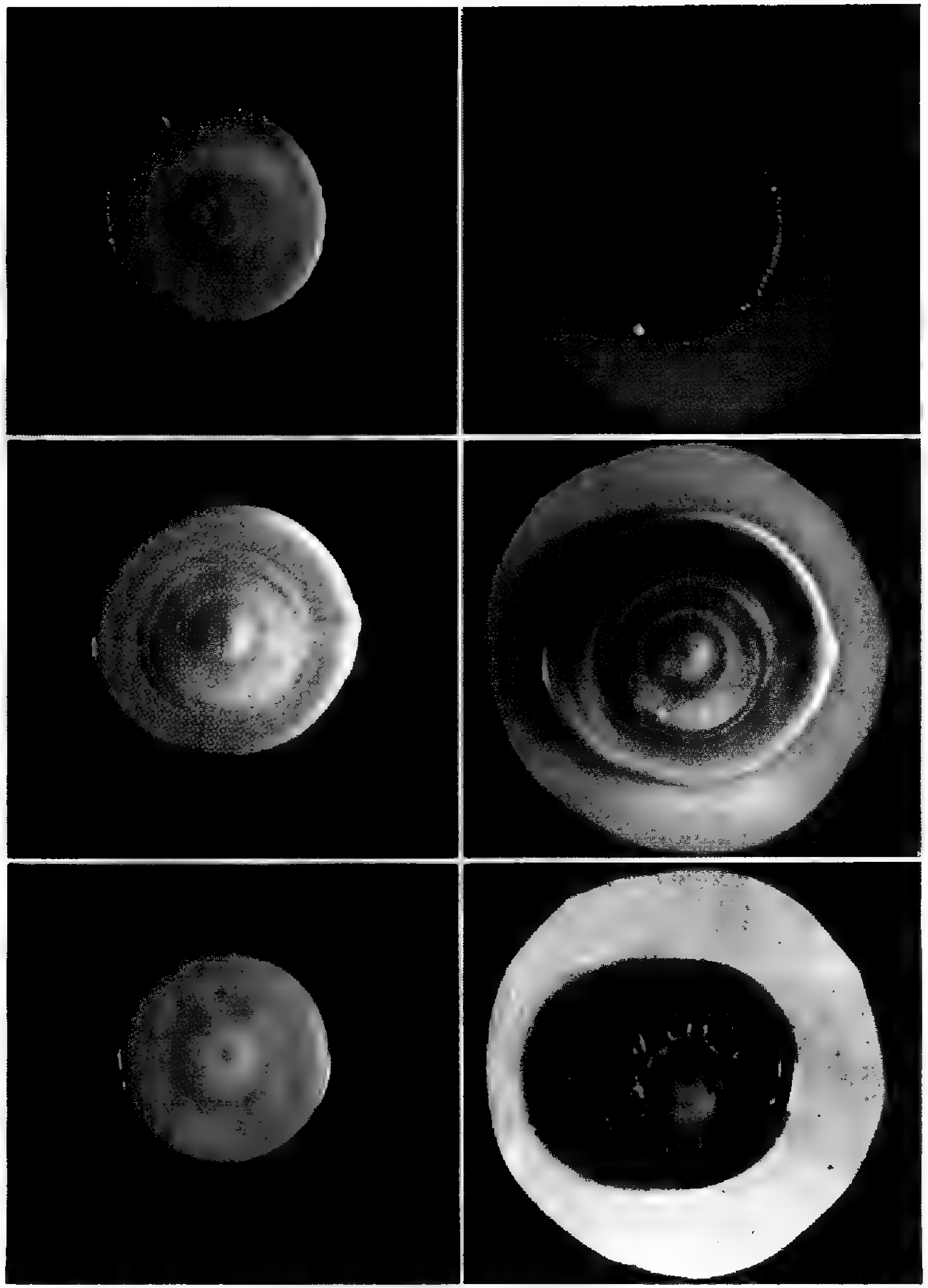
Vegetable-
juice agar
→

Synthetic
vegetable-
juice agar
→

Synthetic
agar-B
→



L. Comparative growth of 2 miscellaneous *Rhodotorula* cultures on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Absorption max. for SY-364 (left), 450 mμ; SY-369 (right) not determined.

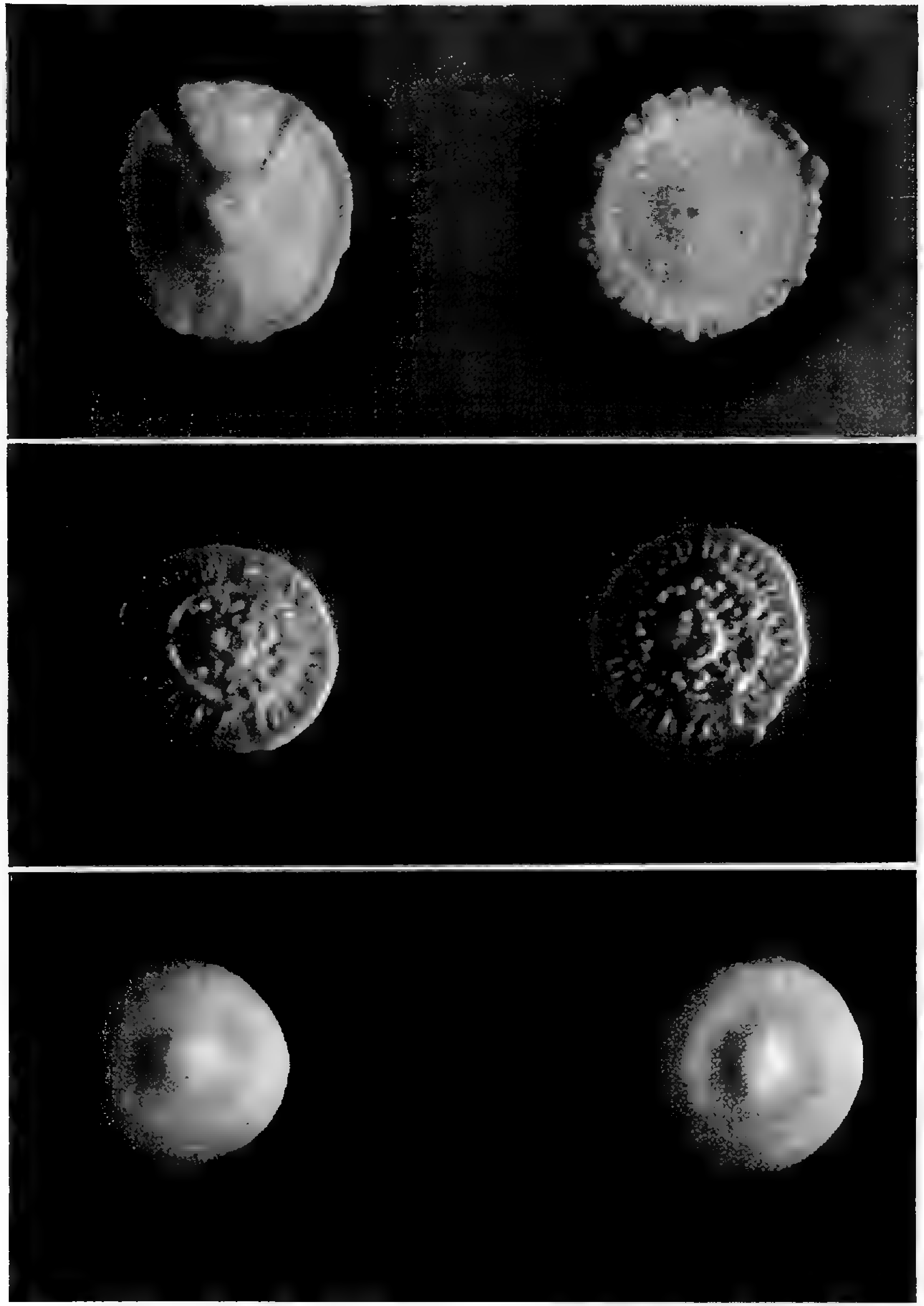


M. Comparative growth of *Rhodotorula* culture SY-1054 on 3 cultural media. *Left:* colonies grown 4 weeks at room temp. *Right:* the same colonies after an additional 3 weeks in the refrigerator (6°C.). Absorption max., 440 mμ.

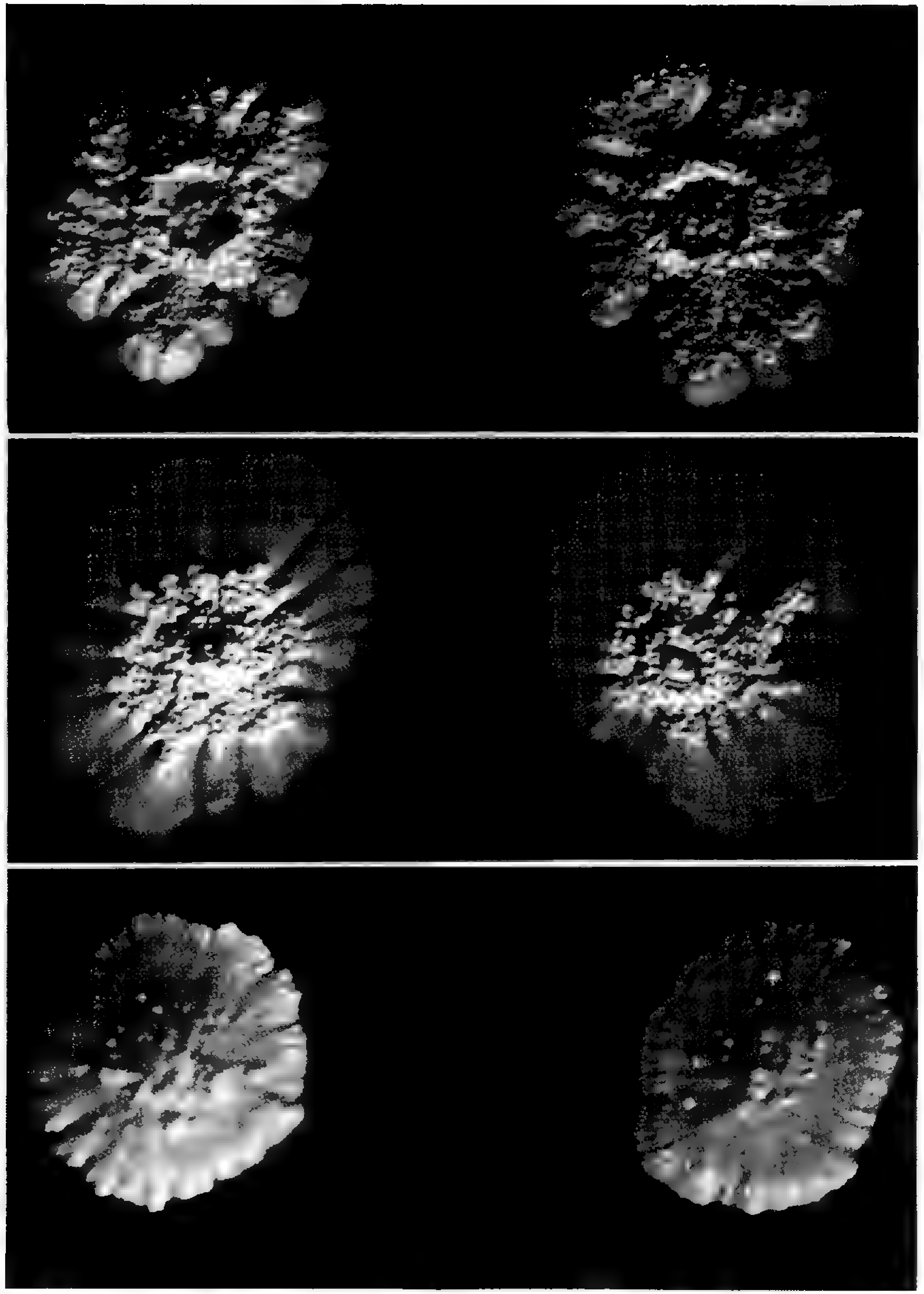
Vegetable-juice agar →

Synthetic vegetable-juice agar →

Synthetic agar-B →



N. Comparative growth of 2 pigmented cultures SY-161 (left) and SY-173 (right) of *Candida pulcherrima* on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Pigments soluble in the media; cells from both cultures negative for carotenoids.



O. Comparative growth of 2 cultures SY-188 (left) and SY-177 (right) of rough, fermentative *Candida* species on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Cells from both cultures negative for carotenoids.

## ACKNOWLEDGMENTS

We wish to express sincere appreciation to the following Station personnel for generous assistance received: Dr. W. J. Peterson, Head, Department of Chemistry, and Dr. W. W. G. Smart, Jr., Department of Animal Industry, for their fine work on extraction and characterization of the carotenoid pigments; Messrs. N. S. Youngsteadt and Lane Palmer, Department of Publications, for their many hours devoted to planning, layout and art work; Mrs. Elsie Harper, Department of Visual Aids for special photographic printing; Dr. R. W. Cummings, Director of Research for the Station, and Professor M. E. Gardner, Head, Department of Horticulture, for their support and cooperation throughout this study. Notable contributions have also been made by Mr. A. L. Demain, University of California, who helped with isolation and identification studies during the summer of 1951; by Mr. L. P. Watson, Raleigh, N. C., who made the color pictures; and, by Mr. Robert Stevens, Lynchburg, Va., who was in charge of reproducing the natural color photographs. Our sincere thanks are given to Dr. Edgar V. Seeler, Editor of Farlowia, and the late Dr. W. Lawrence White, Director of the Farlow Library and Herbarium, Harvard University, for their advice and encouragement during the preparation of this article.

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# THE USTILAGINALES OF CHINA

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The fungus flora of China has been relatively little studied in contrast to the progress made in exploring her well known richness in phanerogams. Until recent decades, fungi were gathered there only incidentally by collectors of flowering plants. These collections have been named by a number of western botanists and are scattered in various herbaria of Europe and America. Most of them have never been re-examined. In order to set forth the nature and extent of her fungus flora, all these collections must be studied critically group by group.

During the past several years the writer tried to locate all collections of the Ustilaginales recorded from China, especially the types of species described from there. Through the courtesy of various herbaria, most of them were made available for study. His former colleagues assisted him in gathering new collections. As a result, the present treatment of these fungi, after placing a number of binomials in synonymy and excluding others as incorrectly identified, includes 105 species, 3 varieties and 1 form. Whenever accessible, type specimens of species related to those occurring in China and known from neighboring areas, were examined to ascertain their relationships; thereby a number of synonyms was added.

Besides the writer's personal collection, the materials considered here are from the following sources: Mycological Collections, Bureau of Plant Industry, U. S. Department of Agriculture; U. S. National Museum; Farlow Herbarium, Harvard University; Naturhistorisches Museum, Vienna; Universitetes Institution för Systematisk Botanik, Uppsala; Naturhistoriska Riksmuseet, Stockholm; Herbarium of the Faculty of Agriculture, Hokkaido Imperial University; University of Nanking; National Tsin Hua University; National Taiwan University; and Taiwan Agricultural Research Institute.

The writer acknowledges his deep indebtedness to Mr. J. A. Stevenson for granting him the facilities of the Mycological Collections, Bureau of Plant Industry, U. S. Department of Agriculture, for his assistance in various ways, and for his review of the manuscript. He is also grateful to Miss Edith K. Cash for preparing the Latin diagnoses; to the late Dr. Th. Arwidsson, Dr. R. Ciferri, Dr. S. Ito, Dr. T. Matsumoto, Dr. J. A. Nannfeldt, Dr. F. Petrak, Mr. K. Sawada, Prof. F. L. Tai, Dr. C. T. Wei, and Dr. W. Lawrence White, through whose kindness specimens were made available for study; to Mrs. Agnes Chase, Dr. A. N. Steward, Mr. J. R. Swallen, and Dr. E. H. Walker for the identification of certain host plants.

## TILLETIACEAE

Sori usually dehiscent at maturity in *Tilletia* and *Urocystis* but indehiscent in other genera. Spore germination by means of a cylindrical promycelium on which a terminal cluster of elongate sporidia is borne. Promycelium usually non-septate until its cytoplasm becomes highly vacuolated. Sporidia usually function as reproductive organs. Conidia often produced.

### TILLETIA Tul.

Ann. Sci. Nat. III. 7: 112. 1847.

Sori in various parts of the host, most frequently in the ovaries. Spore mass usually dusty at maturity. Spores not aggregated into balls, of medium to large size.

Several species of *Tilletia*, including *T. horrida*, have been transferred to the genus *Neovossia* Koern. which, as emended by Brefeld, is characterized by forming a large number of sporidia on germination which do not fuse *in situ*. Since our knowledge of the spore germination of this group of fungi is limited to relatively few species, it will not be surprising if certain species are found in the future with sporidia intermediate in number. As concerns the lack of direct sporidial fusion, it indicates merely that the primary sporidia may function as propagative cells as well as reproductive organs. The conjugation may be delayed to a later stage. Recent studies have shown that even in a single species the homothallic forms may occur along with the heterothallic forms. Sexuality, therefore, cannot be considered as of taxonomic value. Furthermore, if the characters and behavior of sporidia are so important in taxonomy, it is difficult to understand why such genera as *Ustilagidium* Herzb. and *Anthracoidea* Bref. are constantly rejected.

| | |
|---|---|
| Spores smooth | *T. foetida* |
| Spores reticulate | |
|  Reticulations 2–4 μ wide | *T. caries* |
|  Reticulations 1.2–2 μ wide | *T. rhei* |
| Spores with spiny scales | |
|  Sori surrounding the branches of inflorescence | *T. okudaire* |
|  Sori in the ovaries or vegetative organs | |
|   Mature spores light yellow | *T. alopecuri* |
|   Mature spores dark brown | |
|    Sori completely concealed by the glumes | *T. horrida* |
|    Sori more or less exposed | |
|     Sori exceeding 4 mm. in length | |
|      Mature spore with an evident hyaline envelope | *T. pennisetina* |
|      Mature spore without an evident hyaline envelope | *T. setariae* |
|     Sori under 4 mm. in length | |
|      Spores 26–36 μ diam. | *T. arundinellae* |
|      Spores 20–31 μ diam. | *T. pulcherrima* |
|      Spores 19–26 μ diam. | *T. deyeuxiae* |

**Tilletia alopecuri** (Saw.) Ling, Mycologia 41: 252. 1949.

*Entyloma alopecuri* Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 2: 86. 1922.

Sori in the ovaries, infecting most of the spikelets in the inflorescence, inconspicuous, hidden completely by the enveloping glumes and each covered by a thin membrane of host tissue, broadly ellipsoid with a tapering apex, approximately 1 mm. long; also in leaves, leaf sheaths and internodes of culms, subepidermal, forming short or elongate yellow striae, later becoming dark brown, often causing hypertrophy, curvature and bulging of the culms. Spores light yellow, spherical to subspherical, each enclosed in a hyaline envelope, 17–25.5 μ diam., averaging 22.2 μ, covered with prominent spiny scales measuring 2–3 μ high by 2.5–3.5 μ wide at base; immature spores or sterile cells almost hyaline, 12–16.5 μ diam., epispore 1.5 μ thick; conidia on the surface of infected vegetative tissue of the host, hyaline, smooth, 14–35 x 5–8 μ.

On Gramineae:

*Alopecurus geniculatus* L.

Type locality and host: Taipeh, Taiwan, on *Alopecurus geniculatus*.

Distribution: Taiwan.

**Tilletia arundinellae** Ling, Myc. Papers Imp. Myc. Inst. 11: 1. 1945. (Fig. 1,A)

Sori in the ovaries, inconspicuous, protruding between the spreading glumes, cornute or conical, 3.5–4 mm. long, 1–1.5 mm. wide, each covered by a firm purplish membrane which ruptures irregularly revealing a black pulverulent spore mass. Spores when mature dark purplish brown, opaque, chiefly spherical to subspherical, 25.5–36 μ, mostly 28.5–31.5 μ diam., with hyaline, usually curved spinous scales, 1.5 μ long and 1–1.4 μ wide at base, each enclosed by an evident hyaline membrane; sterile cells subhyaline, thick-walled, mostly smaller than the spores, often with pedicel-like projections.

On Gramineae:

*Arundinella anomala* Steud.

Type locality and host: Chengtu, Szechwan, on *Arundinella anomala*.

Distribution: Known only from the type locality.

**Tilletia caries** (D.C.) Tul., Ann. Sci. Nat. III. 7: 113. 1847.

*Uredo caries* DC., Fl. Franç. 6: 78. 1815.

*Tilletia tritici* Wolff, Brand Getreides 13. 1874.

Sori in the ovaries, oval, enclosed by the pericarps, about same size as the wheat kernels. Spores when mature dark olive brown, chiefly spherical to subspherical, 15–20 x 14–18 μ, with shallow to deep winged reticulations, 2–4 μ wide, foetid.

On Gramineae:

*Triticum aestivum* L.

Type locality and host: France, on *Triticum aestivum*.

Distribution: Chekiang, Honan, Hopeh, Kansu, Kiangsu, Shansi, Shensi, Sikang, Szechwan, Yunnan, Chahar, Tsinghai, Suiyuan, Sunkiang, Hokiang, Heilungkiang, Nunkiang, Hsingan; also in all of the wheat growing countries.

**Tilletia deyeuxiae** Ling, Myc. Papers Imp. Myc. Inst. 11: 1. 1945. (Fig. 2,A)

Sori in the ovaries, infecting only occasional ones, ovoid, 3–4 mm. long, protected at first by the ovary walls which rupture at maturity disclosing the dark dusty spore masses. Spores when mature dark olive brown, opaque, spherical to ovoid, occasionally ellipsoid or somewhat angular, 18.5–26 x 16–24.5 μ, averaging 21 x 19 μ, densely covered by hyaline spiny scales, 1–1.5 μ long, 0.7–1.3 μ wide at base, and each enveloped by an evident hyaline membrane often with a short tapering projection at the end of attachment; sterile cells numerous, hyaline, chiefly subspherical, thick-walled, smooth, considerably smaller than the spores, averaging 13.6 x 11.2 μ.

On Gramineae:

*Deyeuxia sylvatica* (Schrad.) Kunth. var. *laxiflora* Rendle

Type locality and host: Sunghsien, Honan, on *Deyeuxia sylvatica* var. *laxiflora*.

Distribution: Known only from the type locality.

**Tilletia foetida** (Wallr.) Liro, Maanviljelys-taloudellinen Koelaitos Vuosikirja 1915–16. 27. 1920.

*Erysibe foetida* Wallr., Fl. Crypt. German. 2: 213. 1833.

*Tilletia laevis* Kuehn, Hedwigia 12: 152. 1873.

*Tilletia foetens* Schroet., in Cohn's Beitr. Biol. Pfl. 2: 365. 1877.

Sori in the ovaries, oval, enclosed by the pericarps, about same size as wheat kernels. Spores globose to ellipsoid, occasionally oblong or angular, light grayish brown to olive brown, smooth, 15–30 x 13–20 μ, foetid.

On Gramineae:

*Triticum aestivum* L.

Type locality and host: Germany, on *Triticum aestivum*.

Distribution: Hopeh, Kiangsu, Shansi, Shensi, Sikang, Szechwan, Yunnan, Kansu, Chahar, Suiyuan, Kirin, Sunkiang, Hokiang, Nunkiang, Heilunkiang, Hsingan; also in all of the wheat growing countries.

**Tilletia horrida** Tak., Bot. Mag. Tokyo 10: 20. 1896.

*Neovossia horrida* Padw. & Azmatullah Khan, Myc. Papers Imp. Myc. Inst. 10: 2. 1944.

Sori in the ovaries, infecting only occasional ones, completely or partially destroying the endosperm, concealed by the glumes. Spores present in various stages of development, when mature dark olive brown and opaque, each enveloped by an evident hyaline membrane, chiefly spherical to subspherical, 22–33 μ diam., with coarse, hyaline, somewhat curved scales, 2–3 μ wide at base; immature spores hyaline, thick-walled.

On Gramineae:

*Oryza sativa* L.

Type locality and host: Tokyo, Japan, on *Oryza sativa*.

Distribution: Chekiang, Hopeh, Kiangsi, Kiangsu, Liaoning, Szechwan, Taiwan, Yunnan; also in Burma, India, Indo-China, Japan, Java, Philippine Islands, Russia, America.

**Tilletia okudairae** (Miyabe) comb. nov.

*Ustilago okudairae* Miyabe apud S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 88. 1935.

*Tilletia taiana* Mundk., Trans. Brit. Myc. Soc. 24: 328. 1940.

Sori infecting the branches of inflorescences and inhibiting the development of racemes, concealed at first by leaf sheaths, then protruding, after the dispersal of olivaceous black spore masses leaving behind the naked branches. Spores olive brown, globose to ellipsoid, rarely somewhat irregular, 10–16.5 x 9–14 μ, with winged polygonal reticulations, 3–4.5 μ wide and 1.5 μ deep; sterile cells in chains intermixed with the spores, thick-walled, light olivaceous brown, chiefly cubical or subglobose, 6–10.5 μ in width.

On Gramineae:

*Coix agrestis* Lour.

Type locality and host: Iyo, Japan, on *Coix agrestis*.

Distribution: Yunnan; also in Japan.

**Tilletia pennisetina** Syd., Ann. Myc. 27: 421. 1929.

*Neovossia macrospora* Petr., Meddel. från Göteb. Bot. Trädg. 17: 114. 1947.

Sori in the ovaries, infecting only a few spikelets in a panicle, broadly oval, 4–7 mm. long, 2–3 mm. wide, each covered by a green, smooth membrane of host tissue which ruptures later disclosing a black, pulverulent spore mass. Spores showing different stages of development, spherical to subspherical, occasionally ellipsoid or oblong, when mature dark olive brown and opaque, 21.5–33 x 21–28.5 μ, with hyaline, slightly curved, aculeate scales, 1.5–2.5 μ long, each enveloped by an evident hyaline membrane often with a tapering pedicel at the end of attachment; immature spores subhyaline to light olivaceous brown, smooth or echinulate; sterile cells often also present, much larger than the spores, thin-walled.

On Gramineae:

*Pennisetum alopecuroides* (L.) Spreng. (= *P. japonicum* Trin., *P. compressum* R. Br.)

Type locality and host: Kuling, Kiangsi, on *Pennisetum alopecuroides*.

Distribution: Anhwei, Hopeh, Hunan, Hupeh, Kiangsi, Kiangsu, Szechwan; also in India, Korea, Japan.

**Tilletia pulcherrima** Ell. & Gall. apud Clint., Proc. Boston Soc. Nat. Hist. 31: 441. 1904.

Sori in the ovaries, infecting only a few spikelets in a raceme, ovoid or cornute, partially exposed between spreading glumes, 2.5–4 mm. long. Spores yellow brown to opaque varying with the degree of maturity, chiefly spherical to subspherical, 19.5–31.5 μ, averaging 25.6 μ in diameter, each with an evident hyaline membrane and prominent, hyaline, straight or slightly curved, truncate scale-like projections, 2–2.5 μ long and 1.6–2 μ wide at base; sterile cells hyaline, thick-walled, 18–28.5 μ diam.

On Gramineae:

*Digitaria sanguinalis* (L.) Heist.

*Echinochloa crus-galli* (L.) Beauv.

Type locality and host: Illinois, United States, on *Panicum virgatum* L.

Distribution: Liaoning, Szechwan; also in Japan, Russia, North America.

**Tilletia rhei** Zundel, Mycologia 36: 410. 1944. (Fig. 3,A)

Sori destroying the seeds, deforming each into a hard, triangular, mummified mass, approximately 2.5 mm. long, 2 mm. wide. Spore mass agglutinate, black at the surface of infected seed but white in the interior, intermixed with starch grains which are abundantly present in the endosperm of the healthy seed. Spores spherical to oval, occasionally slightly angular, 16.5–19.5 μ diam., or 18–24 x 16.5–19.5 μ, epispore orange brown at maturity, with winged polygonal reticulations 1.2–2 μ wide and 1–1.4 μ deep; immature spores present in different stages of development, from hyaline and smooth to light yellow and reticulate, usually slightly larger than the mature ones.

On Polygonaceae:

*Rheum franzenbachii* Muert.

Type locality and host: Yünting-shan, Chiaocheng, Shansi, on *Rheum franzenbachii*.

Distribution: Known only from the type locality.

**Tilletia setariae** Ling, Myc. Papers Imp. Myc. Inst. 11: 2. 1945.

Sori in the ovaries, infecting only occasional ones, ovoid or broadly oval, 4–5 mm. long and 2.5–3 mm. wide, each covered at first by a thick, green, smooth membrane of host tissue; spore mass black, pulverulent. Spores showing different stages of development, opaque brown when mature, chiefly spherical to subspherical, occasionally oval, 21.5–33 μ, mostly 22–28.5 μ diam., with blunt, subhyaline or light brownish scales, 1.5–2.5 μ long, with hyaline envelopes present only at very young stage; sterile cells few, hyaline, thick-walled, mostly smaller than the spores.

On Gramineae:

*Setaria lutescens* (Weigel) Hubbard

Type locality and host: Chengtu, Szechwan, on *Setaria lutescens*.

Distribution: Known only from the type locality.

### ENTYLOMA D. By.

Bot. Zeit. 32: 101. 1874.

Sori usually in the leaves, embedded permanently in the host tissue, indehiscent. Spores either scattered or adhering together, but not forming definite balls, most frequently light-colored, of medium size.

| | |
|---|---|
| Spores firmly adhering together | |
| Spores 9–12 μ long | *E. eleocharidis* |
| Spores 6–10 μ long | *E. oryzae* |
| Spores readily separable | |
| Epispores 3–6 μ thick | *E. microsporum* |
| Epispores under 3 μ thick | |
| Mature spores yellowish to golden brown | *E. australe* |
| Mature spores scarcely colored | |
| Spores densely crowded, 11–18 μ long | *E. guaraniticum* |
| Spores abundant but not crowded, 9–15 μ long | *E. compositarum* |

**Entyloma australe** Speg., Anal. Soc. Cien. Argent. 10: 5. 1880.

Sori in the leaves, often also in the calyxes, forming yellow to dark brown, circular to angular spots, 0.5–7 mm. in length. Spores globose to oval, sometimes ovoid or somewhat angular, 10–16.5 x 9–13.5 μ; epispore smooth, light yellowish to golden brown, 2–3 μ thick, apparently double-layered, outer layer thicker, frequently irregular and crenate.

On Solanaceae:

*Physalis angulata* L.

*Physalis ? minima* L.

Type locality and host: Duncan, Argentina, on *Physalis pubescens* L.

Distribution: Kiangsu, Taiwan; also in Indo-China, Japan, Africa, North and South America.

**Entyloma compositarum** Farl., Bot. Gaz. 8: 275. 1883.

*Entyloma senecionis* Saw., Jour. Taihoku Soc. Agr. For. 7: 27. 1934.

Sori in the leaves, forming angular, brown spots, limited by the veins, 0.5–1.5 mm. long, often confluent. Spores spherical to oval, occasionally ellipsoid, 9–13 μ diam., or 10.5–14.8 x 7.5–12 μ; epispore subhyaline to pale yellowish, smooth, 0.6–1 μ thick.

On Compositae:

*Senecio formosana* Kitamura

Type locality and host: New England, United States, on *Aster puniceus* L.

Distribution: Taiwan; also in North America.

*Entyloma bavaricum* Syd. differs from this species in having much thicker epispores.

**Entyloma eleocharidis** (Saw.) Ling, Mycologia 41: 255. 1949. (Fig. 1,B)

*Ustilago eleocharidis* Saw., Taiwan Agr. Res. Inst. Rep. 85: 39. 1943.

Sori in the upper parts of the culms, circular or irregular in shape, lead black, 0.1–1 mm. long. Spores embedded permanently in the host tissues between the upper and lower epidermis, arranged in parallel columns, firmly agglutinated together, globose to subglobose, often angular, 9–12 x 7–10.5 μ; epispore thin, smooth, light olivaceous brown.

On Cyperaceae:

*Eleocharis dulcis* Trin.

Type locality and host: Taipeh, Taiwan, on *Eleocharis dulcis*.

Distribution: Known only from the type locality.

**Entyloma guaraniticum** Speg., Anal. Soc. Cien. Argent. 17: 127. 1884.

*Protomyces bidentis* Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 2: 53. 1922.

Sori in the leaves, forming subcircular, indistinct spots, 1–4 mm. diam., brownish on the lower surface and dark greenish on the upper. Spores densely embedded in the mesophyll, globose to oval, occasionally ovoid, ellipsoid or oblong, 10.5–13.5 μ diam. or 12–18.5 x 8–11 μ; epispore 1.2–2.2 μ thick, smooth, pale yellowish.

On Compositae:

*Bidens pilosa* L.

Type locality and host: Paraguay, on *Bidens pilosa.*

Distribution: Taiwan; also in North and South America.

*Entyloma bidentis* P. Henn. (type in Myc. Coll. BPI. U. S. Dep. Agr.) on the same host genus is characterized by its yellow to golden yellow epispore measuring 2–4 μ thick. The size of spores, however, is similar to that of this species.

**Entyloma microsporum** (Ung.) Schroet., in Rab. Fungi Eur. 1872. 1874.

*Protomyces microsporus* Ung., Exanth. Pfl. 343. 1833.

Sori in the leaves, often also in the petioles and stems, causing deformation of the infected organs, forming hard, fusoid to hemispherical pustules, thick and elevated, 1–7 mm. in length, yellowish to dark brown according to the age. Spores variable in shape, subglobose to ellipsoid or ovoid, sometimes irregular, often with one or both ends tapering like pedicels, 14–25 x 10–17 μ; epispore usually somewhat crenate, hyaline at first, becoming light yellow to light yellow brown, smooth, 3–6 μ thick; conidia falcate, hyaline, 10–18 x 3.5–4 μ.

On Ranunculaceae:

*Ranunculus vernyii* Fr. & Sav.

Type locality and host: Europe, on *Ranunculus repens* L.

Distribution: Taiwan; also in Europe, North America.

**Entyloma oryzae** Syd., Ann. Myc. 12: 197. 1914.

*Ectostroma oryzae* Saw., Formosan Agr. Rev. 6 (63): 107. 1912.

*Sclerotium phyllachoroides* Hara, Jour. Pl. Prot. Tokyo 2: 949. 1915.

Sori in the leaves, forming short black striae, up to 2.5 mm. in length, permanently covered by the epidermis. Spores firmly and compactly agglutinated together, mostly angular, chiefly 6–10 x 4.7–7.5 μ; epispore smooth, 0.5–0.8 μ thick, light olivaceous brown.

On Gramineae:

*Oryza sativa* L.

Type locality and host: Laguna, Philippine Islands, on *Oryza sativa.*

Distribution: Anhwei, Chekiang, Fukien, Hupeh, Kiangsi, Kiangsu, Antung, Kirin, Szechwan, Taiwan, Yunnan; also in Afghanistan, Burma, India, Japan, Philippine Islands, Russia, America.

This species, though very similar to, is not identical with *Entyloma lineatum* (Cke.) Davis. The spores of *E. lineatum* although light in color, are bright golden brown and lack the dull olivaceous tinge of *E. oryzae* even in mass.

## UROCYSTIS Rab.

Kl. Herb. Viv. Myc. II. 393. 1856.

Sori in various parts of the host, most frequently in the leaves, dehiscent and usually pulverulent at maturity. Spore-balls permanent, each composed of one to several spores invested by few to many sterile cells. Spores generally dark-colored, of medium size.

| | |
|---|---|
| Sori forming regular linear striae | *U. agropyri* |
| Sori forming rather irregular pustules | |
| Cortical cells incompletely investing the spores | *U. anemones* |
| Cortical cells completely investing the spores | |
| Spores usually 1–3 in the balls | *U. dioscoreae* |
| Spores usually 3–6 in the balls | *U. japonica* |

**Urocystis agropyri** (Preuss) Schroet., Abh. Schles. Ges. Nat. Med. 1869–72: 7. 1871.

*Uredo agropyri* Preuss, in Sturm Deuts. Fl. Pilze 6:1. 1848.
*Urocystis tritici* Koern., Hedwigia 16: 33. 1877.

Sori in the leaves, leaf sheaths and upper culms, forming linear striae of varying length, at first lead-colored and protected by the epidermis which soon ruptures. Spore-balls globose to ellipsoid, 18–35 μ long, composed of 1–3, rarely 4, fertile spores and an investing layer of sterile cells. Sterile cells subhyaline to light brown, subglobose to ellipsoid, 4–15 x 4–7 μ. Spores globose to oval, 12–18 x 11–15 μ; epispore reddish brown, smooth.

On Gramineae:
*Agropyron* sp.
*Triticum aestivum* L.

Type locality and host: Hoyerswerda, Germany, on *Agropyrum repens* Beauv.

Distribution: Chekiang, Honan, Hopeh, Hupeh, Kiangsu, Shantung, Shensi, Sunkiang, Szechwan; also in Afghanistan, India, Japan, Palestine, Russia, Africa, America, Australia, Europe.

**Urocystis anemones** (Pers.) Wint., in Rab. Krypt. Fl. 1: 123. 1881.

*Uredo anemones* Pers., Syn. Fung. 223. 1801.
*Tuburcinia anemones* Liro, Ann. Univ. Fenn. Aboensis A. 1: 55. 1922.

Sori in the leaves, petioles and stems, forming conspicuous, irregular galls, upon rupture of the covering host tissue disclosing the black, dusty spore masses. Spore-balls subglobose to oval, often irregular, 19.5–38 x 16.5–30 μ, consisting of 1–6 spores usually incompletely invested by a number of sterile cells. Sterile cells subglobose to oblong, pale yellowish to pale brown, 7–12 x 5–7 μ. Spores deep reddish brown, subglobose to oval, frequently oblong or somewhat irregular, smooth, 12–21 x 8–15 μ.

On Ranunculaceae:
*Anemone raddeana* Regel
*Pulsatilla chinensis* (Bge.) Regel (= *Anemone chinensis* Bge.)

Type locality and host: Europe, on *Anemone nemorosa* L.

Distribution: Kiangsu, Antung; also in Japan, Russia, Europe, North America.

**Urocystis dioscoreae** Syd., Ann. Myc. 8: 173. 1909.

*Tuburcinia dioscoreae* Liro, Ann. Univ. Fenn. Aboensis A. 1: 38. 1922.

Sori in the leaf veins and petioles, forming elongate pustules, causing distortion of the infected organs, covered at first by the host tissue which ruptures later revealing the dusty black spore masses. Spore-balls globose to oblong, sometimes irregular, composed of usually 1, often 2–3 spores completely invested by a layer of sterile cells. Peripheral sterile cells subglobose to ellipsoidal, compressed, chiefly 6–12 μ long, light yellowish brown. Spores globose to oval, often oblong, dark reddish brown, smooth, 10–16.5 x 9–12.5 μ.

On Dioscoreaceae:
*Dioscorea quinqueloba* Thunb.

Type locality and host: Tosa, Japan, on *Dioscorea tokoro* Makino.

Distribution: Honan; also in Japan.

**Urocystis japonica** (P. Henn.) Ling, Myc. Papers Imp. Myc. Inst. 11:3. 1945.

*Urocystis anemones* (Pers.) Wint. var. *japonica* P. Henn., Hedwigia 43: 150. 1904.
*Tuburcinia japonica* Liro, Ann. Univ. Fenn. Aboensis A. 1: 65. 1922.

Sori in the leaves, petioles and stems, forming conspicuous and irregular galls of considerable size, usually causing distortion to the host, upon rupturing of the covering host tissue disclosing the semi-agglutinate black spore masses. Spore-balls dark reddish brown, subglobose to oval, often irregular, 18–45 μ in length, consisting of 3–12 fertile spores completely invested by a layer of sterile cells. Sterile cells pale olivaceous brown to cinnamon brown, oval, ellipsoid or oblong, compressed, 7.5–13.5 x 6–9 μ, rarely up to 17 μ long. Spores deep ochraceous brown, globose to ellipsoid, or somewhat irregular, smooth, 12–16 x 9–12.5 μ.

On Ranunculaceae:

*Anemone japonica* Sieb. & Zucc.

*Anemone* sp.

Type locality and host: Tosa, Japan, on *Anemone japonica.*

Distribution: Jehol, Szechwan; also in Japan.

### BURRILLIA Setch.

Proc. Amer. Acad. 26: 18. 1891.

Sori generally in the leaves, permanently embedded in the host tissues, indehiscent. Spore-ball without a distinct cortex, composed of numerous spores, in some species with sterile parenchymatous cells in the center or intermixed with the spores. Spores light-colored, of medium size.

**Burrillia ajrekari** Thirumalachar, Mycologia 39: 607. 1947. (Fig. 3,B)

*Stereosorus monochoriae* Saw., Taiwan Agr. Res. Inst. Rep. 85: 45. 1943.

Sori in the leaves, punctiform, densely aggregated in circular to irregular spots of 3–15 mm. long, which are chlorotic on the lower surface and brownish on the upper side and sometimes coalescing. Spore-balls embedded in the mesophyll, oval to ellipsoidal, 157–287 x 96–136 μ, composed of scattered spores interspersed among sterile parenchymatous cells. Spores spherical to oval, 9–13 x 8–11 μ; epispore thin, smooth, light cinnamon-yellow.

On Pontederiaceae:

*Monochoria vaginalis* Presl

Type locality and host: Bangalore, India, on *Monochoria vaginalis.*

Distribution: Taiwan; also in India.

### DOASSANSIA Cornu

Ann. Sci. Nat. VI. 15: 285. 1883.

Sori generally in the leaves, permanently embedded in the host tissues, indehiscent. Spore-ball consisting of a distinct layer of cortex and a central mass of spores. Spores light-colored, of medium size.

**Doassansia opaca** Setch., Proc. Amer. Acad. 26: 15. 1891.

Sori in the leaves, forming at first yellow but eventually yellow brown, subcircular spots, visible on both surfaces, 3–5 mm. diam. Spore-balls closely compacted in the mesophyll, usually in one layer, each consisting of a central mass of fertile spores invested by an olive brown cortex, subglobose to ellipsoidal, 157–290 x 105–248 μ. Cortical cells elongate and more or less angular, pale olivaceous yellow when isolated, 15–24 x 9–16.5 μ, faintly verruculose. Spores rather loosely compacted, spherical to ellipsoid, mostly somewhat angular, 11–16.5 x 9–12.5 μ; epispore smooth, 1 μ thick, pale yellowish.

On Alismaceae:

*Sagittaria trifolia* L.

Type locality and host: Massachusetts, United States, on *Sagittaria latifolia* Willd.

Distribution: Taiwan; also in North America.

### DOASSANSIOPSIS Dietel

Engl. & Prantl, Nat. Pflanzenfam. I. 1: 21. 1897.

Sori generally in the leaves, permanently embedded in the host tissues, indehiscent. Spore-ball consisting of a cortex, one or more layers of spores and a central mass of parenchymatous cells. Spores usually firmly united, of medium size.

**Doassansiopsis horiana** (P. Henn.) Shen, Sinensia 4: 319. 1934.

*Doassansia horiana* P. Henn., in Engl. Bot. Jahrb. 37: 157. 1905.
*Doassansiopsis horiana* Nishikado, Bericht. Ohara Inst. Landw. Forsch. 7: 419. 1936.

Sori in the leaves and petioles, forming brown pustules which at the advanced stages of development frequently become thickened and raised as hemispherical galls, up to 2.5 cm. in length, causing distortion of the infected parts of the host. Spore-balls densely filling the mesophyll in single layer, subglobose to oval, 77–218 x 67–188 μ, opaque, firm, each consisting of a cortical layer investing a single layer of fertile spores and a mass of parenchymatous cells filling the interior. Cortical cells irregularly arranged in 3–4 layers, polyhedral, subhyaline, 5–7 x 4–5 μ. Parenchymatous cells thin-walled, pale olivaceous, variable in size, up to 21 μ in length. Spores firmly united, elongate and angular, smooth, reddish brown in mass, 10–17 x 7–10.5 μ.

On Alismaceae:
*Sagittaria sagittifolia* L.

Type locality and host: Tokyo, Japan, on *Sagittaria sagittifolia*.

Distribution: Chekiang, Kwangsi, Szechwan; also in Japan, Russia.

## USTILAGINACEAE

Sori usually dehiscent at maturity exposing spore masses. Spore germination usually by means of a transversely septate promycelium which produces terminal and lateral sporidia or promycelial branches. Sporidia frequently function as propagative cells as well as reproductive organs. Conidia are not produced in nature except in a few species in *Ustilago* and *Cintractia*.

### USTILAGO (Pers.) Roussel

Fl. Calvados II. 47. 1806.

Sori in various parts of the host. Spore mass dusty at maturity. Spores not aggregated into balls, of small to medium size.

| | |
|---|---|
| Spores smooth | |
| Sori destroying the inflorescences | |
| Sori whip-like, involving the floral stems | |
| Sori under 30 cm. in length | *U. shimadae* |
| Sori exceeding 30 cm. in length | *U. kusanoi* |
| Sori not whip-like, confined to the inflorescences | *U. cynodontis* |
| Sori destroying various floral parts | |
| Sori confined to the anthers | *U. vaillantii* |
| Sori confined to the ovaries | |
| Spores 6–9 μ in length | *U. cynodontis* f. *ovariicola* |
| Spores 7–12 μ in length | *U. crameri* |
| Sori involving the ovaries and the glumes | *U. hordei* |
| Sori surrounding the internodes of stems | *U. shiraiana* |
| Spores variously ornamented but not reticulate | |
| Sori forming galls | |

| | |
|---|---|
|     Sori covered by hispid membranes | *U. crus-galli* |
|     Sori covered by smooth membranes | *U. maydis* |
|   Sori not forming galls | |
|     Sori in various floral parts | |
|       Sori confined to the ovaries | |
|         Sori covered by hispid membranes | *U. spherogena* |
|         Sori covered by smooth membranes | |
|           Sori over 3 mm. in width | *U. coicis* |
|           Sori under 3 mm. in width | |
|             Sori over 2 mm. in length | |
|               Spores chiefly over 10 μ in length | |
|                 Spores with echinulations over 1 μ in length | *U. bothriochloae* |
|                 Spores with short echinulations | *U. neglecta* |
|               Spores under 10 μ in length | |
|                 Spores distinctly echinulate | *U. sparsa* |
|                 Spores punctate | *U. kenjiana* |
|             Sori under 2 mm. in length | *U. spermophora* |
|       Sori involving both the ovaries and the glumes | |
|         Sori usually infecting only the basal parts of the glumes | *U. bullata* |
|         Sori usually destroying all the floral parts | |
|           Spores in germination producing sporidia | *U. avenae* |
|           Spores in germination producing mycelial branches | *U. nuda* |
|     Sori involving the inflorescences | |
|       Sori whip-like, very long | *U. scitaminea* |
|       Sori not whip-like | |
|         Sori containing long shreds of host remnants | *U. rabenhorstiana* |
|         Sori not containing host remnants | *U. sporoboli-indici* |
|     Sori in the vegetative parts of the host | |
|       Sori forming striae | |
|         Spores 7–11.5 μ in length | *U. sporoboli-indici* |
|         Spores 9–15 μ in length | *U. striiformis* |
|         Spores 10.5–20 μ in length | *U. aculeata* |
|       Sori not forming striae | |
|         Sori confined to the leaves | *U. heufleri* |
|         Sori in the stems | |
|           Spores with verrucae in spiral striae | |
|             Sori encircling the stems | *U. koenigiae* |
|             Sori destroying the entire young shoots | *U. ocrearum* |
|           Spores verruculose but not striate | *U. esculenta* |
| Spores with winged reticulations | |
|   Spore mass traversed by fine filaments of host tissue | *U. emodensis* |
|   Spore mass not mixed with host tissue | |
|     Sori in the floral parts | |
|       Sori in the filaments of stamens | *U. filamenticola* |
|       Sori in the anthers | *U. violacea* |
|       Sori in the ovaries | |
|         Reticulations of spores under 2 μ in width | *U. warmingii* |
|         Reticulations chiefly over 2 μ in width | |
|           Spore mass brown | *U. anhweiana* |
|           Spore mass dark purple | |
|             Reticulations 2–3.3 μ in width | *U. cordai* |
|             Reticulations 3–5 μ in width | *U. reticulata* |
|     Sori in the leaves | |
|       Sori isolated, circular | *U. tuberculiformis* |
|       Sori usually confluent, indefinite in shape | *U. warmingii* |
|     Sori chiefly in stems and peduncles | *U. nepalensis* |

**Ustilago aculeata** (Ule) Liro, Ann. Acad. Sci. Fenn. A. 17: 66. 1924.

*Tilletia aculeata* Ule, Abh. Bot. Ver. Prov. Brand. 25: 213. 1884.

Sori in the leaves and leaf sheaths, forming linear striae, often merged and extending the whole length of the leaf, at first subepidermal, lead-colored, later becoming exposed. Spores globose to oval, occasionally ovoid or ellipsoid, 10.5–16.5 μ diam. or 11–20 x 9–15 μ; epispore olive brown, coarsely tuberculate, frequently even appearing incompletely cerebriform.

On Gramineae:
*Agropyron* sp.
Type locality and host: Berlin, Germany, on *Agropyron repens* Beauv.
Distribution: Kiangsu; also in Russia, Japan, Europe, North America.

**Ustilago anhweiana** Zundel, Mycologia 35: 167. 1943.

Sori in the ovaries, protected by the floral envelops, ovate, 2–3 mm. diam., forming dusty, "Mikado Brown" (Ridgway) spore masses. Spores globose to ellipsoidal, rarely elongate, 7.5–12 μ diam., pale buff, with pentagonal or hexagonal, purple tinged reticulations of 2–3 μ in width.

On Polygonaceae:
*Polygonum* sp.
Type locality and host: Chiuhua-shan, Anhwei, on *Polygonum* sp.
Distribution: Known only from the type locality.

**Ustilago avenae** (Pers.) Rostr., Overs. K. Danske Vid. Selsk. Forh. 13. 1890.

*Uredo segetum* subsp. *avenae* Pers., Syn. Fung. 224. 1801.

Sori in the spikelets, more or less destroying all the floral parts, 5–10 mm. long, forming dusty, dark brown spore masses. Spores globose to subglobose, occasionally more elongate, yellowish to olivaceous brown, lighter colored on one side, finely echinulate, 6–9 μ in length.

On Gramineae:
*Avena fatua* L.
*Avena sativa* L.
Type locality and host: Europe, on *Avena sativa*.
Distribution: Heilungkiang, Hokiang, Hopeh, Hsingan, Kiangsu, Kirin, Liaoning, Nunkiang, Shansi, Sunkiang, Szechwan, Taiwan; also in India, Japan, Philippine Islands, Palestine, Russia, Europe, Africa, America, Australia.

**Ustilago bothriochloae** Ling, Myc. Papers Imp. Myc. Inst. 11: 4. 1945.

Sori in the ovaries, infecting only occasional ones, inconspicuous, each at first protected by a green host membrane, more or less exposed between the glumes, ovoid to ellipsoidal, 2–3 mm. long. Spores globose to ellipsoidal, 11.5–15.5 x 10–13 μ; epispore deep reddish brown, approximately 1.5 μ thick, distinctly and coarsely echinulate, echinulations up to 1.5 μ long.

On Gramineae:
*Bothriochloa pertusa* (L.) A. Camus
Type locality and host: Chengtu, Szechwan, on *Bothriochloa pertusa*.
Distribution: Known only from the type locality.

**Ustilago bullata** Berk., in J. D. Hooker's Fl. Novae-Zealand. 2: 196. 1855.

*Ustilago bromivora* Fisch. v. Waldh., Bull. Soc. Nat. Mosc. 40: 252. 1867.

Sori in the spikelets, bullate, destroying the ovaries and the basal parts of the glumes, each enclosed at first by a grayish membrane of host tissue and rather compact, then becoming exposed and pulverulent. Spores chiefly globose to oval, deep olivaceous brown, mostly 7.5–11 μ in length, densely verrucose.

On Gramineae:

*Bromus unioloides* H. B. K.

Type locality and host: Antarctic Regions, on *Agropyron scabrum* (Lab.) Beauv.

Distribution: Kirin; also in India, Russia, South-Western Asia, Australia, Africa, Europe, North America.

**Ustilago coicis** Bref., Unters. Gesammtg. Myk. 12: 110. 1895.

Sori in the ovaries, subglobose with tapering apices, partially hidden by the sheaths, each enclosed by a thick brownish membrane of host tissue; spore mass dusty, brownish black. Spores globose to ellipsoid, 7–12 x 6–10.5 μ; epispore reddish brown, minutely echinulate, about 0.7 μ thick.

On Gramineae:

*Coix lachryma-jobi* L.

Type locality and host: Simla, India, on *Coix lachryma-jobi*.

Distribution: Fukien, Hopeh, Kirin, Szechwan; also in India, Java, Japan.

**Ustilago cordai** Liro, Ann. Acad. Sci. Fenn. A. 17: 12. 1924.

*Ustilago utriculosa* Auct.

*Ustilago bungeana* Yen, Contr. Inst. Bot. Nat. Acad. Peiping 4: 190. 1937.

*Ustilago reticulisporus* Petr., Meddel. från Göteb. Bot. Trädg. 17: 116. 1947.

Sori in the ovaries, partially enclosed by the perianths, subglobose to ovoid, 2–4 mm. long, forming dark purple spore masses. Spores globose to ellipsoidal, occasionally elongate and irregular, 9–14 μ, rarely up to 16.5 μ long; epispore pale buff to pale vinaceous, with distinct winged reticulations, chiefly 2–3.3 μ wide and 1 μ deep.

On Polygonaceae:

*Polygonum barbatum* L.

*Polygonum barbatum* L. var. *gracile* (Danser) Steward

*Polygonum bungeanum* Turcz.

*Polygonum caespitosum* Bl.

*Polygonum caespitosum* Bl. var. *longisetum* (De Bruyn) Steward

*Polygonum hydropiper* L.

*Polygonum hydropiper* L. var. *flaccidum* (Meisn.) Steward

Type locality and host: Finland, on *Polygonum hydropiper*.

Distribution: Anhwei, Chekiang, Fukien, Kwangtung, Shansi, Taiwan, Kirin, Liaoning, Inner Mongolia; also in Japan, Palestine, Philippine Islands, Russia, Europe, Australia, North and South America.

**Ustilago crameri** Koern., in Fckl. Jahrb. Nass. Ver. Nat. 27–28: 11. 1873.

Sori in the ovaries, ovoid, 2–3 mm. long, partially concealed by the glumes. Spores spherical to oval, occasionally elongate and irregular, 7–12 μ long; epispore smooth, orange brown, approximately 0.5 μ thick.

On Gramineae:

*Setaria italica* Beauv.

Type locality and host: Zurich, Switzerland, on *Setaria italica*.

Distribution: Honan, Hopeh, Sikang, Szechwan, Shantung, Shansi, Taiwan, Antung, Heilungkiang, Hokiang, Kirin, Liaoning, Liaopeh, Sunkiang, Suiyuan, Jehol; also in India, Japan, Russia, Europe, Africa, North America, Australia.

**Ustilago crus-galli** Tracy & Earle, Bull. Torrey Bot. Club 22: 175. 1895.

*Ustilago trichophora* (Link) Kunze var. *crus-galli* Lavr., Trav. Inst. Sci. Biol. Tomsk 2: 9. 1936.

Sori infecting the stems near or at the nodes, or at the place of inflorescence involving both stem and leaves, nodular or as a series of gall-like structures, variable in size, 0.5 mm. to several centimeters in length, each covered by a tough hispid membrane which ruptures irregularly revealing a dusty, olive brown spore mass. Spores globose to oval, often oblong, 7.5–10 μ diam. or 7.5–12 x 6.7–9 μ; epispore reddish brown, distinctly echinulate.

On Gramineae:

*Echinochloa crus-galli* (L.) Beauv.

Type locality and host: Utah, United States, on *Panicum crus-galli* L.

Distribution: Anhwei, Taiwan, Hokiang, Kirin; also in Japan, Russia, India, Australia, Europe, North America.

The collections from China are intermediate between the American collections of this species and *Ustilago holubii* Syd. in the characters of the spores. The latter species has light olivaceous, finely echinulate spores, measuring 6.7–9 μ diam. or 7.5–9.7 x 6–8.2 μ.

**Ustilago cynodontis** P. Henn., Bull. Herb. Boiss. 1: 114. 1893.

Sori in the inflorescences, elongate, 3–4 cm. long, concealed at an early stage by the enveloping leaf sheaths, but soon naked exposing the black dusty spore masses intermixed with crinkled remnants of the rachis. Spores spherical to subspherical, often oval, 6–9 μ diam.; epispore olivaceous brown, smooth, thin.

On Gramineae:

*Cynodon dactylon* (L.) Pers.

Type locality and host: Eritrea, East Africa, on *Cynodon dactylon.*

Distribution: Anhwei, Chekiang, Fukien, Honan, Kiangsu, Kwangtung, Kweichow, Taiwan; also in Afghanistan, Burma, India, Indo-China, Japan, Russia, South-Western Asia, Africa, Australia, Europe, North America.

**Ustilago cynodontis** P. Henn. forma **ovariicola** f. nov.

A specie differt in evolutione in ovariis, glumis intactis.

Differs from the species by the occurrence of sori in the ovaries, with glumes intact.

On Gramineae:

*Cynodon dactylon* (L.) Pers.

Type locality and host: Amoy, Fukien, on *Cynodon dactylon* (intercepted at Inspection House, Washington, D. C., U. S. A., Jan. 12, 1917, R. K. Beattie).

Distribution: Known only from the type locality.

**Ustilago emodensis** Berk., in Hooker's Jour. Bot. 3: 202. 1851.

*Ustilago treubii* Solms Laubach, Ann. Jard. Bot. Buitenz. 6: 79. 1886.
*Elateromyces treubii* Bub., Arch, Prirodoved. Vyzkum Cech. 15(3): 33. 1912.
*Ustilago rosulata* Syd., Ann. Myc. 10: 77. 1912.
*Farysia emodensis* Syd., Ann. Myc. 17: 42. 1919.
*Liroa emodensis* Cif., Nuovo Giorn. Bot. Ital. n. s. 40: 263. 1933.
*Ustilago lycoperdiformis* Zundel, Mycologia 36: 402. 1944.

Sori in the flowers, irregularly globoid, up to 7 mm. in diameter, also infecting the stems, causing the formation of stipitate, conical, clustered outgrowths, with pulvinate, often lobate apexes, varying from several millimeters to 1.5 cm. or larger in diameter. Spore mass "Deep Livid Brown" (Ridgway), traversed by profuse, fine filaments of remnant host tissue. Spores globose to ovoid, often angular or oblong, chiefly 6–8.7 x 4.7–7.5 μ, unusually large ones up to 11.5 μ in length; epispore about 1.5 μ thick, pale yellowish, with extremely fine, light purplish, regular reticulations, approximately 0.7 μ diam., appearing as verrucae under lower magnifications.

On Polygonaceae:

*Polygonum chinense* L.

*Polygonum* sp.

Type locality and host: Tonglo, India, on *Polygonum* sp.

Distribution: Kwangsi, Taiwan; also in Ceylon, India, Indo-China, Java, Philippine Islands.

Both the sori and spores of this species are very variable in size. In the type of *U. lycoperdiformis* which is in a very advanced stage of development, the flower-occupying sori are extremely irregular in magnitude; while in certain Philippine collections they are very regular in shape and measure only around 1 mm. in diameter. Unusually large or small spores are often present, with extremes at 3 and 13 μ in length respectively, but the ornamentation of spores always serves as an invariable character.

**Ustilago esculenta** P. Henn., Hedwigia 34: 10. 1895.

*Melanopsichium esculentum* Mundk. & Thirumal., Myc. Papers Imp. Myc. Inst. 16: 2. 1946.

Sori in the young stems, causing conspicuous hypertrophy. Spore mass formed in round or elongate cavities in the hypertrophied organ, bounded by the sclerenchyma tissue, deep "Hay's Brown" (Ridgway), at first agglutinate but soon dusty. Spores globose to ellipsoid, 6–10 x 4.6–7 μ; epispore ochraceous brown, verruculose, 1 μ thick.

On Gramineae:

*Zizania latifolia* (Griseb.) Turcz.

Type locality and host: Hanoi, Indo-China, on *Zizania latifolia.*

Distribution: Chekiang, Fukien, Honan, Hopeh, Hunan, Kiangsu, Kwangsi, Kwangtung, Szechwan, Taiwan; also in India, Indo-China, Japan, Russia, North America.

This fungus destroys only the parenchyma or ground tissue of the host and fails to attack the sclerenchyma and fibro-vascular bundles. It does not cause the formation of any abnormal tissue in the host and the spore mass is dusty at maturity. It appears to be different from *Melanopsichium*, therefore it is retained here in *Ustilago.*

**Ustilago filamenticola** Ling, Myc. Papers Imp. Myc. Inst. 11: 5. 1945.

Sori in the filaments of the stamens, causing hypertrophy, with ovaries and styles intact, each protected by a thin membrane of host tissue which disintegrates later revealing a dusty "Rood's Brown" (Ridgway) spore mass. Spores globose to oval, 9–13 μ diam.; epispore pale yellowish, with winged penta- or hexagonal reticulations, chiefly 2–3.3 μ wide and 1.5 μ deep.

On Polygonaceae:

*Polygonum japonicum* Meisn.

Type locality and host: Chengtu, Szechwan, on *Polygonum japonicum.*

Distribution: Known only from the type locality.

**Ustilago heufleri** Fckl., Jahrb. Nass. Ver. Nat. 23–24: 39. 1870.

*Ustilago tulipae* Wint., in Rab. Krypt. Fl. 1: 86. 1881.

Sori in the leaves, forming lenticular, convex pustules, 5–12 mm. long, 1–2 mm. wide, covered by the host tissue which later ruptures into a longitudinal slit disclosing a dusty black spore mass. Spores globose to oblong, occasionally ovoid or pyriform, 15–22 x 13.5–17 μ, each loosely invested by a hyaline, somewhat wrinkled envelope; epispore 1.5–2.5 μ thick, light yellow brown, sparsely but very deeply pitted, with pits frequently arranged in irregular striae; endospore with an evident wall, 1–1.5 μ thick, deep cinnamon brown to deep reddish brown.

On Liliaceae:
*Tulipa edulis* Baker
Type locality and host: Vienna, Austria, on *Tulipa sylvestris* L.
Distribution: Kiangsu; also in Europe, North America.

**Ustilago hordei** (Pers.) Lagh., Mitt. Badeschen Bot. Ver. 70. 1889.
*Uredo segetum* subsp. *hordei* Pers., Syn. Fung. 224. 1801.
*Ustilago avenae* (Pers.) Rostr. var. *levis* Kell. & Swing., Ann. Rep. Kans. Agr. Exp. Sta. 2: 259. 1890.
*Ustilago kolleri* Wille, Bot. Notiser 10. 1893.
*Ustilago levis* Magn., Ber. Natur-Wiss.-Mediz. Ver. Innsbruck 21: 22. 1894.

Sori in the spikelets, usually involving the basal parts of the glumes, compact. Spores globose to subglobose, rarely elongate, smooth, light to medium olivaceous brown, lighter colored on one side, 5–9 μ diam., rarely up to 11 μ in length.
On Gramineae:
*Avena sativa* L.
*Hordeum vulgare* L.
Type locality and host: Europe, on *Hordeum* sp.
Distribution: Anhwei, Chahar, Chekiang, Fukien, Hokiang, Honan, Hopeh, Hupeh, Jehol, Kansu, Kiangsu, Kwangsi, Kwangtung, Kweichow, Kirin, Ninghsia, Shansi, Shantung, Shensi, Sikang, Suiyuan, Sunkiang, Szechwan, Taiwan, Tsinghai, Yunnan; also in all of the barley and oats growing countries.

**Ustilago kenjiana** S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 87. 1935.

Sori in ovaries, infecting only a few spikelets in a panicle, ovoid or oval, 3–6 mm. long, similar to healthy seeds in size, each at first covered by a pale brown membrane of host tissue which ruptures later disclosing a dark, dusty spore mass; columella lacking. Spores globose to oval, 4.5–8 μ diam.; epispore olivaceous brown, finely punctate.
On Gramineae:
*Sorghum vulgare* Pers.
Type locality and host: Kungchulin, Liaoning, on *Sorghum vulgare*.
Distribution: Known only from the type locality.

**Ustilago koenigiae** Rost., Medd. Grønland 3: 352. 1888.

Sori encircling the stems, forming dark purplish brown spore masses, less than 1 cm. long. Spores variable in shape and size, mostly ellipsoid, often globose, ovoid or irregular, 4.5–8 μ diam., or 5.5–11.4 x 4–7.5 μ, the most elongate up to 15.4 μ long; epispore 0.6–1.2 μ thick, subhyaline to pale yellowish, ornamented with light vinaceous to reddish purple verruculae densely and regularly arranged in spiral striae.
On Polygonaceae:
*Polygonum pilosum* (Maxim.) Forbes & Hemsl.
Type locality and host: Greenland, on *Koenigia islandica* L.
Distribution: Sikang; also in Greenland, Russia, Europe.

In the type of this species, the verruculate-striae are light vinaceous in color and almost undetectable under a high power lens. The Sikang collection, however, possesses spores with somewhat coarser verruculations which are deep purple and readily detectable. *Ustilago ocreanum* Berk. and *Ustilago piperii* Clint., both occurring on *Polygonum*, are similar to this species in the morphology of spores.

**Ustilago kusanoi** Syd., Mém. Herb. Boiss. 4: 4. 1900.
*Ustilago morobiana* Zundel, Mycologia 36: 402. 1944.

Sori in the apical buds, involving both the axes of inflorescences and the floral stems, transforming each into a long, curved whip-like structure, up to 50 cm. or more in length, protected at first by the epidermis which soon flakes away revealing a dusty, dark olive brown spore mass surrounding the remnant main axis. Spores spherical to ellipsoid, 3.6–4.7 μ diam., or 4.3–6 x 3.4–4.5 μ; epispore very thin, light olivaceous brown, smooth.

On Gramineae:
*Miscanthus floridulus* (Labill) Warb.
*Miscanthus sinensis* Anderss.

Type locality and host: Musashi, Japan, on *Miscanthus sacchariflorus* (Maxim.) Hack.

Distribution: Chekiang, Fukien, Kiangsu, Kweichow, Taiwan; also in Japan, New Guinea, Russia, Philippine Islands.

A form, which occurs in the ovaries of *Miscanthus sinensis* and converts them into elongate filiform bodies, was described by Y. Ling and Chen (Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 6. 1945.) as *Ustilago kusanoi* f. *anomala-ovariicola*. Its type has not been examined.

**Ustilago maydis** (DC.) Corda, Icon. Fung. 5: 3. 1842.
*Uredo maydis* DC., Fl. Franç. 6: 77. 1815.
*Ustilago zeae* Ung., Einfl. Bodens 211. 1836.

Sori in various parts of the host, forming irregular galls varying in size, at first covered by white membranes, soon rupturing and revealing brown, dusty spore masses. Spores globose to ellipsoid, or somewhat irregular, prominently echinulate, light olivaceous brown, 8–12 μ diam.

On Gramineae:
*Zea mays* L.

Type locality and host: France, on *Zea mays*.

Distribution: Chekiang, Fukien, Honan, Hopeh, Hupeh, Kiangsu, Shansi, Sikang, Szechwan, Liaoning, Antung, Kirin, Liaopeh, Sunkiang, Hokiang, Suiyuan, Nunkiang, Heilungkiang, Jehol; also in India, Japan, Malaya, Palestine, Philippine Islands, Russia, Europe, Africa, America, Australia.

**Ustilago neglecta** Niessl, in Rab. Fungi Eur. 1200. 1868.
*Ustilago panici-glauci* Wint., in Rab. Krypt. Fl. 1: 97. 1881.

Sori in the ovaries, usually infecting all of the spikelets in a panicle, ovoid, 2–3 mm. long, protected by the glumes. Spores chiefly globose to oval, 9–14 μ long; epispore deep reddish brown, prominently and abundantly echinulate, 0.5 μ thick.

On Gramineae:
*Setaria lutescens* (Weigel) Hubbard
*Setaria viridis* Beauv.

Type locality and host: Gratz, Austria, on *Setaria lutescens*.

Distribution: Chekiang, Hainan, Hopeh, Kiangsu, Liaoning, Szechwan, Taiwan; also in India, Indo-China, Japan, Russia, Europe, North and South America.

**Ustilago nepalensis** Liro, Ann. Acad. Sci. Fenn. A. 17: 184. 1924.
*Liroa nepalensis* Cif., Fl. Ital. Crypt. I. 17: 247. 1938.
*Sphacelotheca nankingensis* Zundel, Mycologia 36: 406. 1944.

Sori in the young stems, peduncles, often extending to the basal parts of the flowers, sometimes also in pedicels, from where the infection may spread to the leaves along midribs; infected tissues somewhat hypertrophied. Spores globose to oval, often oblong to slightly angular, 9.5–14 x 9–13.5 μ; epispore reddish purple, 1.5 μ thick, with fine winged, chiefly hexagonal reticulations, 1.2–2.7 μ wide.

On Polygonaceae:
*Polygonum nepalense* Meisn.
Type locality and host: Shensi, on *Polygonum nepalense*.
Distribution: Anhwei, Hunan, Shensi; also in India, Japan, Russia.

**Ustilago nuda** (Jens.) Rostr., Tidsskrift. Landokonomi 8: 745. 1889.
*Ustilago segetum* var. *nuda* Jens., Jour. Roy. Agr. Soc. England 24 (Ser. 2): 406. 1888.
*Ustilago tritici* Rostr., Overs. Kong. Danske Vidensk. Selsk. Forh. 15. 1890.

Sori in the spikelets, usually destroying all the floral parts, about 7–12 mm. long, forming olivaceous brown to almost black spore masses loosely adhering to remnant rachis. Spores globose to oval, minutely echinulate, light olivaceous brown, lighter colored and often almost smooth on one side, 5–7 μ diam. or 6.5–9 x 5–6.5 μ.

On Gramineae:
*Hordeum vulgare* L.
*Triticum aestivum* L.
Type locality and host: Europe, on *Hordeum* sp.
Distribution: Anhwei, Chekiang, Fukien, Honan, Hopeh, Kiangsi, Kiangsu, Kwangsi, Kwangtung, Shantung, Shansi, Sikang, Szechwan, Taiwan, Yunnan, Jehol, Liaoning, Liaopeh, Kirin, Sunkiang, Hokiang, Nunkiang, Heilungkiang, Hsingan; also in all of the wheat and barley growing countries.

**Ustilago ocrearum** Berk., in Hookers' Jour. Bot. 6: 207. 1854.
*Ustilago caulicola* Zundel, Mycologia 34: 123. 1942.
*Sphacelotheca smithii* Petr., Meddel. från Göteb. Bot. Trädg. 17: 115. 1947.

Sori completely destroying the young shoots or the young axillary branches, extending to over 10 cm. in length, often causing fasciation of the infected parts, occasionally also in the basal parts of the leaves. Spore mass dusty, dark purple brown. Spores variable in shape and size, mostly ellipsoid, often globose, ovoid or irregular, 4.5–8 μ diam., or 5.5–10.5 x 4–7.5 μ, the most elongate rarely up to 13.5 μ long; epispore 0.6–1.2 μ thick, subhyaline to pale yellowish, ornamented with reddish purple verruculae densely and regularly arranged in spiral striae.

On Polygonaceae:
*Polygonum campanulatum* Hook. f. var. *fulvidum* Hook. f.
*Polygonum* sp.
Type locality and host: Nangki, East Nepal, on *Polygonum campanulatum*.
Distribution: Sikang; also in Nepal.

**Ustilago rabenhorstiana** Kuehn, Hedwigia 15: 4. 1876.
*Ustilago setariae* Rab. ex Fisch. v. Waldh., Aperçu Syst. Ustil. 24. 1877.
*Ustilago royleani* Syd. & Butl., Ann. Myc. 4:426. 1906.
*Ustilago eleusines* Syd., Ann. Myc. 27: 241. 1929.
*Ustilago belgiana* Zundel, Mycologia 36: 401. 1944.

Sori usually involving entire inflorescences, linear-ellipsoidal, 2–5 cm. long, often infecting only the lower parts of inflorescences, leaving the upper parts intact but abortive, at first hidden by the enveloping leaf sheaths, later becoming exposed as dusty, brownish black spore masses, each surrounding a number of elongate remnants of the inflorescence. Spores globose to oval, occasionally somewhat angled, 9–14.5 x 8–12 μ; epispore deep ochraceous brown to deep reddish brown, distinctly echinulate.

On Gramineae:
*Digitaria chinensis* Hornem.
*Digitaria ischaemum* (Schreb.) Muhl.
*Digitaria sanguinalis* (L.) Scop.
*Digitaria sanguinalis* (L.) Scop. var. *ciliaris* (Retz.) Parl.
*Digitaria ternata* (Rich.) Stapf
*Digitaria* sp.

Type locality and host: Europe, on *Panicum sanguinale* L.

Distribution: Anhwei, Hopeh, Hupeh, Kiangsu, Sikang, Szechwan; also in India, Japan, Russia, Africa, Australia, Europe, North and South America.

**Ustilago reticulata** Liro, Ann. Acad. Sci. Fenn. A. 17: 20. 1924.

*Ustilago utriculosa* Auct.

Sori in the ovaries, partially enveloped by the perianths, subglobose to ovoid, 2–4 mm. long, forming dark purple spore masses. Spores globose to ellipsoid, 9–14 μ long; epispore deep purplish vinaceous, with prominent winged reticulations, chiefly 3–5 μ wide and 1.5 μ deep.

On Polygonaceae:
*Polygonum lapathifolium* L.
*Polygonum lapathifolium* L. var. *lanatum* (Roxb.) Steward.
*Polygonum opacum* Samuels.
*Polygonum viscosum* Ham.

Type locality and host: Finland, on *Polygonum tomentosum* Schrank. (= *P. lapathifolium*)

Distribution: Fukien, Kwangsi, Shansi, Sikang, Szechwan, Taiwan; also in India, Japan, Russia, Europe, North America.

**Ustilago scitaminea** Syd., Ann. Myc. 22: 281. 1924.

Sori in the apical buds, destroying the entire floral stems and transforming each into a curved whip-like growth up to 120 cm. long, partially concealed by the sheath, enclosed in a delicate membrane of host tissue which ruptures later disclosing a dusty, dark brown spore mass. Spores globose to oval, occasionally somewhat irregular, reddish brown, echinulate, 6.5–10 x 6–9 μ.

On Gramineae:
*Saccharum officinarum* L.
*Saccharum sinense* Roxb.

Type locality and host: Southern Asia, on *Saccharum officinarum*.

Distribution: Fukien, Hainan, Kwangsi, Kwangtung, Szechwan, Taiwan; also in Burma, India, Indo-China, Japan, Java, Philippine Islands, Russia, Africa, West Indies, South America.

**Ustilago shimadae** Saw., Taiwan Agr. Res. Inst. Rep. 87: 34. 1943.

Sori in the apical buds, involving both the axes of inflorescences and the floral stems, transforming each into a long, curved flagelliform structure, covered by a whitish delicate membrane of host tissue, approximately 25 cm. long. Spores chiefly globose to subglobose, 4.4–6.5 μ diam.; epispore thin, smooth, light olivaceous brown.

On Gramineae:
An undetermined species of Andropogoneae.

Type locality and host: Taipeh, Taiwan, on Andropogoneae.

Distribution: Known only from the type locality.

**Ustilago shiraiana** P. Henn., in Engl. Bot. Jahrb. 28: 260. 1900.

*Cintractia bambusae* Miyabe & Hori in Yoshino, Bot. Mag. Tokyo 19: (199). 1905.

Sori surrounding the internodes of young shoots, forming blackish brown, semi-agglutinate spore masses, enclosed at first by leaf sheaths, often causing witches-broom effect. Spores spherical to oval, occasionally ovoid, 6–9 μ diam., or 8–10 x 6.5–8 μ; epispore light olivaceous, 0.6–0.8 μ thick, smooth.

On Gramineae:

*Phyllostachys congesta* Rendle
*Phyllostachys makinoi* Hayata
*Phyllostachys spp.*

Type locality and host: Nikko, Japan, on *Bambusa veitchi* Carr.

Distribution: Fukien, Honan, Kiangsi, Kiangsu, Kweichow, Taiwan; also in India, Japan, Russia, North America.

**Ustilago sparsa** Underw., Bull. Torrey Bot. Club 24: 86. 1897.

Sori in the ovaries, infecting only occasional ones, ovoid, 2–3 mm. long, partially exposed between the spreading glumes, each covered at first by a grayish brown membrane. Spores spherical to oval, often ellipsoid or ovoid, 6–10 μ long; epispore 1 μ thick, clear reddish brown, distinctly echinulate.

On Gramineae:

*Dactyloctenium aegypticum* (L.) Richt.

Type locality and host: Alabama, United States, on *Dactyloctenium aegypticum.*

Distribution: Taiwan; also in India, North America.

**Ustilago spermophora** Berk. & Curt. ex de Toni, in Sacc. Syll. Fung. 7: 466. 1888.

*Ustilago kusanoana* P. Henn., Hedwigia 43: 140. 1904.
*Sphacelotheca kusanoana* P. Henn., in Engl. Bot. Jahrb. 34: 594. 1905.
*Ustilago spermophora* Berk. & Curt. var. *orientalis* Yen, Ann. Crypt. Exot. 7: 86. 1934.
*Ustilago orientalis* Yen, Contr. Inst. Bot. Nat. Acad. Peiping 3: 7. 1935.
*Sphacelotheca cheoana* Zundel, Mycologia 35: 168. 1943.
*Ustilago spermophoroides* Y. Ling & Chen, Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 5. 1945.

Sori in the ovaries, infecting only a few spikelets in a panicle, 0.5–1.5 mm. long, each at first enclosed in a green membrane of host tissue and a delicate inner membrane of fungous tissue. Spores globose to ellipsoid, 7.5–14 x 6–12 μ; epispore olivaceous to reddish brown, minutely to prominently echinulate.

On Gramineae:

*Eragrostis cilianensis* (All.) Link
*Eragrostis ferruginea* Beauv.
*Eragrostis japonica* (Thunb.) Trin.
*Eragrostis tenella* (L.) Beauv.

Type locality and host: South Carolina, United States, on *Eragrostis cilianensis.*

Distribution: Anhwei, Fukien, Kiangsu, Szechwan; also in India, Japan, Europe, North and South America.

The type collection of this species has minutely echinulate spores measuring 7.4–11.4 x 6.7–9.4 μ. It agrees very well with the type of *U. kusanoana* and certain collections from China. Other collections from China and North America, however, show considerable variation in the degree of echinulation, and color and size of spores. *Ustilago egenula* Syd. & Butl. from India and *Ustilago eragrostidis-japonicana* Zundel from South Africa appear to represent the two extremes of this fluctuating and variable group. The former has minutely echinulate and deep reddish brown spores measuring 9.5–13.5 x 8.7–12 μ; while the latter has distinctly echinulate, light olivaceous brown spores measuring 6.7–8.7 x 6–8.7 μ. The collection on *Eragrostis tenella* from Anhwei has spores similar to *U. egenula* in size and color but with prominent echinulations.

The type of *Ustilago spermophoroides* has not been examined. According to its description, it may be identical with either *U. spermophora* or *U. egenula.*

**Ustilago spherogena** Burr. ex De T., in Sacc. Syll. Fung. 7: 468. 1888.

Sori in the ovaries, subglobose or ovoid, 2–4 mm. in length, in earlier stages compact and each covered with a greenish tough hispid membrane which ruptures irregularly from the apex disclosing finally a dusty spore mass. Spores globose to oval, occasionally ellipsoid or oblong, 6.5–9 μ diam. or 7–10.5 x 6–9 μ, averaging 8.7 μ in length; epispore light olivaceous brown, sparsely but distinctly echinulate; hyaline immature spores abundant in the interior of the sori.

On Gramineae:
*Echinochloa colonum* (L.) Link
*Echinochloa crus-galli* (L.) Beauv.
*Echinochloa crus-pavonis* (H.B.K.) Schult.
*Echinochloa frumentacea* Link

Type locality and host: Illinois, United States, on *Panicum crus-galli* L.

Distribution: Fukien, Kiangsu, Kweichow, Szechwan, Taiwan; also in Japan, Russia, South Africa, North and Central America.

The two American collections examined (Ell. & Ev., N. Am. Fungi 1892; Ill. 1882, A. B. Seymour, type ?, in Farl. Herb.) have slightly larger spores than the Chinese and Japanese collections, averaging 9.7 μ in length. *Ustilago trichophora* (Link) Kunze (type in Clint. Herb., Conn.) is similar to this species except possessing ochraceous brown spores measuring 9–10.5 μ diam. or 9–12 x 7–9 μ, with an average of 10.2 μ in length. The type of *Ustilago panici-frumentacei* Bref. has not been seen, but it is doubtful whether it is distinct from this species.

**Ustilago sporoboli-indici** Ling, Myc. Papers Imp. Myc. Inst. 11: 7. 1945 (Fig. 2,B)

Sori in the leaves, leaf sheaths and stems, forming long or short striae, frequently also destroying partially and deforming the panicles, first covered by the epidermis which ruptures later exposing the dark, pulverulent spore mass. Spores globose to ellipsoid, 7–8.5 μ diam. or 7–11.5 x 5.5–9.5 μ; epispore reddish brown, verruculose.

On Gramineae:
*Sporobolus indicus* (L.) R. Br.

Type locality and host: Chengtu, Szechwan, on *Sporobolus indicus*.

Distribution: Szechwan; also in Philippine Islands, Africa.

**Ustilago striiformis** (Westend.) Niessl, Hedwigia 15: 1. 1876.

*Uredo striaeformis* Westend., Bull. Acad. Roy. Belg. 18: 406. 1851.

Sori in the leaves and leaf sheaths, forming short or long linear striae, at first covered by the epidermis which soon ruptures exposing the dark spore mass, after the dispersal of spores the infected leaves becoming shredded. Spores spherical to ellipsoid, occasionally somewhat irregular, 9–15 x 8–11.5 μ, reddish brown, prominently echinulate.

On Gramineae:
*Hierochloa glabra* Trin.

Type locality and host: Courtrai, Belgium, on *Holcus lanatus* L.

Distribution: Hopeh; also in India, Japan, Russia, Australia, Europe, North America.

**Ustilago tuberculiformis** Syd., Ann. Myc. 1: 22. 1903. (Fig. 1,C)

*Ustilago foliorum* S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 88. 1935.

Sori in the leaves, hypophyllous, circular, 1–2 mm. diam., slightly raised, protected at first by host epidermis, then becoming naked exposing compact, "Prussian Red" (Ridgway) spore masses, causing indefinite, tawny or purplish spots on the upper surface of the leaves. Spores globose to oval, occasionally subangular, 9.4–12.8 x

8.7–11.4 μ; epispore subhyaline to pale yellowish, approximately 1 μ thick, with fine winged reticulations, 1.3–2 μ wide and 0.5–0.7 μ deep.

On Polygonaceae:
*Polygonum runcinatum* Hamilt. ex D. Don (= *P. morrisonense* Hayata)
Type locality and host: Hupeh, on *Polygonum runcinatum.*
Distribution: Hupeh, Taiwan.

**Ustilago vaillantii** Tul., Ann. Sci. Nat. III. 7: 90. 1847.

Sori in the anthers, sometimes also in the ovaries, forming dusty "Sepia" (Ridgway) spore masses. Spores variable in shape, chiefly oval, occasionally globose, ovoid to narrowly ellipsoid, 6–12 x 5.5–8 μ; epispore buffy olive, approximately 0.5 μ thick, smooth; endospores indistinctly pitted.

On Liliaceae:
*Scilla sinensis* (Lour.) Merr. (= *S. chinensis* Benth.)
Type locality and host: Europe, on *Muscari comosum* (L.) Mill.
Distribution: Chekiang; also in Japan, Russia, Persia, Europe, North America.

**Ustilago violacea** (Pers.) Roussel, Fl. Calvados 47. 1806.
*Uredo violacea* Pers., Syn. Fung. 225. 1801.

Sori in the hypertrophied anthers, rather inconspicuous, filling each with a purplish spore mass. Spores chiefly globose to oval, occasionally ovoid, oblong or somewhat angular, 5–10.5 μ in length; epispore pale yellowish to pale vinaceous, with violet winged reticulations, 1–2 μ wide and 0.5 μ deep.

On Caryophyllaceae:
*Dianthus superbus* L.
*Silene tatarinowii* Regel
*Silene tenuis* Willd. var. *rubescens* Franch.
Type locality and host: Europe, on *Silene nutans* L.
Distribution: Hopeh, Sikang, Sunkiang; also in Japan, Russia, South-Western Asia, Africa, Europe, North and South America.

The collections on *Dianthus superbus* and *Silene tenuis* var. *rubescens* have spores measuring 7–10.5 μ in length which are larger than that ordinarily described for this species, but approach the size of spores of *Ustilago major* Schroet. It is considered, however, only as the variation of a single species.

**Ustilago warmingii** Rostr., Bot. Tidsskr. 15: 229. 1886.

Sori in the flowers or forming circular to elongate pustules in the leaves, destroying all the leaf tissues except vascular bundles and epidermis, upon rupture of the epidermis exposing deep brown dusty spore masses. Spores globose or ovoid, often oblong or somewhat angular, 6–10 μ in length; epispore pale yellowish, with violet polygonal winged reticulations, 1–1.8 μ wide and 0.5–0.7 μ deep.

On Polygonaceae:
*Rumex aquaticus* L.
Type locality and host: Finnmark, Norway, on *Rumex domesticus* L.
Distribution: Hsingan; also in Russia, Europe.

## SPHACELOTHECA D. By.

Verg. Morph. Biol. Pilze 187. 1884.

Sori chiefly in the inflorescences, often limited to the ovaries, each provided with a false membrane composed of fungous cells. Spore mass usually dusty at maturity, surrounding one to numerous columellae. Spores not aggregated into balls, developed often in a centripetal manner, of small to medium size.

| | |
|---|---|
| Sori involving the inflorescences | |
|   Spores surrounding a central columella | |
|     Spores smooth or apparently smooth | |
|       Sori under 2 cm. in length | |
|         Columella filiform, very slender and twistable | *S. apludae* |
|         Columella not filiform, stiff | *S. anthistiriae* |
|       Sori exceeding 3 cm. in length | |
|         Spores under 6.5 μ in length | *S. nankinensis* |
|         Spores chiefly exceeding 6.5 μ in length | *S. rottboelliae* |
|     Spores punctate, verruculose or echinulate | |
|       Sori long, whip-like, involving the floral stems | |
|         Spores 5–8 μ in length | *S. miscanthi* |
|         Spores 10–15 μ in length | *S. ophiuri* |
|       Sori not whip-like, confined only to the inflorescences | |
|         Sori frequently destroying inflorescences only partially | *S. capillipedii* |
|         Sori usually destroying inflorescences completely | |
|           Columella simple, usually strongly curved | *S. isachnes* |
|           Columella usually more or less branched, stiff | |
|             Sori chiefly under 1.5 cm. in length | *S. anthistiriae* var. *punctata* |
|             Sori chiefly over 1.5 cm. in length | *S. andropogonis* |
|   Spores intermixed with numerous filaments | |
|     Spores smooth to punctate | *S. destruens* |
|     Spores densely echinulate | *S. reiliana* |
| Sori confined to the ovaries | |
|   Columella largely composed of fungous tissue | |
|     Spores chiefly 7–11 μ in length | *S. hydropiperis* var. *borealis* |
|     Spores chiefly 9–14 μ in length | *S. hydropiperis* |
|   Columella composed of host tissue | |
|     Spores smooth to punctate | |
|       False membrane after rupture usually persistently attached to the sorus | *S. sorghi* |
|       False membrane after rupture usually disappears | |
|         Columella prominent, exceeding 5 mm. in length | *S. cruenta* |
|         Columella rather inconspicuous, under 5 mm. in length | |
|           Spores 5.5–9 μ in length | *S. taiana* |
|           Spores 7–12 μ in length | *S. sacchari* |
|     Spores verrucose or echinulate | |
|       Sori chiefly under 4 mm. in length | |
|         Spores 6.5–10 μ in length | *S. tanglinensis* |
|         Spores 9–12 μ in length | *S. tanglinensis* var. *hainanae* |
|       Sori chiefly exceeding 4 mm. in length | |
|         Spores 5–9 μ in length | *S. sorghi* |
|         Spores 9–13.5 μ in length | *S. monilifera* |
|         Spores 10.5–16 μ in length | *S. penniseti-japonica* |

**Sphacelotheca andropogonis** (Opiz) Bub., Arch. Prirodoved. Vyzkum Cech. 15 (3): 25. 1912.

*Uredo andropogonis* Opiz, Naturalient. 43. 1823–24.
*Ustilago ischaemi* Fckl., Annal. Soc. Nass. Nat. Scrut. F. 15: 22. 1860.
*Sphacelotheca ischaemi* Clint., Jour. Myc. 8: 140. 1902.

Sori destroying entire inflorescences, 1.5–3 cm. long, frequently forming aggregated spikelet-like branches which are blended together around the rachis by a wood brown false membrane, upon rupture of the membrane exposing a shortly branched columella surrounded by the dark agglutinate spore mass. Sterile cells of the false membrane hyaline, chiefly globose to ellipsoid 8.5–22 x 7–17 μ. Spores globose to oval, 8.5–10 μ diam. or 8–11.5 x 7–10 μ, rarely up to 14 μ long; epispore very finely echinulate, reddish brown.

On Gramineae:

*Heteropogon contortus* (L.) Roem. & Schultes

Type locality and host: Prague, Czechoslovakia, on *Andropogon ischaemum* L.

Distribution: Szechwan; also in Philippine Islands, Russia, South-Western Asia, Europe, Africa, North and Central America.

**Sphacelotheca anthistiriae** (Petch) comb. nov.

*Ustilago anthistiriae* Petch, Ann. Roy. Bot. Gard. Peradeniya 4: 304. 1909.
*Cintractia exserta* McAlp., Smuts Austral. 169. 1910.
*Sphacelotheca exserta* Cif., Ann. Myc. 26: 32. 1928.
*Sphacelotheca vryburgii* Zundel, Mycologia 23: 298. 1931.
*Sphacelotheca exserta* Yen, Contr. Inst. Bot. Nat. Acad. Peiping 4: 196. 1937.
*Ustilago condigna* Syd., Ann. Myc. 36: 295. 1938.

Sori in the inflorescences, destroying entire racemes, 4–16 mm. in length, often forming aggregated, spikelet-like branches which are blended together around the rachis, each enclosed at first in a brown false membrane which flakes away disclosing a black, agglutinate spore mass surrounding a central, frequently branched columella; sterile cells of the membrane globose to oval, thin-walled, hyaline, 7.5–16.5 x 6–16 μ. Spores chiefly globose to broadly oval, often compressed, 6–8.7 μ diam. or 6.5–10 x 5.4–8.7 μ, mostly 6.7–8.7 μ in length; epispore smooth, 0.5 μ thick, light to medium yellowish brown.

On Gramineae:

*Themeda triandra* Forsk.

Type locality and host: Peradeniya, Ceylon, on *Themeda tremula* (Nees) Hack.

Distribution: Honan; also in Ceylon, Australia, Africa.

The sole collection from Honan differs from the type and all other specimens from Australia and Africa available for examination in having smaller spores which are 5.4–8 x 4.5–7.5 μ.

**Sphacelotheca anthistiriae** (Petch) Ling var. **punctata** var. nov.

A specie differt in sporis minute punctulatis, majoribus, magnitudine variabilibus, 5.5–11.4 x 6.7–10 μ, praecipue 7.5–8.8 μ longis.

Differs from the species in the spores being finely punctate, averaging larger but more variable in size, measuring 5.5–11.4 x 6.7–10 μ, mostly 7.5–8.8 μ long.

On Gramineae:

*Themeda triandra* Forsk.

Type locality and host: Chengtu, Szechwan, on *Themeda triandra* (Nov. 1947, K. R. Lin).

Distribution: Kiangsu, Szechwan.

**Sphacelotheca apludae** (Syd.) Pavgi & Mundk., Indian Phytopath. 1: 110. 1948.

*Ustilago apludae* Syd., Ann. Myc. 17: 141. 1919.

Sori in the racemes, concealed by the spathes, 4–7 mm. long, 1 mm. wide, tapering at both ends, each enclosed at first by a thin false membrane composed of hyaline, thin-walled, subglobose to oblong sterile cells, 6–10.5 x 5–10 μ; columella filiform, single, often forked at the apex, 1–2 cm. long, protruding beyond the sorus. Spores globose to oval, 4.7–7.5 x 4.5–6.7 μ; epispore olivaceous brown, smooth.

On Gramineae:

*Apluda mutica* L. var. *aristata* Hack.

Type locality and host: Kumaon, Himalayas, India, on *Apluda mutica* var. *aristata*.

Distribution: Kwangtung; also in India.

The type collection of this species from India has spores slightly larger than those of the Kwangtung collection, measuring 6–8 μ in diameter.

**Sphacelotheca capillipedii** Ling, Myc. Papers Imp. Myc. Inst. 11: 8. 1945.

*Sorosporium andropogonis-micranthi* Y. Ling & Chen, Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 21. 1945.

Sori either involving entire inflorescences, or destroying only certain branches or branchlets in a panicle and leaving remaining parts intact but abortive, concealed at first by the leaf sheaths, later protruding, each enclosed by a deep livid brown false membrane which dehisces irregularly revealing a dark brown, agglutinate spore mass adhering to a branched columella. Sterile cells of the false membrane hyaline, globose or angular, 5.5–11 μ in length. Spores agglutinated into balls at an early stage, chiefly globose to subglobose, 7–11 μ, mostly 8.5–9.5 μ diam.; epispore thin, light smoky brown, finely punctate.

On Gramineae:

*Capillipedium parviflorum* (R. Br.) Stapf

Type locality and host: Chengtu, Szechwan, on *Capillipedium parviflorum*.

Distribution: Fukien, Szechwan.

**Sphacelotheca cruenta** (Kuehn) A. A. Potter, Phytopath. 2: 98. 1912.

*Ustilago cruenta* Kuehn, Hamburg. Gart. Blumenzeitg. 28: 178. 1872.

Sori in the ovaries, often also involving the floral bracts, ovoid-oblong, up to 1 cm. or more in length, each covered by a delicate false membrane which flakes away early revealing a dark brown spore mass surrounding a prominent, pointed, usually curved, central columella; sterile cells of the membrane breaking up into groups, hyaline, subglobose to ellipsoidal, 7.5–16.5 x 5.5–13.5 μ. Spores globose to oval, chiefly 5.5–9 μ long, punctate, reddish brown.

On Gramineae:

*Sorghum vulgare* Pers.

Type locality and host: Halle, Germany, on *Sorghum vulgare*.

Distribution: Anhwei, Honan, Hopeh, Hupeh, Kiangsu, Shansi, Taiwan, Yunnan, Liaoning, Antung, Kirin, Liaopeh, Sunkiang, Hokiang, Nunkiang, Heilungkiang, Jehol; also in India, Indo-China, Iran, Japan, Russia, Africa, America, Europe.

**Sphacelotheca destruens** (Schlecht.) Stevenson & A. G. Johnson, Phytopath. 34: 613. 1944.

*Caeoma destruens* Schlecht., Fl. Berol. 2: 130. 1824.

*Ustilago panici-miliacei* Wint., in Rab. Krypt. Fl. 1: 89. 1884.

*Sorosporium panici-miliacei* Tak., Bot. Mag. Tokyo 16: (253). 1902.

*Sorosporium manchuricum* S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 93. 1935.

*Sphacelotheca lioui* Yen, Contr. Inst. Bot. Nat. Acad. Peiping 4: 193. 1937.

Sori destroying the inflorescences, narrowly ellipsoidal, concealed at first by the leaf sheaths, later becoming partially exposed, about 3–5 cm. long, each enclosed by a whitish false membrane which gradually flakes away disclosing a dusty dark spore mass intermixed with numerous strands of remnant host tissue. Spores often loosely united at an early stage, globose to oval, occasionally oblong, chiefly 6.5–10 μ in length; epispore ochraceous brown, approximately 0.5 μ thick, smooth to finely punctate.

On Gramineae:

*Panicum miliaceum* L.

Type locality and host: Europe, on *Panicum miliaceum*.

Distribution: Antung, Chahar, Jehol, Kansu, Kirin, Liaoning, Shansi, Shensi, Suiyuan, Sunkiang; also in India, Japan, Philippine Islands, Russia, Australia, Europe, North America.

**Sphacelotheca hydropiperis** (Schum.) D. By., Verg. Morph. Biol. Pilze 187. 1884.

*Uredo hydropiperis* Schum., Enum. Pl. Saell. 2: 234. 1803.

*Sphacelotheca polygoni-senticosi* Miyabe & Tak. apud S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 90. 1935.

*Sphacelotheca borealis* Schellenb. var. *chinensis* Zundel, Mycologia 36: 404. 1944.

Sori in the ovaries, cylindrical, 3–7 mm. in length, protected by the floral envelopes at base, each enclosed at first in a grayish, rather thick false membrane which dehisces from the apex revealing a purplish-black spore mass surrounding a central prominent columella. Sterile cells besides forming the membrane also constituting the essential parts of the columella, hyaline, thick-walled, globose to ellipsoid, 7–20 μ in length. Spores light to deep reddish purple, chiefly globose to subglobose, occasionally oval or somewhat angular, densely verruculose, 8–17.5 μ, mostly 9–14 μ in length.

On Polygonaceae:

*Polygonum caespitosum* Bl.
*Polygonum caespitosum* Bl. var. *longisetum* (De Bruyn) Steward
*Polygonum hydropiper* L.
*Polygonum nummularifolium* Meisn.
*Polygonum sagittatum* L.
*Polygonum sagittifolium* Levl. & Van.
*Polygonum senticosum* (Meisn.) Fr. & Sav.
*Polygonum strindbergii* Schuster

Type locality and host: Europe, on *Polygonum hydropiper.*

Distribution: Anhwei, Fukien, Hunan, Kirin, Sikang, Taiwan, Yunnan; also in Ceylon, India, Java, Russia, Philippine Islands, Australia, Europe, America.

**Sphacelotheca hydropiperis** (Schum.) D. By. var. **borealis** Clint., Proc. Bost. Soc. Nat. Hist. 31: 395. 1904.

*Sphacelotheca borealis* Schellenb., Ann. Myc. 5: 386. 1907.

Differs from the species chiefly in the smaller spores which measure 7–11 μ in length.

On Polygonaceae:

*Polygonum bistorta* L.

Type locality and host: Washington, United States, on *Polygonum bistortoides* Pursh.

Distribution: Sunkiang; also in Russia, Europe, North America.

**Sphacelotheca isachnes** (Syd.) Ling, Mycologia 41: 262. 1949.

*Ustilago isachnes* Syd., Ann. Myc. 12: 77. 1912.

*Ustilago isachnes* Saw., Taiwan Agr. Res. Inst. Rep. 87: 33. 1943.

Sori in the inflorescences, linear, 1–2 cm. long, concealed by the sheaths, becoming partially exposed later, each enclosed at first in a light brownish false membrane which flakes away revealing a black dusty spore mass surrounding a simple, frequently curved columella; sterile cells of the false membrane hyaline, thin-walled, subglobose to oblong, 6–15 x 7.5–10.5 μ. Spores chiefly globose to oval, 9–14 μ diam. or 10–16.5 x 8.5–13.5 μ; epispore reddish brown, 0.7 μ thick, densely verruculose.

On Gramineae:

*Isachne globosa* (Thunb.) Kuntze

Type locality and host: Manila, Philippine Islands, on *Isachne miliacea* Roth.

Distribution: Taiwan; also in Philippine Islands.

**Sphacelotheca miscanthi** Yen, Contr. Bot. Nat. Acad. Peiping 4: 192. 1937.

Sori in the apical buds, each involving an entire floral stem and transforming it into a curved whip-like structure, up to 50 cm. or more in length, first enclosed by the epidermis of the host and a thin false membrane, upon the rupture of both and the scattering of the dusty spore mass disclosing the remnant main axis. Sterile cells of the false membrane hyaline, chiefly cubical or oblong, 6–13.5 x 4–9 μ, occasionally subglobose, 9–12 μ diam. Spores chiefly spherical to oval, 5.4–8 μ in length; epispore deep reddish brown, punctate to indistinctly verruculose.

On Gramineae:
*Miscanthus anomala* Steud.
*Miscanthus sacchariflorus* (Maxim.) Hack.
Type locality and host: Chefoo, Shantung, on *Miscanthus anomala.*
Distribution: Shantung, Szechwan.

**Sphacelotheca monilifera** (Ell. & Ev.) Clint., Jour. Myc. 8: 141. 1902.
*Ustilago monilifera* Ell. & Ev., Bull. Torrey Bot. Club 22: 362. 1895.

Sori in the ovaries, infecting all the spikelets in a raceme, elongate, 4–7 mm. long, partially concealed by the glumes, each enclosed by a brown false membrane which later ruptures irregularly revealing a semi-agglutinate, dark spore mass surrounding a well-developed simple columella; sterile cells of the false membrane firmly bound together, cubical, subglobose or oblong, subhyaline, 7.5–15 x 6–12 μ. Spores globose to oval, 9–13.5 μ long; epispore 1 μ thick, reddish brown to deep reddish brown, finely but abundantly echinulate.

On Gramineae:
*Heteropogon contortus* (L.) Beauv.
Type locality and host: Arizona, United States, on *Heteropogon contortus.*
Distribution: Yunnan; also in Ceylon, India, Africa, North and Central America.

**Sphacelotheca nankinensis** Zundel, Mycologia 31: 587. 1939.

Sori involving entire inflorescences and floral stems, linear, exceeding 10 cm. in length, with lower parts concealed by the sheaths, at first each enclosed by the epidermis and a delicate, thin false membrane composed of hyaline, subglobose to ellipsoid sterile cells, 9–18 μ long, upon rupture of the membrane and dispersal of the dark reddish brown spore mass exposing a central, simple columella. Spores globose to ellipsoid, 4.3–6.5 x 4–5.5 μ; epispore thin, smooth, light olivaceous brown.

On Gramineae:
*Paspalum ? orbiculare* Forst.
Type locality and host: Nanking, Kiangsu, on *Paspalum ? orbiculare.*
Distribution: Known only from the type locality.

**Sphacelotheca ophiuri** (P. Henn.) Ling, Sydowia 3: 127. 1949. (Fig. 2,C)
*Ustilago ophiuri* P. Henn., in O. Warburg's Monsunia 1: 1. 1899.
*Ustilago flagellata* Syd., Ann. Myc. 9: 144. 1911.
*Sphacelotheca flagellata* Zundel, Bothalia 3: 301. 1938.
*Sphacelotheca ophiuri-monostachydis* Tai apud Ling, Myc. Papers Imp. Myc. Inst. 11: 8. 1945.

Sori culmicolous, destroying entirely or partially the inflorescences, transforming each into a whip-like structure, up to 10 cm. in length, covered at first by a rather thick, brownish membrane consisting of globoid and hyaline cells, 7–15 μ diam., finally naked and exposing the dark semi-agglutinate spore mass. Spores globose to oval, sometimes elongate or angular, 10–15 x 9–12 μ; epispore smoky reddish brown, densely verruculose, approximately 1 μ thick.

On Gramineae:
*Ophiurus monostachys* J. S. Presl.
Type locality and host: Java, on *Ophiurus exaltatus* (L.) Kuntze.
Distribution: Yunnan; also in India, Java, Philippine Islands, South Africa.

**Sphacelotheca penniseti-japonici** (P. Henn.) S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 91. 1935.

*Ustilago penniseti* Rab. var. *tokinensis* Pat., Jour. de Bot. 4: 57. 1890.
*Ustilago penniseti-japonici* P. Henn., Hedwigia 43: 140. 1904.

Sori in the ovaries, infecting all the spikelets in a panicle, elongate-ellipsoidal, 5–8 mm. long, extending beyond the enveloping glumes, each with a pallid false membrane rupturing from the apex to disclose 1–4 filaments surrounded by a semi-agglutinate black spore mass; sterile cells of the false membrane hyaline, oblong, 9–24 x 3–4.5 μ, firmly united into long chains. Spores globose to subglobose, occasionally slightly angular, 10.5–16 μ long; epispore deep cinnamon brown, densely verrucose.

On Gramineae:
*Pennisetum alopecuroides* (L.) Spreng. (= *P. compressum* R. Br., *P. japonicum* Trin.)

Type locality and host: Tokyo, Japan, on *Pennisetum japonicum*.

Distribution: Anhwei, Chekiang, Fukien, Hainan, Hunan, Hupeh, Kiangsu, Kweichow, Szechwan; also in Indo-China, Japan, North America.

**Sphacelotheca reiliana** (Kuehn) Clint., Jour. Myc. 8: 141. 1902.

*Ustilago reiliana* Kuehn, in Rab. Fungi Eur. 1998. 1875.
*Sorosporium reilianum* McAlp., Smuts Austral. 181. 1910.

Sori destroying the inflorescences, very prominent, each enclosed at first in a white false membrane which soon disintegrates disclosing a dusty, dark brown spore mass intermixed with numerous long shredded remnants of host tissue; sterile cells after the decomposition of the membrane scattered throughout the spore mass in groups, subhyaline, globose to oblong, 7–16 μ in length. Spores often loosely united, opaque reddish brown, densely echinulate, globose to subglobose, occasionally ovoid or somewhat angular, 8–15 μ in length.

On Gramineae:
*Sorghum vulgare* Pers.
*Zea mays* L.

Type locality and host: Cairo, Egypt, on *Sorghum vulgare*.

Distribution: Chekiang, Honan, Hopeh, Kiangsu, Kweichow, Shansi, Sikang, Szechwan, Taiwan, Liaoning, Antung, Kirin, Liaopeh, Suiyuan, Sunkiang, Hokiang, Nunkiang, Heilungkiang, Jehol; also in Burma, India, Indonesia, Japan, Russia, Palestine, Philippine Islands, Africa, Australia, America, Europe.

**Sphacelotheca rottboelliae** (Syd. & Butl.) Mundk., Trans. Brit. Myc. Soc. 23: 111. 1939.

*Ustilago rottboelliae* Syd. & Butl., Ann. Myc. 5: 486. 1907.
*Cintractia densa* McAlp., Smuts Austral. 168. 1910.
*Ustilago rottboelliae* Miyake, Bot. Mag. Tokyo 27: 42. 1913.
*Sphacelotheca densa* Cif., Ann. Myc. 26: 32. 1928.

Sori destroying entirely or partially the inflorescences, up to 6 cm. long, each at first covered by a brownish false membrane composed of hyaline, globoid or oblong sterile cells, upon rupture of the false membrane and dispersal of the dark spore mass leaving behind a curved rachis. Spores spherical to oval, rarely oblong, 6–8.5 μ long; epispore light olive brown, thin, smooth or very faintly punctate.

On Gramineae:
*Manisuris compressa* (L. f.) Kuntze (= *Rottboellia compressa* L. f., *Hemarthria compressa* R. Br.)

Type locality and host: Pusa, India, on *Rottboellia compressa*.

Distribution: Hupeh, Szechwan; also in India, Japan, Australia, South Africa.

**Sphacelotheca sacchari** (Rab.) Cif., Fl. Ital. Crypt. I. 17: 262. 1938.

*Ustilago sacchari* Rab., Sitzungsber. Naturwiss. Ges. Isis 4: 227. 1870.
*Ustilago sacchari-ciliaris* Bref., Unters. Gesammtg. Myk. 12: 109. 1895.
*Ustilago courtoisi* Cif., Ann. Myc. 29: 71. 1931.
*Sphacelotheca schweinfurthiana* (Thuem.) Sacc. var. *minor* Zundel, Mycologia 35: 168. 1943.
*Sphacelotheca sacchari* Y. Ling & Chen. Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 11. 1945.

Sori in the ovaries, destroying all the spikelets in a panicle, 3–5 mm. long, partially exposed between the spreading glumes, each enclosed at first by a brownish false membrane which soon flakes away revealing a dusty spore mass surrounding a simple, well-developed, frequently somewhat curved columella; sterile cells of the false membrane hyaline, subglobose to ellipsoid, or cubical, 9–19.5 x 7.5–13.5 μ. Spores chiefly globose to oval, 7–12 μ in length; epispore ochraceous brown, finely punctate, 0.5 μ thick.

On Gramineae:
*Saccharum arundinaceum* Retz.
*Saccharum* sp.

Type locality and host: Marasch, Iran, on *Saccharum ravennae* (L.) Murr.

Distribution: Chekiang, Fukien, Hainan, Kiangsu, Kwangsi, Szechwan; also in Burma, India, Java, Malaya, Iran, Europe.

**Sphacelotheca sorghi** (Link) Clint., Jour. Myc. 8: 140. 1902.

*Sporisorium sorghi* Link, in Willd. Sp. Pl. 6 (2): 86. 1825.
*Ustilago sorghi* Pass. apud Thuem., Hedwigia 12: 114. 1873.
*Ustilago sorghicola* Speg., Anal. Mus. Nac. Buenos Aires III. 1: 58. 1902.
*Ustilago bulgarica* Bub., Zeitsch. Landwirtsch. Vers. Oesterr. 53. 1910.
*Sphacelotheca sorghicola* Zundel, Mycologia 22: 131. 1930.

Sori in the ovaries, cylindrical to subconical, 3–7 mm. long, each enclosed at first by a tough and brown, or light gray and thin false membrane which is usually composed of the prosenchymatous tissue, and rather persistent even after rupture; spore mass deep reddish brown, surrounding a short, central, simple columella. Spores light olivaceous brown to reddish brown, globose to oval, occasionally ovoid, 4.7–9 μ, mostly 5–7 μ in length, punctate to finely echinulate.

On Gramineae:
*Sorghum vulgare* Pers.

Type locality and host: Egypt, on *Sorghum vulgare*.

Distribution: Honan, Hopeh, Taiwan, Shansi, Suiyuan, Liaoning, Liaopeh, Kirin; also in Afghanistan, Burma, Ceylon, India, Indo-China, Japan, Philippine Islands, Russia, Africa, America, Europe.

**Sphacelotheca taiana** (Syd.) Ling, Myc. Papers Imp. Myc. Inst. 11: 9. 1945.

*Ustilago taiana* Syd., Ann. Myc. 27: 421. 1929.

Sori in the ovaries, 3–4 mm. long, partially exposed between the spreading glumes, each enclosed at first by a thin, grayish false membrane which soon disintegrates into hyaline, globose to cubical cells, 6.5–12 x 4.5–10.5 μ; columella simple, inconspicuous. Spores chiefly globose to subglobose, occasionally ovoid or ellipsoid, 5.4–7 μ diam. or 6.7–9 x 5–7 μ; epispore light to medium ochraceous brown, 0.5 μ thick, smooth.

On Gramineae:
*Sorghum nitidum* (Vahl.) Pers.

Type locality and host: Nanking, Kiangsu, on *Sorghum nitidum*.

Distribution: Known only from the type locality.

**Sphacelotheca tanglinensis** (Tracy & Earle) Zundel, Mycologia 36: 406. 1944.

*Ustilago tonglinensis* Tracy & Earle, Bull. Torrey Bot. Club 22: 175. 1895.
*Ustilago arthraxonis* Pat., Jour. de Bot. 11: 346. 1897.
*Ustilago ischaemi-akoenses* Saw., Taiwan Agr. Res. Inst. Rep. 87: 33. 1944.
*Sphacelotheca tonglinensis* Y. Ling & Chen, Res. Bull. Inst. Zool. Bot. Fukien Acad. 1:10. 1945.

Sori in the ovaries, infecting all the florets in a raceme, 3–4 mm. long, concealed by the glumes but later protruding, each covered by a pallid false membrane which ruptures at maturity revealing a dark dusty spore mass surrounding a simple central columella; sterile cells of false membrane subglobose, oval or angular, chiefly in chains, 7.5–20 x 6.7–13 μ. Spores globose, subglobose or ellipsoid, 9.5–11.5 μ diam., or 9–12 x 8.7–10 μ; epispore ochraceous brown to reddish brown, distinctly echinulate.

On Gramineae:
*Ischaemum aristatum* L.
*Ischaemum ciliare* Retz.
*Ischaemum ciliare* Retz. var. *genuinum* Hack.

Type locality and host: Tanglin, Singapore, on *Ischaemum ciliare*.

Distribution: Fukien, Hainan, Kwangtung, Taiwan; also in Indo-China, India, Ceylon, Malay States, Philippine Islands, Java.

The collections on *Ischaemum aristatum* usually have slightly smaller and darker spores than those on *I. ciliare*.

**Sphacelotheca tanglinensis** (Tracy & Earle) Zundel var. **hainanae** (Zundel) comb. nov.

*Sphacelotheca hainanae* Zundel, Mycologia 31: 585. 1939.

Differs from the species in the smaller spores which measure 6.5–10 μ diam.

On Gramineae:
*Ischaemum rugosum* Salisb.

Type locality and host: Kachek, Hainan, on *Ischaemum rugosum*.

Distribution: Known only from the type locality.

### CINTRACTIA Cornu

Ann. Sci. Nat. VI. 15: 279. 1883.

Sori in various parts of the host, usually enclosed by membranes of fungus tissue. Spore mass compact and firmly agglutinated, developed in a centripetal manner, often with outer parts becoming pulverulent at later stages but its interior remaining firm and immature. Spores not aggregated into balls, usually dark-colored, of medium to large size.

| | |
|---|---|
| Spores smooth to indistinctly pitted | |
| Spores 9–14 μ in length | *C. limitata* |
| Spores 12–17 μ in length | *C. axicola* |
| Spores 15–21 μ in length | *C. elynae* |
| Spores verrucose to tuberculate | |
| Sori surrounding the peduncles or stems | *C. scleriae* |
| Sori in the ovaries | |
| Spores usually strongly angular | *C. caricis* |
| Spores usually spherical to oval | |
| Spores 16–22.5 μ in length | *C. subinclusa* |
| Spores 9.5–14.5 μ in length | *C. fimbristylis-miliaceae* |

**Cintractia axicola** (Berk.) Cornu, Ann. Sci. Nat. Bot. VI. 15: 279. 1883.

*Ustilago axicola* Berk., Ann. Mag. Nat. Hist. II. 9: 200. 1852.
*Ustilago peribebuyensis* Speg., Anal. Soc. Cien. Argent. 17: 89. 1884.
*Cintractia peribebuyensis* Speg., Anal. Soc. Cien. Argent. 26: 11. 1888.

*Cintractia fimbristylis-kagiensis* Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 2: 79. 1922.

*Cintractia peribebuyensis* Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 2: 80. 1922.

*Cintractia suedae* Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 2: 81. 1922.

*Cintractia mundkuri* Chowdhury, Indian Jour. Agr. Sci. 14: 231. 1944.

*Cintractia fimbristylis-kagiensis* Saw. var. *fukiensis* Y. Ling & Chen, Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 17. 1945.

*Cintractia pilulifera* Y. Ling & Chen, Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 17. 1945.

*Cintractia peribebuyensis* Speg. var. *major* Pavgi & Mundk., Indian Phytopath. 1: 109. 1948.

Sori at the base of primary or auxiliary rays, less often in the ovaries, globoid to oblong, 1–4 mm. in length, at first each covered by a whitish false membrane which soon disappears exposing the black, agglutinate, compact spore mass. Spores when mature medium to deep reddish brown, often with smoky tint, globose to oval, occasionally oblong or subangular, sometimes laterally compressed, smooth to indistinctly pitted, or faintly ornamented with short, fine, sinuous striae, 12–17 x 9–15.5 μ, epispore 1–1.5 μ thick.

On Cyperaceae:

*Fimbristylis annua* (All.) Roem. & Schult. (= *F. diphylla* Vahl.)
*Fimbristylis annua* (All.) Roem. & Schult. var. *pluricostata* Clarke
*Fimbristylis kagiensis* Hayata
*Fimbristylis schoenoides* Vahl.

Type locality and host: Dominican Republic, on *Fimbristylis* sp.

Distribution: Fukien, Kiangsi, Kwangtung, Kweichow, Szechwan, Taiwan; also in Ceylon, India, Indo-China, Philippine Islands, Australia, America.

**Cintractia caricis** (Pers.) Magn., Abh. Bot. Ver. Prov. Brand. 37: 79. 1896.

*Uredo caricis* Pers., Syn. Fung. 225. 1801.

Sori in the ovaries, subgloboid, 2–3 mm. diam., partially concealed by the perigyniums, at first each enclosed in a white false membrane which soon flakes away disclosing a black, firmly agglutinated mass of spores. Spores dark reddish brown, subopaque, strongly polyhedral, often with hyaline fragments still attached, verrucose, 16.5–27 x 10.5–19.5 μ, epispore 1.5–2.5 μ thick, unevenly thickened.

On Cyperaceae:

*Carex capilliformis* Franch.
*Carex capilliformis* Franch. var. *major* Kuekenth.
*Carex laticeps* C. B. Clarke

Type locality and host: Europe, on *Carex pilulifera* L.

Distribution: Kiangsu, Shensi; also in India, Japan, Russia, Europe, North America.

**Cintractia elynae** Syd., Ann. Myc. 22: 289. 1924.

*Cintractia hyperborea* Cif., Ann. Myc. 29: 64. 1931.

*Cintractia chinensis* Yen, Contr. Inst. Bot. Nat. Acad. Peiping 3: 41. 1935.

Sori in the ovaries, subgloboid, 3–4 mm. diam., each enclosed at first in a white false membrane that soon flakes away disclosing a black, firmly agglutinated spore mass. Spores dark reddish brown, spherical to oval, occasionally oblong or slightly angular, 14.5–21 μ in length, smooth to indistinctly pitted, epispore 1.5–2 μ thick.

On Cyperaceae:

*Kobresia scirpina* Willd. (= *Elyna spicata* Schrad.)

Type locality and host: Switzerland, on *Elyna spicata*.

Distribution: Chahar; also in India, Russia, Europe, North America.

**Cintractia fimbristylis-miliaceae** (P. Henn.) S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 92. 1935.

*Ustilago fimbristylis-miliaceae* P. Henn., in Engl. Bot. Jahrb. 37: 156. 1905.
*Cintractia pulchra* S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 92. 1935.

Sori in the ovaries, forming globoid, black, compact spore masses, 0.5–1.5 mm. in diameter, each covered at an early stage by a whitish false membrane. Spores when mature yellowish brown, spherical to oval, occasionally subangular, densely verruculose, 9.5–14.5 μ in length, epispore 0.5–1 μ thick.

On Cyperaceae:
*Fimbristylis miliacea* Vahl.
Type locality and host: Yukatabara, Japan, on *Fimbristylis miliacea.*
Distribution: Fukien; also in Japan, Mexico.

**Cintractia limitata** Clint., Proc. Bost. Soc. Nat. Hist. 31: 399. 1904.

*Cintractia axicola* (Berk.) Cornu var. *minor* Clint., Jour. Myc. 8: 143. 1902.
*Cintractia togoensis* P. Henn., in Engl. Bot. Jahrb. 38: 119. 1905.
*Cintractia congensis* P. Henn., Ann. Mus. Congo Bot. V. 2: 87. 1907.
*Cintractia cyperi-polystachyi* P. Henn., Philipp. Jour. Sci. C. 3: 41. 1908.
*Cintractia minor* Jacks., Mycologia 12: 153. 1920.
*Ustilago chaconensis* Hirschh., Not. Mus. La Plata 6: 479. 1941.
*Ustilago mariscana* Zundel, Mycologia 35: 165. 1943.
*Cintractia distans* Mundk., Indian Jour. Agr. Sci. 14: 50. 1944.

Sori at the base of primary or auxiliary rays, cylindrical, forming black, agglutinate spore masses surrounding the branches, extending up to 1 cm. in length and 7 mm. in diameter, each covered at first by a whitish false membrane which soon disintegrates; often also infecting the ovaries, each forming a globoid black spore mass surrounding a rudimentary columella, 1–2 mm. in diameter, agglutinate at earlier stages, becoming rather dusty, exposed between the spreading glumes, and often spreading to adhere to the glumes and other floral parts. Spores when mature ochraceous brown to deep reddish brown, often with smoky tint, spherical to oval, occasionally subangular, frequently laterally compressed, 9–14.5 x 7.5–13 μ; epispore smooth, 1 μ or less thick.

On Cyperaceae:
*Cyperus compressus* L.
*Cyperus distans* L.
*Cyperus malaccensis* Roxb.
Type locality and host: Puerto Rico, on *Cyperus ligularis* L.
Distribution: Taiwan; also in Ceylon, India, Philippine Islands, Africa, America.

**Cintractia scleriae** (DC.) Ling, Mycologia 43: 314. 1951.

*Uredo scleriae* DC. in Poiret, Encycl. Meth. Bot. 8: 879. 1808.
*Ustilago ? scleriae* Tul., Ann. Sci. Nat. Bot. III. 7: 89. 1847.
*Cintractia javanica* Racib., Bull. Intern. Acad. Sci. Krakow 1909: 351. 1909.
*Cintractia albida* S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 93. 1935.

Sori surrounding the pedicels and the branches of the inflorescence, oblong, occasionally oval or even subgloboid, extending up to 3.5 cm. in length, 2.5–4 mm. in diameter, each covered at first by a thick white false membrane enclosing a black, firmly agglutinated spore-mass; infection rarely spreading onto the scales of the rudimentary abortive inflorescences which are invariably present in the infected plants. Spores ochraceous brown, chiefly globose to oval, often cupped at one side, 12–16.5 μ, occasionally up to 18 μ in length, prominently verrucose, verrucae rarely confluent into short, irregular striae or cerebriform; epispore 1–1.5 μ thick; immature spores invariably present in the inner parts of the sorus.

On Cyperaceae:
*Rhynchospora corymbosa* (L.) Britt.

Type locality and host: Cayenne, French Guiana, on *Rhynchospora* sp.
Distribution: Taiwan; also in Ceylon, Indo-China, Indonesia, Philippine Islands, Africa, Central and South America.

**Cintractia subinclusa** (Koern.) Magn., Abh. Bot. Ver. Prov. Brand. 37: 79. 1896.
*Ustilago subinclusa* Koern., Hedwigia 13: 159. 1874.

Sori in the ovaries, subgloboid, 3–4 mm. diam., partially concealed by the perigyniums, each enclosed at first in a white false membrane which soon flakes away exposing a black, firmly agglutinated spore mass. Spores dark reddish brown, subopaque, spherical to oval, sometimes laterally compressed, 16–22.5 μ, mostly 18–21 μ diam., densely ornamented with coarse, blunt tubercles.

On Cyperaceae:
*Carex siderosticha* Hance.
Type locality and host: Dresden, Germany, on *Carex riparia* Curt.
Distribution: Shensi; also in Japan, Russia, Europe, North America.

### MELANOPSICHIUM Beck

Ann. Nat. Hofmus. Wien 9: 122. 1894.

Sori in various parts of the host, causing the formation of conspicuous galls. Spores not aggregated into balls, developed in cavities in the host tissue, permanently imbedded in a mucilaginous matrix, discharging from the mass by absorption of water, of medium size.

| | |
|---|---|
| Spores chiefly subhyaline, verrucose | *M. inouyei* |
| Spores chiefly brownish, echinulate | *M. pennsylvanicum* |

**Melanopsichium inouyei** (P. Henn. & Shirai) comb. nov.
*Uredo inouyei* P. Henn. & Shirai apud P. Henn., in Engl. Bot. Jahrb. 28: 263. 1901.
*Cintractia machili* Hino & Nagaoka, Bull. Miyazaki Coll. Agr. For. 3: 55. 1931.
*Ustilago machili* S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 89. 1935.
*Ustilago inouyei* S. Ito & Yoshinaga apud S. Ito & Homma, Trans. Sapporo Nat. Hist. Soc. 15: 113. 1938.

Sori in the winter buds, forming conspicuous lobate galls, up to 3.5 cm. in length, protected by smooth, yellow to brown host tissue which ruptures irregularly disclosing deep brown, agglutinate spore masses. Spores formed in cavities, chiefly oval to ellipsoid, often subglobose, oblong, or somewhat irregular, 10.5–21 x 6.5–13 μ; epispore 1.5 μ thick, subhyaline to pale buff or pale olivaceous, densely verrucose, verrucae rather irregular.

On Lauraceae:
*Machilus* sp.
Type locality and host: Tosa, Japan, on ? *Symplocos* sp.
Distribution: Szechwan; also in Japan.

**Melanopsichium pennsylvanicum** Hirschh., Not. Mus. La Plata 6: 149. 1941.
*Melanopsichium pennsylvanicum* Hirschh. var. *besseyanum* Zundel, Mycologia 35: 183. 1943.
*Melanopsichium pennsylvanicum* Hirschh. var. *caulicola* Zundel, Mycologia 35: 184. 1943.

Sori in the inflorescences, stems and leaves, causing the formation of irregular, conspicuous, hard galls, variable in size, up to 3 cm. in length. Spores permanently and firmly agglutinate, globose, ovoid, oval or oblong, often somewhat irregular, 7–14 μ diam. or 7.5–16 x 6–12 μ, light to medium olivaceous brown, finely to distinctly echinulate, with more or less evident hyaline gelatinous envelopes.

On Polygonaceae:
*Polygonum glabrum* Willd.
*Polygonum lapathifolium* L.
*Polygonum ? minus* Hudson
*Polygonum* sp.

Type locality and host: Kansas, United States, on *Polygonum pennsylvanicum* L.

Distribution: Chekiang, Kiangsu, Kweichow, Szechwan, Taiwan, Yunnan; also in India, Indo-China, Japan, Russia, Australia, Europe, North America.

### Farysia Racib.

Bull. Intern. L'Acad. Sci. Cracovie 354. 1909.

Sori in the ovaries or surrounding the peduncles, each covered at first by a false membrane which dehisces later. Spore mass traversed by numerous fascicles of hyphae, pulverulent at maturity. Spores not aggregated into balls, of small to medium size.

| | |
|---|---|
| Mass of spores and fascicles brownish olive | *F. subolivacea* |
| Mass of spores and fascicles dark brown to nearly black | |
| Sori 2–4 mm. in diameter | *F. butleri* |
| Sori 3–12 mm. in diameter | *F. orientalis* |

**Farysia butleri** (Syd.) Syd., Ann. Myc. 17: 42. 1919.
*Ustilago butleri* Syd., Ann. Myc. 4: 424. 1906.
*Farysia caricis-filicinae* S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 91. 1935.

Sori in the ovaries, subgloboid, 2–4 mm. diam., each enclosed in a brownish fungous membrane which soon ruptures disclosing a black dusty spore mass intermixed with brown olive hyphal fascicles. Fascicles usually not profuse, yellowish olive, 10.5–22.5 μ wide. Spores predominently globose to subglobose, often ovoid, oval, or irregular, occasionally with one or both ends tapering, 5.4–9.5 μ diam. or 6.7–10.5 x 6–8.7 μ, deep olivaceous brown, striate-verrucose, often more or less areolate, frequently each with an evident central globule.

On Cyperaceae:
*Carex cruciata* Wahl.

Type locality and host: Assam, India, on *Carex cruciata.*

Distribution: Fukien, Hainan, Kwangtung, Kwangsi, Kweichow, Sikang, Szechwan, Taiwan; also in India, Java.

**Farysia orientalis** Ling, Sydowia 3: 130. 1949.

Sori destroying the ovaries, 3–12 mm. diam., each covered with a thick, brownish fungous membrane of prosenchymatous tissue which later disintegrates revealing a "Chaetura Drab" to "Chaetura Black" (Ridgway) mass of spores and conspicuous hyphal fascicles. Fascicles very abundant and profuse, olivaceous, 7.5–20 μ wide, composed of a number of fine hyphae. Spores variable in shape and size, globose, oval ovoid, pyriform, or lenticular with elongate tapering ends, 4–6.7 μ diam. or 5–9.5 x 4–8 μ, most elongate ones up to 17 μ in length, frequently with an evident central globule, areolate in some cases; epispore olive brown, striate-verrucose.

On Cyperaceae:
*Carex baccans* Nees

Type locality and host: Ootacamund, India, on *Carex baccans.*

Distribution: Yunnan; also in Burma, Ceylon, India.

**Farysia subolivacea** (P. Henn.) Cif., Nuovo Giorn. Bot. Ital. 4: 258. 1933.
*Ustilago subolivacea* P. Henn., Ann. R. Inst. Bot. Roma 6: 84. 1896.

Sori in the ovaries, subgloboid, 3–7 mm. diam., at first more or less concealed by the perigyniums, soon exposing the "Brownish Olive" (Ridgway) masses of spores and hyphal fascicles. Fascicles usually profusely developed, 7.5–30 μ wide. Spores globose to oval, or oblong, 4.5–7.5 μ diam. or 5–10 x 4.5–6 μ, elongate and irregular ones rarely up to 13.4 x 6 μ, light to medium olivaceous brown, frequently with evident central globules, verrucose, sometimes verrucae arranged in irregular striae.

On Cyperaceae:
*Carex nemostachys* Steud.
*Carex simulans* C. B. Clarke

Type locality and host: Somalia, Africa, on *Carex ramosa* Schkuhr.

Distribution: Szechwan; also in Africa.

The determination of this species is uncertain, as the type has not been available for study.

## Sorosporium Rud.

Linnaea 4: 116. 1829.

Sori in the inflorescences, forming pulverulent spore masses. Spore-balls consisting of numerous spores, semi-permanent or evanescent at maturity, invested at earlier stages by mycelial strands which become gelatinized later. Spores of small to medium size.

| | |
|---|---|
| Sori involving the inflorescences | |
| Sori completely concealed at maturity | *S. cantonensis* |
| Sori more or less exposed at maturity | |
| Spores under 8 μ in length | |
| Spores smooth | *S. andropogonis-aciculati* |
| Spores punctate | *S. formosanum* |
| Spores exceeding 8 μ in length | |
| Outer spores indistinctly pitted | *S. paspali-thunbergii* |
| Outer spores verruculose to verrucose | |
| Sori under 2 cm. in length | *S. cymbopogonis-distantis* |
| Sori exceeding 2 cm. in length | |
| Spores surrounding a central columella | *S. flagellatum* |
| Spores intermixed with numerous filaments | *S. caledonicum* |
| Sori in the ovaries | |
| Spores verruculose | *S. cymbopogonis-distantis* |
| Spores coarsely verrucose or tuberculate | |
| Sori 2–3 mm. wide | *S. anthistiriae* |
| Sori 5–7 mm. wide | *S. ehrenbergii* |

**Sorosporium andropogonis-aciculati** (Petch) Petch, Ann. Roy. Bot. Gard. Peradeniya 5: 227. 1912.

*Ustilago andropogonis-aciculati* Petch, Ann. Roy. Bot. Gard. Peradeniya 4: 303. 1909.

Sori destroying entire inflorescences, concealed first by the leaf sheaths, then protruding, linear, 2–6 cm. long, 1–2 mm. wide, each enclosed by a pallid false membrane which lacerates from the apex revealing a granular black spore mass surrounding a number of long, slender filaments of host tissue. Spore-balls rather permanent, subglobose to oblong, many spored, opaque, 30–70 x 20–67 μ. Spores chiefly globose to oval, 4.2–6.2 μ diam.; epispore smooth, thin, light olivaceous brown, outer and inner spores uniformly colored.

On Gramineae:
*Rhaphis aciculata* (Retz.) Desv. (= *Andropogon aciculatus* Retz.)

Type locality and host: Peradeniya, Ceylon, on *Andropogon aciculatus*.

Distribution: Taiwan; also in Ceylon, Philippine Islands.

**Sorosporium anthistiriae** (Cobb) Ling, Myc. Papers Imp. Myc. Inst. 11: 9. 1945.

*Tolyposporium anthistiriae* Cobb, Agr. Gaz. N.S.W. 3: 1006. 1892.
*Sorosporium holstii* P. Henn., in Engler, Pflanzenw. Ost.-Afrikas Nachb. C: 49. 1895.
*Tolyposporium anthistiriae* P. Henn., Hedw. 37: 283. 1898.

Sori in the ovaries, infecting occasional or all spikelets in the inflorescence, protruding conspicuously beyond the glumes, cylindrical, tapering at both ends, 1.5–4.5 cm. long, 2–3 mm. wide, each enclosed by a whitish or yellowish false membrane which breaks up irregularly or lacerates into long shreds, exposing a granular, black spore mass intermixed with 5–8 threads of host tissue. Spore-balls subglobose to oblong, opaque, permanent, 45–175 x 37–115 μ. Spores globose, ovoid or ellipsoidal, mostly somewhat angular; outer spores 9.5–16.5 x 8.5–14 μ, epispore coarsely granulate-verrucose, dark reddish brown, 1.2–2 μ thick, often unevenly thickened; inner spores almost hyaline to light brown, smooth, smaller in size.

On Gramineae:
*Heteropogon contortus* (L.) Roem. & Schultes
*Themeda gigantea* (Cav.) Hack.
*Themeda triandra* Forsk.

Type locality and host: New South Wales, Australia, on *Themeda ciliata* (L. f.) Hack.

Distribution: Fukien, Honan, Hopeh, Hunan, Hupeh, Kiangsu, Szechwan, Chekiang; also in Australia, Africa.

**Sorosporium caledonicum** Pat., Bull. Soc. Myc. Fr. 3: 173. 1887.

*Sorosporium contortum* Griff., Bull. Torrey Bot. Club 31: 83. 1904.

Sori destroying the racemes, linear, 3–7 cm. long, partially concealed by the leaves, each enclosed by a light brown false membrane which later lacerates from the apex into long shreds disclosing a black granular spore mass intermixed with a number of long slender filaments of host tissue; cells of the false membrane subhyaline, thick-walled, cubical to oblong. Spore-balls permanent, opaque, subglobose to oblong, 38–106 μ long. Spores globose to oval, rarely polyhedral, 8.5–11.5 μ diam. or 10–13 x 8.5–10 μ, epispore 1–1.5 μ thick; outer spores deep reddish brown, verruculose on the free surface; inner spores subhyaline to light yellow brown, smooth.

On Gramineae:
*Heteropogon contortus* (L.) Beauv.

Type locality and host: New Caledonia, on *Heteropogon contortus.*

Distribution: Szechwan; also in India, New Caledonia, North America.

**Sorosporium cantonensis** Zundel, Mycologia 31: 584. 1939.

Sori in individual inflorescences, completely and tightly enclosed by the reduced leaves, 5–8 mm. long, less than 1 mm. wide, each covered by a light grayish false membrane composed of hyaline, oblong sterile cells. Spore mass compact, black, surrounding a central, simple columella. Spore-balls usually opaque, oval to oblong, semi-permanent, 52–180 x 37–107 μ. Spores mostly polyhedral, often subglobose, ovoid or ellipsoid, 13.5–18.5 x 12–15 μ, the most elongate up to 21 μ long, epispore 1.5–2 μ thick; outer spores deep reddish brown, verrucose; inner spores light brown, smooth or indistinctly verruculate.

On Gramineae:
*Cymbopogon tortilis* (Presl) Hitchc. (= *C. hamatulus* A. Camus)

Type locality and host: Canton, Kwangtung, on *Cymbopogon hamatulus.*

Distribution: Known only from the type locality.

**Sorosporium cymbopogonis-distantis** sp. nov. (Fig. 3,C; and 4,B)

Soris in ovariis evolutis, glumis ex parte tectis, 0.5–1 cm. longis, 1–2 mm. latis, vel inflorescentiam destruentibus, spatha tectis, 1–1.7 cm. longis, linearibus, utrinque attenuatis, primum singulis membrana falsa brunnea tectis, hac membrana dehiscenti et massam subagglutinatam sporarum et fila tenuia hospitis detegenti. Glomerulis sporarum opacis, ovalibus vel ellipsoideis, 65–100 x 50–90 μ, in maturitate evanescentibus; sporis periphericis plerumque polyedricis, saepe subglobosis ovalibusve, 13.5–16.5 μ, rare usque 19 μ longis, 10.5–13.5 μ latis, granulosis, episporis atro-rubro-brunneis, dense verrucosis; sporis centralibus in forma et dimensionibus similibus, sed pallidioribus et minus distincte verruculosis.

Sori in the ovaries, partially concealed by the glumes, 0.5–1 cm. long, 1–2 mm. wide, or destroying individual inflorescences, concealed by the spathes, 1–1.7 cm. long, linear, tapering at both ends, each covered at first by a wood brown false membrane which dehisces exposing a semi-agglutinate spore mass surrounding several slender threads of host tissue. Spore-balls opaque, oval to ellipsoid, 65–110 x 50–90 μ, evanescent at maturity; peripherical spores mostly polyhedral, often subglobose to oval, 13.5–16.5 μ, rarely up to 19 μ long, 10.5–13.5 μ wide, contents granular, epispore deep reddish brown, densely verrucose; inner spores similar in shape and size, light olivaceous, with less distinct verruculations.

On Gramineae:

*Cymbopogon distans* (Nees) W. Wats.

Type locality and host: Vicinity of Chengtu, Szechwan, on *Cymbopogon distans* (Nov. 1947, K. R. Lin).

Distribution: Known only from the type locality.

**Sorosporium ehrenbergii** Kuehn, Mitt. Ver. Erdkunde 87. 1887.

*Tolyposporium ehrenbergii* Pat., Bull. Soc. Myc. Fr. 19: 254. 1903.
*Tolyposporium filiferum* Busse, Arb. Biol. Abt. Land-Forstwirtsch. 4: 384. 1904.
*Sorosporium filiferum* Zundel, Mycologia 22: 148. 1930.

Sori in the ovaries, oblong, somewhat tapering at both ends, often curved, 1.5–2 cm. long and 5–7 mm. wide, each enclosed in a pale yellow, rather persistent false membrane which later ruptures from the apex disclosing a granular, black spore mass surrounding a number of shreds of host tissue; sterile cells of the false membrane hyaline, globose to oval, mostly much larger than the spores. Spore-balls rather permanent but easily broken, subglobose to oblong, or irregular, 38–123 x 34–93 μ. Spores from the periphery of spore-balls medium to deep reddish brown, opaque and coarsely tuberculate on the free surface, globose to oval, or somewhat angular, 10.5–15 μ long; inner spores subhyaline to pale brownish, smooth, globose to ellipsoid, 9–15 μ long; epispore 1.5–2 μ thick.

On Gramineae:

*Sorghum vulgare* Pers.

Type locality and host: Egypt, on *Sorghum vulgare.*

Distribution: Hopeh; also in India, Russia, Africa.

**Sorosporium flagellatum** Syd. & Butl., Ann. Myc. 5: 489. 1907.

*Ustilago burmanica* Syd. & Butl., Ann. Myc. 10: 250. 1912.
*Sorosporium geminellum* Syd. & Butl., Ann. Myc. 10: 253. 1912.

Sori in the inflorescences, cylindrical, 2–6 cm. long, concealed at first by the leaf sheaths, later protruding, each enclosed by a brown false membrane which ruptures irregularly revealing the dark spore mass surrounding a simple columella. Spore-balls subglobose to oblong, evanescent, 37–77.5 x 30–52.5 μ, rarely up to 120 μ long. Spores globose to oval, occasionally elongate or angular, 11–16.5 μ diam. or 12–17 x 10.5–15 μ; epispore reddish brown, 1–1.3 μ thick, verruculose.

On Gramineae:
*Ischaemum timorense* Kunth var. *peguense* Hack.
Type locality and host: Malabar, India, on *Ischaemum timorense.*
Distribution: Fukien, Taiwan; also in Burma, India, Java.

**Sorosporium formosanum** (Saw.) Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 35: 29. 1928.

*Ustilago digitariae* (Ktze.) Rab. f. *panici-repentis* Kuehn, Hedwigia 15: 5. 1876.
*Ustilago formosana* Saw., Trans. Taiwan Nat. Hist. Soc. 8: 16. 1918.
*Ustilago overeeimi* Cif., Nuovo Giorn. Bot. Ital. n. s. 40: 254. 1933.
*Ustilago amadelpha* Syd. & Butl. var. *glabriuscula* Cif., Nuovo Giorn. Bot. Ital. 40: 255. 1933.
*Sorosporium punctatum* Malenç. & Yen, Rev. Myc. 2: 130. 1937.
*Sorosporium yoshinagae* Zundel, Mycologia 31: 589. 1939.
*Sorosporium overeeimi* Malenç., Rev. Myc. 10: 121. 1945.

Sori destroying the inflorescences, 4–10 cm. long, each covered at first by a pale brown false membrane which gradually flakes away revealing numerous long, slender threads of host tissue intermixed with the dark spore mass. Spore-balls rather permanent, 60–195 x 45–115 μ, reniform or oblong. Spores globose to oval, 5–7.5 x 4.5–6.5 μ, finely punctate, olivaceous brown; inner spore lighter in color.
On Gramineae:
*Panicum repens* L.
Type locality and host: Taiwan, on *Panicum repens.*
Distribution: Fukien, Taiwan; also in Ceylon, India, Japan, Java, Europe, Africa.

**Sorosporium paspali-thunbergii** (P. Henn.) S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 94. 1935.

*Ustilago paspali-thunbergii* P. Henn., Hedwigia 43: 140. 1904.
*Sorosporium paspali* McAlp., Smuts Austral. 180. 1910.

Sori in the inflorescences, cylindrical, up to 10 cm. long, in earlier stages concealed by the leaf sheaths but protruding later, each enclosed in a pale brown false membrane which ruptures irregularly revealing the semi-agglutinate but finally powdery spore mass and a simple, frequently twisted columella. Spore-balls evanescent, subglobose to oblong, often irregular, 28–70 x 26–56 μ, surrounded by several layers of mycelial strands which become gelatinized at maturity. Spores mostly angular, often subglobose, oval or oblong 12–19 x 9.5–14.5 μ, epispore 1.3–2 μ thick, usually unevenly thickened; outer spores deep reddish brown, finely and indistinctly pitted; inner spores clear reddish brown, smooth or nearly smooth.
On Gramineae:
*Paspalum scrobiculatum* L.
*Paspalum* sp.
Type locality and host: Nikko, Japan, on *Paspalum thunbergii* Kunth.
Distribution: Fukien, Hopeh, Kiangsi, Kwangtung, Taiwan; also in Ceylon, Hawaii, India, Japan, Philippine Islands, Australia.

### TOLYPOSPORIUM Woronin

Abh. Senck. Nat. Ges. 12: 577. 1882.

Sori usually in the ovaries, forming granular spore masses at maturity. Spore-balls composed of numerous, permanently united spores. Spores bound together by ridged folds or thickenings of their outer walls, of small to medium size.

| | |
|---|---|
| Sori infecting only occasional ovaries in the inflorescence | |
| Sori subglobose, 1.5–3 mm. in length | *T. evernium* |
| Sori oval or ovoid, 3–4 mm. in length | *T. bullatum* |
| Sori infecting almost all of the ovaries | *T. globuligerum* |

**Tolyposporium bullatum** (Schroet.) Schroet., Krypt. Fl. Schles. 3: 276. 1887.

*Sorosporium bullatum* Schroet., Abh. Schles. Ges. Abth. Nat. Med. 1869–72: 6. 1871.

Sori in ovaries, infecting only a few spikelets in a panicle, oval or ovoid, 3–4 mm. in length, each covered by a green, smooth membrane which ruptures later disclosing a granular black spore mass. Spore-balls opaque, globose to oblong, 78–375 x 68–225 μ. Spores globose to oval, 7.5–12 x 6–9 μ, pale olivaceous yellow, folded in ridges by which the spores are bound together and which on rupture of spore-balls show as truncate projections at spore margins, epispore 1.5 μ thick.

On Gramineae:
*Echinochloa crus-galli* (L.) Beauv.
*Echinochloa crus-galli* (L.) Beauv. var. *mitis* (Pursh) Peterm.

Type locality and host: Silesia, on *Panicum crus-galli* L.

Distribution: Fukien, Szechwan, Taiwan; also in Japan, Russia, Europe, North America.

**Tolyposporium evernium** Syd., Ann. Myc. 37: 443. 1939. (Fig. 4,C)

Sori in the ovaries, infecting only occasional ones, subglobose, 1.5–3 mm. diam., each enclosed by a thick smooth membrane of host tissue. Spore-balls opaque, irregular in shape, subglobose or pyriform, often broadly ellipsoidal, 70–336 x 64–242 μ, permanent. Spores globose to oval, covered by 5–10 short projections by which the spores are firmly bound together, 5.6–12.6 x 5.6–10.5 μ, averaging 9.1 x 8.2 μ; outer spores light reddish brown to reddish brown, epispore 0.5 μ thick; inner spores almost hyaline.

On Gramineae:
*Paspalum distichum* L.

Type locality and host: Panjab, India, on *Paspalum distichum.*

Distribution: Kiangsu; also in India.

**Tolyposporium globuligerum** (Berk. & Br.) Ricker, Jour. Myc. 11: 112. 1905.

*Thecaphora globuligera* Berk. & Br., Trans. Linn. Soc. II. 1: 407. 1879.

Sori infecting most of the ovaries in the inflorescence, oblong or cornute, 3–5 mm. long, partially hidden by the glumes, each covered by a thick, green, smooth membrane of host tissue which finally ruptures disclosing a granular black spore mass. Spore-balls opaque, subglobose to ellipsoidal, sometimes oblong or irregular, permanent, 70–220 x 45–150 μ. Spores globose to ellipsoid, often angular, 6.7–10.5 x 6–9 μ, light olivaceous yellow, each with 4–7 truncate projections by which the spores are firmly bound together, epispore 1.5 μ thick.

On Gramineae:
*Leersia japonica* Makino

Type locality and host: Brisbane, Australia, on *Leersia hexandra* Swartz.

Distribution: Szechwan; also in India, Africa, Australia, North and South America.

### DERMATOSORUS Saw.

Mycologia 41: 267. 1949.

Sori in the ovaries, pulverulent, each enclosed in a false membrane which dehisces eventually. Spore-ball consisting of numerous spores invested by a cortex of pseudoparenchymatous tissue. Spores loosely united, of small to medium size.

**Dermatosorus eleocharidis** Saw. apud Ling, Mycologia 41: 268. 1949.

Sori in the ovaries, often involving the basal parts of anthers, with glumes intact, each covered at first by a firm, thick, black false membrane which is composed of yellow brown cells, firmly bound together, ovoid, ellipsoidal or angular in outline, 9–16 x 6.5–15 μ diam., with walls 1.5 μ thick, and which later ruptures irregularly revealing an aggregate of spore-balls. Spore-balls many-spored, rectangular, ellipsoidal or subglobose, opaque, 112–606 x 88–358 μ diam., each covered by a delicate but rather permanent cortex of pseudoparenchymatous tissue, 15–75 μ thick, consisting of reddish brown cells, 3–6.5 μ diam., with walls 1 μ thick. Spores loosely united, globose to ellipsoidal, 6–11 μ diam., chiefly 7–9 μ; epispore smooth, reddish brown, approximately 1 μ thick.

On Cyperaceae:
*Eleocharis dulcis* Trin.

Type locality and host: Kaohsiung, Taiwan, on *Eleocharis dulcis.*

Distribution: Known only from the type locality.

## EXCLUDED SPECIES

*Cintractia leucoderma* Ling, Mycologia 41: 264. 1949. = Cintractia scleriae.
*Entyloma bidentis* Saw., Taiwan Agr. Res. Inst. Rep. 85: 43. 1943. = Entyloma guaraniticum.
*Farysia olivacea* Saw., Trans. Taiwan Nat. Hist. Soc. 32: 29. 1942. = Farysia butleri.
*Farysia pseudocyperi* Zundel, Mycologia 23: 297. 1931. = Farysia butleri.
*Melanopsichium austro-americanum* in several reports = Melanopsichium pennsylvanicum.
*Sorosporium arundinellae* Syd. = Ustilaginoidea arundinellae P. Henn.
*Sorosporium clintonii* Ling, Myc. Papers Imp. Myc. Inst. 11: 10. 1945. = Sorosporium anthistiriae.
*Sphacelotheca seymouriana* Teng, Contr. Biol. Lab. Sci. Soc. China 8: 148. 1932. = Sphacelotheca taiana.
*Sphacelotheca themedae* Ling, Myc. Papers Imp. Myc. Inst. 11: 9. 1945. = Sphacelotheca anthistiriae var. punctata.
*Tilletia barclayana* Yen, Contr. Inst. Bot. Nat. Acad. Peiping 3: 55. 1935. = Tilletia pennisetina.
*Ustilago egenula* Zundel, Mycologia 35: 167. 1943. = Ustilago spermophora.
*Ustilago flavo-nigrescens* Keissler, in Handel-Mazzetti's Symbolae Sinicae 2: 4. 1937. = Farysia butleri.
*Ustilago grandis* Wei & Hwang, Nanking Jour. 9: 34. 1941. = Hyphomycetes.
*Ustilago koordersiana* Yates, Philipp. Jour. Sci. C. 12: 315. 1917. = Ustilago cordai.
*Ustilago panici-frumentacei* Ling, Myc. Papers Imp. Myc. Inst. 11: 6. 1945. = Ustilago sphaerogena.
*Ustilago penniseti* Sacc., Philipp. Jour. Sci. C. 18: 596. 1921. = Sphacelotheca penniseti-japonica.
*Ustilago pustulata* Teng, Contr. Biol. Lab. Sci. Soc. China 8: 148. 1932. = Sphacelotheca penniseti-japonica.
*Ustilago tonkinensis* Reinking, Philipp. Agr. 8: 120. 1919. = Sphacelotheca tanglinensis.

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  - Ustilago maydis
- Zizania latifolia
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**Fig. 1. A.** *Tilletia arundinellae* on *Arundinella anomala*, type. × 2. **B.** *Entyloma eleocharidis* on *Eleocharis dulcis*, type. × 1. **C.** *Ustilago tuberculiformis* on *Polygonum runcinatum*, Taiwan collection. × 1.

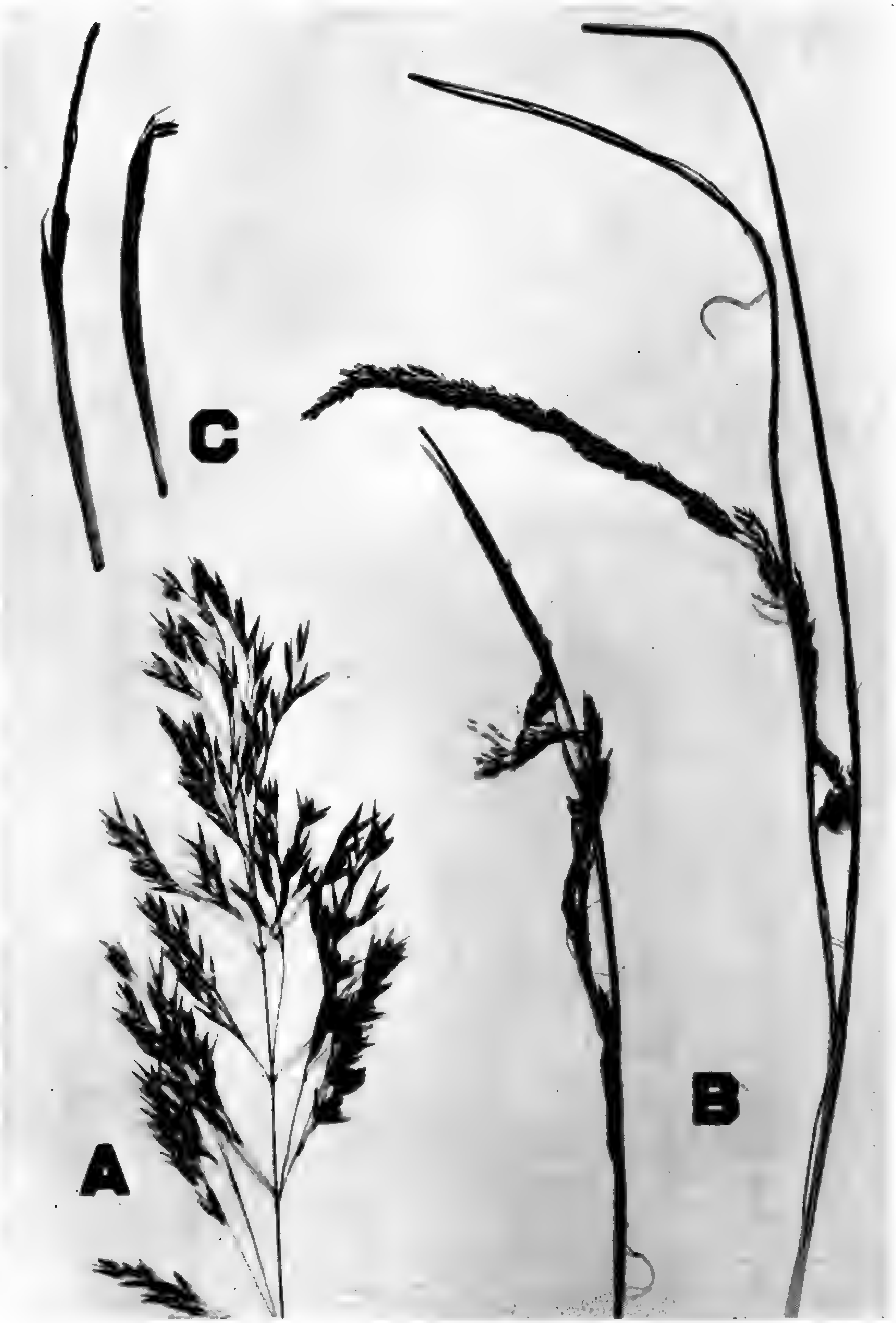

**Fig. 2.** **A.** *Tilletia deyeuxiae* on *Deyeuxia sylvatica* var. *laxiflora*, type. **B.** *Ustilago sporoboli-indici* on *Sporobolus indicus*, type. **C.** *Sphacelotheca ophiuri* on *Ophiurus monostachys*, Yunnan collection. All × 1.

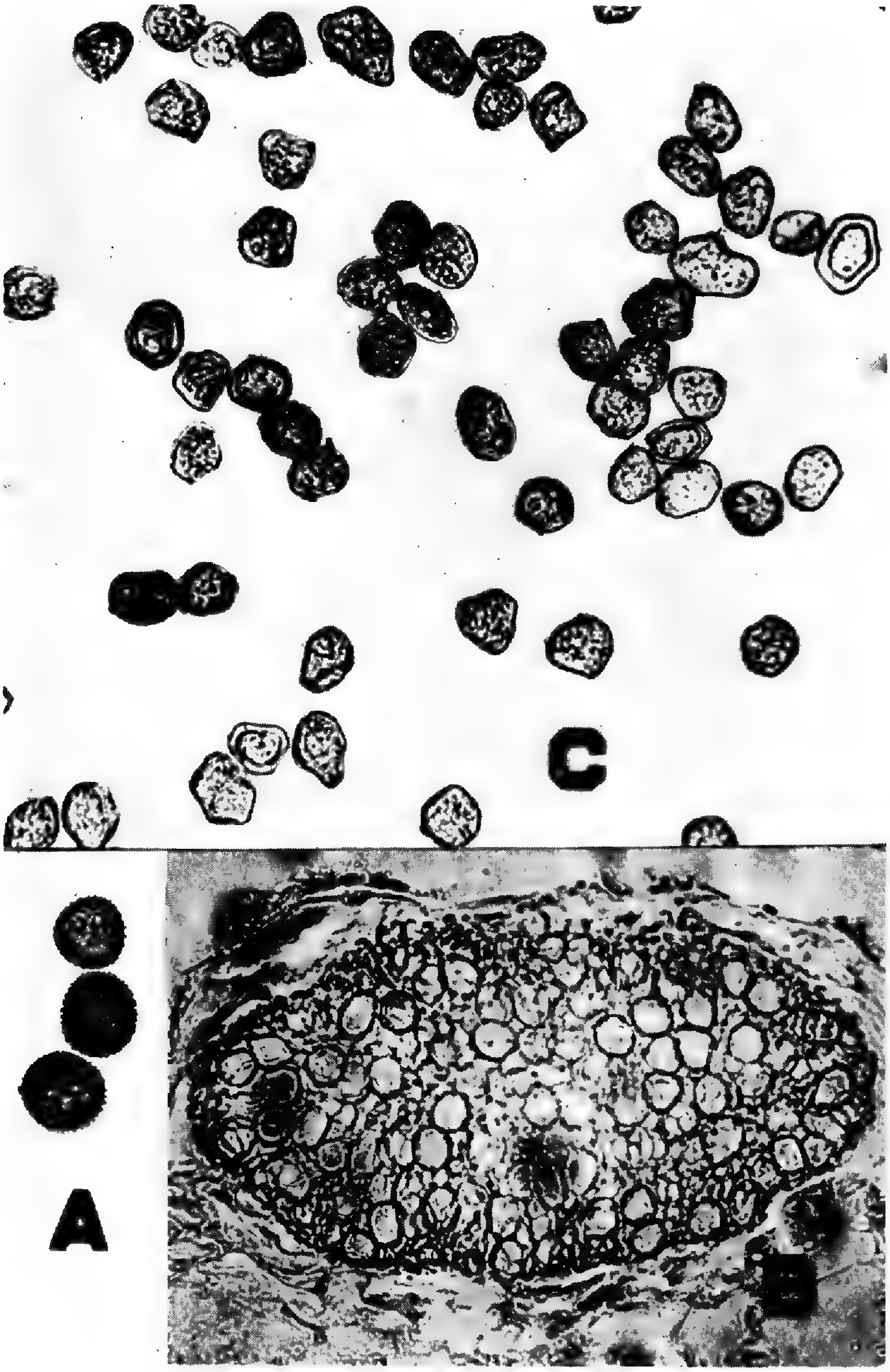

**Fig. 3.** **A.** *Tilletia rhei*, teleutospores, type. × 500. **B.** *Burrillia ajrekari*, sorus, Taiwan collection. × 450. **C.** *Sorosporium cymbopogonis-distantis*, teleutospores, type. × 500.

**Fig. 4. A.** *Sphacelotheca apludae* on *Apluda mutica* var. *aristata*, type. **B.** *Sorosporium cymbopogonis-distantis* on *Cymbopogon distans*, type. Left, healthy plant; center, plant with infection involving the inflorescences; right, plant with infection in the ovaries. **C.** *Tolyposporium evernium* on *Paspalum distichum*, Kiangsu collection. All × 1.

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# THE AQUATIC HYPHOMYCETES OF CALIFORNIA [1]

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The term "aquatic fungi" has been customarily applied to the aquatic Phycomycetes. It has, however, become apparent in recent years that the Phycomycetes, though still the dominant group from the standpoint of numbers, are only a part of a very diversified fresh-water flora. A number of discomycetous genera, *Vibrissea* Fr., *Apostemidium* Karst. and *Mitrula* Fr. in particular, encompass species that are wholly aquatic. These organisms grow on twigs submerged in cold fresh-water streams and lakes and discharge their spores beneath the surface of the water. In the Pyrenomycetes at least one member of the *Metasphaeria-Melomastia* alliance, as well as the striking *Loramyces juncicola* Wes. (Weston, 1929), are known to be fresh-water aquatics. Thus with the Phycomycetes and Ascomycetes represented in the fresh-water flora, it is not surprising that some of the ubiquitous Fungi Imperfecti have adapted themselves to the aquatic habit.

De Wildeman in 1893, 1894 and again in 1895 observed the spores of several species of fungi in his collections of algae. Three of these species, *Tetracladium marchalianum*, *Fusarium elongatum* (now *Anguillospora longissima*) and *Lemonniera aquatica*, were placed in the Moniliales. The other species, *Clavariopsis aquatica*, was placed in the Mycelia Sterilia because he was unable to observe the germination of the tetraradiate spores.

Though De Wildeman was the first to recognize these free-floating objects as spores of fungi, Riensch (1888) was the first to describe them. Reinsch thought the spores of *Tetracladium marchalianum* were free-floating algae and described them as varieties of his alga *Cerasterias raphidioides*. For many years, from 1895 to 1935, the fungus and the alga were involved in a bewildering synonomy that has only recently been settled (Karling, 1935).

To the aquatic Fungi Imperfecti, Kegel (1906) added a monotypic genus, *Varicosporium Elodeae*, that he found growing on some *Elodea* that had been used in an experimental study. In 1912, Grove added still another species to the group, *Tridentaria setigerum* (now *Tetracladium setigerum* (Grove) Ing.). From 1912 to 1942 matters lay in abeyance save for a few sporadic accounts of some of these six species which placed two of them within the continental limits of North America.

C. T. Ingold, while engaged in an investigation of another kind, observed a large number of fungus spores floating in the waters of a stream near

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[1] This paper presents a portion of a doctorate thesis completed at the University of California, Berkeley.

Leicester. He found that these spores came from fungi growing on decaying leaves in the stream. He then embarked on a long series of investigations (1942, 1943a, 1943b, 1944, 1949) of the fungus flora of these decaying leaves. He studied the development and the morphology of the spores in a most careful and meticulous way. Ingold's outstanding contributions, added to those of the earlier investigators, brought the total of fresh-water Fungi Imperfecti to sixteen genera and twenty-six species.

Virtually nothing was known about these organisms in North America except for an isolated account or two of *Tetracladium marchalianum* (Karling, 1935) and *Varicosporium Elodeae* (Bessey, 1939). It seemed of value, therefore, to discover the nature and distribution of the aquatic Fungi Imperfecti of California.

A survey was made of the fresh-water streams, lakes and ponds, both permanent and temporary, throughout the greater part of the state of California. Nearly all of the waters explored contained representatives of this group; the exceptions will be discussed later. Fifteen genera and twenty-two species were collected (Fig. 1); five of these species appear to be undescribed. The substratum proved to be quite variable but the fungi were found most commonly on leaves that had undergone considerable decay. Though a vascular system seemed to be necessary as a substratum, all gymnosperm material examined was void of these fungi.

1. *Collection and isolation.* The leaves, or other debris, best suited for collection were those in which decay had proceeded to the point where only the vascular system remained; leaves belonging to such genera as *Salix*, *Populus*, *Alnus*, *Acer*, *Platanus*, *Cornus*, *Fraxinus* and *Rubus* skeletonize well and are specially suitable for these aquatics. Even on leaves that do not skeletonize well, such as various species of *Quercus*, a number of aquatic Hyphomycetes was found. Although they occur in great abundance on leaf material, the aquatic Hyphomycetes are by no means entirely restricted to it. Maple samaras, peach stones, fern rhizomes, small twigs and decomposing sporophylls of *Isoetes*, onion scales and paper seemed to serve as well as leaves as substrata.

The collected material was brought into the laboratory and placed in crystallizing dishes partially filled with autoclaved tap or distilled water. In most instances, twelve to twenty-four hours later, large numbers of sporophores and spores were produced. Usually several species were represented on any one substratum. The spores, when shed, gradually settled to the bottom of the crystallizing dish. Using a Spencer Stereoscopic Dissecting Microscope with 15 X oculars and 3 X objectives, it was possible to pick up single spores with pasteur pipettes and transfer them to prune agar plates. Difco Prune Agar was used because it is a very clear medium and as such is ideal for microscopic examination of the planted spores through the bottom of the petri dish. At the end of twenty-four hours the plates were examined for germinated spores. Usually 100 percent germination had occurred and single germlings were cut out and transferred to a solid medium composed of 2 percent agar and 1 percent malt extract.

2. *Pure culture.* In those instances where the fungus grew more rapidly than the bacteria usually isolated with the spore, the bacterium-free hyphal tips were cut out and used to start pure cultures. If this was not the case, Raper's van Teighem ring technique (Raper, 1937) was employed. One rim of a van Teighem ring was notched to a depth of one or two millimeters in several places. The ring was placed in a petri dish with the notched rim on the bottom. The plates, after sterilization, were filled with malt agar to a level just above that of the notches. After the agar had solidified and all moisture on the glass surfaces had disappeared, the area confined by the ring was inoculated. The mycelium grew into the agar, through the notches and back to the agar surface again. Blocks of agar and mycelium cut from the growing edge of the colony were free of bacteria and were used to start pure cultures. Stock cultures were maintained on malt agar slants in test tubes two centimeters in diameter.

3. *Taxonomic criteria and definition of terms.* It is not the purpose of this work to delve into a profound and searching examination of the merits and demerits of the several systems of classification of the Fungi Imperfecti. Neither is it the purpose to erect a system of classification for the entire group of imperfects on the strength of an examination of a small number of specialized aquatics. It is necessary, however, to employ meaningful characters for the establishment of taxonomic criteria.

In the absence or relative rarity of the occurrence of sexual reproduction in the majority of Fungi Imperfecti, it is necessary to use the characters of the asexual reproductive structures. Thus it is the development and morphology of the asexual reproductive unit, the spore, that provides the basis for the taxonomic criteria. The greater part of these criteria were originally proposed by Vuillemin (1910, 1911) in which he discarded the saccardian system with its loosely used term "conidium" to a large extent. Vuillemin made a clear-cut distinction between conidiospores and thallospores and used this distinction as a point of departure.

According to Vuillemin (1910), the name "conidia" should be reserved for spores that are distinct from the mycelium from the beginning, i.e., they are not modifications of already existing hyphae. Conidia are also deciduous, i.e., they are set free from the conidiophore or the hypha that bears them as soon as they are mature. Thallospores, on the other hand, are at first a part of the vegetative system and are secondarily adapted to disseminative functions, i.e., merely enlarged or otherwise modified portions of already existing hyphae. Thallospores are also not deciduous and remain attached to the mycelium until decay of the latter sets them free. The thallospores were divided into three types, blastospores, hemispores and chlamydospores. In 1911, Vuillemin added a fourth type, the aleuriospore. The aleuriospore seemed to be an intermediate between the chlamydospore and the conidium and differed only in not being clearly set off from the hyphae from the beginning nor deciduous; in all other characters the aleuriospores were indistinguishable from conidia.

In the aquatic Hyphomycetes *all* of the fungi examined released their spores, as nearly as observation and germination studies could determine, as soon as the spores were mature. Thus it would appear that the aleuriospore is not a spore type to be found in this group if it were not for the fact that the remainder of Vuillemin's definitions and the amplifications made by Mason and Ingold of these definitions can be applied to many, if not all, of these fungi. The concept of the conidium and the aleuriospore was extended (Mason, 1933, 1937; Ingold, 1942) to include the insertion on and the manner of separation from the parent hypha. The conidium is inserted on the hypha by a surface less than the diameter of the hypha and the separating septum is formed just prior to the release of the conidium. The aleuriospore, on the other hand, is inserted on a surface equal in diameter to the hypha and is separated from the parent hypha by a septum that forms very early in the development of the spore. If these amendments of Mason and Ingold are accepted, the problem of differentiating between the aleuriospore and the conidium is not only greatly simplified, but a set of terms with ontogenetic implications is substituted for those less precise terms now in general use.

Great emphasis was placed by Vuillemin (1910) on the mode of attachment of the conidium. The conidium can be produced directly on the mycelium, or it may be borne on a differentiated conidiophore, or it may develop on or in a phialide. The phialide, as originally conceived and as regarded by Mason, Ingold and Langeron (1945), is conventionally described as a unicellular flask-shaped structure with a comparatively enlarged venter and a narrow, more or less attenuated, neck-like portion and bears conidia or a conidium (phialospore) at or within the tip. The sterigma of the Aspergillaceae provides a classical example of a phialide.

The terms that will be used in the body of the text are defined as follows:

*Spore*: A general term for the asexual reproductive bodies of the cryptogams.

*Sporophore*: The hypha that gives rise to the spore.

*Conidium*: A spore produced terminally on a hypha; the point of insertion is less than the diameter of the hypha that bears it and the septum which separates it from the hypha is formed just prior to its release.

*Conidiophore*: A differentiated hypha that bears conidia directly or phialides. When phialides are produced the conidiophore may be reduced to the phialide itself.

*Phialide*: A unicellular ampulliform structure which consists of an enlarged venter and a narrow neck-like portion and produces conidia at or within the tip.

*Phialospore*: A conidium borne on or in a phialide.

*Aleuriospore*: A modified terminal portion of a hypha that resembles and behaves like a conidium but is separated from the rest of the hypha by a septum formed very early in its development; the point of insertion is equal to the diameter of the hypha.

*Aleuriophore*: The hypha, relatively unmodified, that gives rise to the aleuriospores.

The initial separation into genera is based on the spore type, i.e., aleuriospores, conidia, chlamydospores. If, for example, Fungus A produces aleuriospores, Fungus B produces conidia and Fungus C produces its conidia on phialides, it follows that these three species must be placed in three separate genera regardless of the morphological similarity the spores may have to each other. In fact, if Vuillemin's system were to be followed more exactly, these three fungi would have to be placed in different orders.

A second criterion used to categorize genera is based on the manner of spore development. If both Fungus A and Fungus B produce spores with three lateral branches and in A the branches are produced simultaneously whilst in B the branches are produced successively, then these two fungi are assigned to different genera. As a third criterion, it follows that fungi having spores with branches should not be assigned to a genus characterized by fungi with spores unbranched. The nature and number of branches is also taken into consideration.

Using the criteria set forth above, it is possible to arrange the aquatic Fungi Imperfecti into seemingly natural groups.

## THE GENERA

All of the Moniliaceous aquatic Fungi Imperfecti have a well developed, branched, septate mycelium. When these fungi are observed growing on the natural substrata the hyphae are generally contained within the vascular system and only the sporophores and spores are seen; in nature the hyphae are colorless, in culture, however, pigments are produced by many of the species which either accumulates in the mycelium or diffuses out into the surrounding medium or both. The sporophores are simple or branched, more or less distinct from the mycelium, scattered and colorless, both in nature and in culture. In culture, depending upon the species, the sporophores may also be produced in dense clusters or tufts on sclerotia. The spores are one- to many-celled, branched or unbranched, and colorless, both in nature and in culture. Secondary fruiting bodies, pycnidia or sporodochia, were never observed in nature and were infrequent in culture.

There are now seventeen genera of the Fungi Imperfecti represented in the fresh-water flora of Britain and the United States; eleven of these genera have been added since 1940. Of the described genera and species of the aquatic Hyphomycetes, only six of the genera, *Varicosporium*, *Clavariopsis*, *Lemonniera*, *Tetracladium*, *Heliscus* and *Dactylella* have been placed in taxonomic keys and until recently two of them, *Heliscus* (Ingold, 1942) and *Dactylella*, were represented by terrestrial species only. Thus it is felt that a systematized arrangement of the genera of all the Hyphomycetes having aquatic species would be valuable in the identification of those genera that have never before been placed in such a key.

## KEY TO GENERA OF THE FRESH-WATER AQUATIC FUNGI IMPERFECTI

I. Spores aleuriospores
  A. Aleuriospores not branched
    1. Aleuriospores released by a rounding off process
      a. Aleuriospores clavate to limoniform to fusiform-eliptical ........................................................................................................ *Dactylella*
      b. Aleuriospores scolecosporus, sigmoid or falcate ..... *Anguillospora*
    2. Aleuriospores released by breakdown of separating cells
      a. Aleuriospores continuous with the aleuriophore, scolecosporus, sigmoid or falcate ........................................................................ *Anguillospora*
      b. Aleuriospores borne on stalk-cells on tips of aleuriophores; stalk-cells attached at a point some distance from either end of the spores; spores lunate or sigmoid ........................................................................ *Lunulospora*
  B. Aleuriospores branched
    1. Branches formed in succession
      a. Branches four or more
        (1). Aleuriospores dendroid with elongated main axes and secondary and tertiary branching .................................................. *Dendrospora* (not treated)
        (2). Aleuriospores of four divergent branches only ........................................................................................................ *Articulospora*
        (3). Aleuriospores of four divergent branches and one or more subspherical or oblong knobs situated at or near the point of divergence ........................................................................................................ *Tetracladium*
      b. Branches three or less
        (1). Aleuriospores consist of elongated axes, two or three lateral branches situated at different levels on the main axes..... *Tricladium*
        (2). Aleuriospores consist of elongated axes, three divergent branches from the same level at the lower end of the axes..... *Tricelophorus*
    2. Branches formed simultaneously
      a. Aleuriospores symetrical
        (1). Aleuriospores with clavate axes and three divergent branches from the apices ........................................................................ *Clavariopsis*
        (2). Aleuriospores with elongated filiform axes and two divergent branches midway on axes; spores shed by breakdown of separating cells ........................................................................................................ *Tetrachaetum*
      b. Aleuriospores asymmetrical, each consists of a large central cell with two divergent appendages and a lateral branch with two appendages ........................................................................................................ *Campylospora*

II. Spores conidia
  A. Conidia formed on phialides
    1. Conidia not branched
      a. Conidia spherical, tetrahedral or broadly fusiform ........................................................................................................ *Margaritispora* (not treated)
      b. Conidia scolecosporus, sigmoid ................................ *Flagellospora*
    2. Conidia branched
      a. Branches develop simultaneously
        (1). Conidia clavate with three divergent branches at the apices ........................................................................................................ *Heliscus*
        (2). Conidia consist of elongated axes with two lateral branches inserted side by side midway on the axes ........................ *Alatospora*
        (3). Conidia consist of four divergent branches only, inserted on the phialide at the point of juncture of the branches ........................................................................................................ *Lemonniera*
  B. First formed and terminal conidium only borne on a phialide, others pleurogenous

1. Conidia consist of elongated axes with two or three lateral branches on one side of the axis; tertiary branches from the laterals also one-sided........................................................................................................*Varicosporium* (not treated)

## DESCRIPTION AND DISCUSSION OF SPECIES

The discussion will be concerned with the morphology, including the phases of development of the spores from their initiation to maturity and release, and the behavior of these fungi in culture. At the end of the general discussion of each species, a short summary of the diagnostic characters will be given which will include only such characters as have been observed on the natural substrata. Since *Anguillospora longissima* (Sacc. & Syd.) Ing., *Clavariopsis aquatica* De Wild., *Lemonniera aquatica* De Wild., *Tetracladium marchalianum* De Wild., and *T. setigerum* (Grove) Ing. are better known than the other species and have been discussed in detail more than once in the past, they will be given only the most generalized treatment.

All drawings were made with the aid of a camera lucida from hanging-drop cultures prepared either from bits of agar strips from pure culture or from bits of decaying leaf material taken from nature.

### DACTYLELLA AQUATICA (Ing.) n. comb.

Though Ingold (1943) described this fungus under the binomial *Piricularia aquatica*, he was not at all certain that his choice of a genus was a good one. The reasons for transferring this species to the genus *Dactylella* will be discussed later in the section.

A fungus (Figs. 1 L, 2) differing, if at all, in few details from the organisms described and figured by Ingold was found on a skeletonized leaf collected by Dr. Lee Bonar in August of 1949 from the Klamath River in southern Oregon close to the northern boundary of California.

The unbranched sporophores are ordinarily short, usually no longer than 65 mu though an occasional sporophore will attain a length of 200 mu. The first spore, a truly terminal structure, is initiated by the formation of a clavate swelling at the tip of the sporophore (Fig. 2 C). The swelling is soon delimited from the sporophore by a transverse septum (Fig. 2 E). As the spore primordium continues to develop, the clavate form changes gradually to a limoniform one. During this change, a septum is usually formed somewhat below the region of greatest width (Fig. 2 F). A second septum is frequently formed just above the region of greatest widts as well, but ordinarily the spore is shed in the unequally two-celled condition. The spores often become three- or four-celled after they are shed but before germination. The spore, clearly an aleuriospore by Vuillemin's definitions, is shed by a gradual disarticulation and rounding off process at the basal septum.

As soon as the first spore is shed, a second is initiated in one of two observed ways. In the first, the process is like that described by Ingold, i.e., a slight elongation of the sporophore slightly to one side of the tip. Thus, after a series of spores, the sporophore may become somewhat scorpioid with barely discernible scars. In the second, the sporophore elongates through the scar left by the first spore (Fig. 2 B, D, H) and then a new spore is formed. Thus after a series of spores, the sporophore is similar in appearance to that of a Fusicladium sporophore with barely discernible circumscissile scars.

The fungus was isolated in pure, single-spore culture several times from the one collection made. On malt agar it formed a compact colony that was at first white and then, as it aged, became greenish-grey. After attaining a diameter of three or four centimeters, the colony became markedly zonate with alternating rings of greenish-grey and white mycelium. The thin, fluffy aerial mycelium also became greenish-grey. Also as the culture aged, the agar became yellow. At first this coloration was visible only in the center of the colony but soon the entire plate or slant became yellow. At no time were the fuscous aerial spores observed such as those described by Ingold. Since it is only during a very brief period that the brown aerial spores are produced, and since the American material agrees so closely with the fungus Ingold described, it is possible that the spores were formed and overlooked. When a slice of the colony was placed in water, perfectly normal sporophores and spores were formed. The spores germinated readily in water or on malt agar and behaved like those isolated from nature.

Whether Ingold is correct in his selection of a genus for this species or not, it is clear the fungus he collected and described and our fungus are the same species. As Ingold (1943, 1944) has pointed out this fungus is difficult to classify. The difficulty arises not so much from the fuscous vs. the colorless aquatic spores, which is a relatively minor matter, but from the nondescript nature of the sporophore and the generalized character of the spores. A case could be made for assigning this species to any one of a number of genera, viz., *Monacrosporium* Oud., *Ramularia* Sacc., *Dactylella* Grove as well as *Piricularia* Sacc.

When the original descriptions of the two best genera, *Piricularia* (Saccardo, 1880) and *Dactylella* (Grove, 1884), are consulted there seems to be little to choose between them. *Piricularia* was described as follows: "Hyphae biogenae subsimplices; conidia obclavato-pyriforma, 2 - pluriseptate, solitarie acrogena." *Dactylella*, on the other hand, was described as "Mucedinea, macronemea, saprophila. Hyphae fertilis erectiusculae, simplices. Sporae elongatae, solitarie acrogenae, pluriseptatae."

Though the chief differences between them, as described, are the habit and the shape of the spores, actual practice has tended to delineate these two genera more sharply. *Piricularia* has come to encompass those parasitic fungi (some species have been induced to produce spores in culture) with generally simple sporophores and acrogenous, obclavate, septate spores with a small abscission collar. *Dactylella* has come to encompass nematode-attacking (Drechsler, 1947, 1950) as well as those saprophytic fungi with simple sporophores bearing a single acrogenous phragmospore or several in succession; the spores in general vary from limoniform to fusiform-elliptical and may be two- to many-celled.

Since the species concerned is a saprophytic organism with simple sporophores bearing several acrogenous, limoniform spores in succession that have one or two transverse septa and no evidence of a basal abscission collar, it is proposed that this species be removed from the genus *Piricularia* and placed in the genus *Dactylella* as *D. aquatica* (Ing.) n. comb.

**Dactylella aquatica** (Ing.) n. comb.

*Piricularia aquatica* Ing., *Trans. Brit. Myc. Soc.*, Vol. XXVI, 107:1943.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores 15–65 mu long, 2.5–3.5 mu broad, simple, colorless. Aleuriospores limoniform, colorless, 20–30 mu long, 8–13 mu broad at the widest point; when uniseptate the septum is near the base, when biseptate the septa are near each end with the largest cell in the middle; aleuriospores produced in succession, first formed one truly terminal, secondary ones produced by scorpioid elongations of the aleuriophore or by terminal elongations, scars of former aleuriospores remaining.

### ANGUILLOSPORA LONGISSIMA (Sacc. & Syd.) Ing. and ANGUILLOSPORA PSEUDOLONGISSIMA n. sp.

*Anguillospora longissima* was found throughout the year on a wide variety of submerged and decaying angiosperm debris. It is very common in California and has been found in almost every collection. It is frequently the dominant fungus on the substratum.

De Wildeman (1893) collected and described a fungus under the binomial *Fusarium elongatum*. Since he was unable to culture it or find stages in the development of it other than the sickle-shaped spores and some faintly pigmented mycelium, the genus *Fusarium* seemed like a good choice. Saccardo and Sydow (1899) changed the name to *F. longissimum* since the specific epithet applied by De Wildeman had already been preempted. Ingold (1942) was the first to study the development and release of the spores as well as the first to culture it. He found that the spores, unlike those of a *Fusarium*, were aleuriospores and in addition were released by the breakdown of a specialized separating cell (Fig. 1 A). On the basis of the separating cell and the fact that the spores are aleuriospores whereas the spores of *Fusarium* are phialospores, Ingold made this fungus the type of a new genus, *Anguillospora*.

**Anguillospora longissima** (Sacc. & Syd.) Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 389: 1942.

*Fusarium elongatum* De Wild., *Ann. Soc. Belge Microsc.*, Vol. XVII, 40:1893.
*Fusarium longissimum* (De Wild.) Sacc. & Syd., *Syll.*, 1128:1899.

Submerged aquatic fungus with branched, septate mycelium, colorless. Aleuriophores simple or sparingly branched, colorless, bearing at the tips one spore. Aleuriospores terminal, colorless, sigmoid or falcate, scolecosporus, 150–350 mu long, 5–6 mu broad in the middle and tapering to 2.5–3 mu at the tips, 6–10 or more cells; separating from the aleuriophores by the breakdown of special separating cells at the ends of the aleuriophores.

That this fungus is not a *Fusarium* is clearly evident. That the separating cell is a good generic character is not so evident. A number of isolates, apparently of this species, were found to release their spores by a disarticulation and rounding off process at one of the septa near the end of the sporophore (Fig. 1 T). These isolates were otherwise but little different from the fungus described by Ingold. On malt agar they produced a dense whitish colony that soon became brownish- or greenish-black with a narrow white margin. No spores were formed aerially, but when a slice of the colony was placed in water, spores were produced in fairly large numbers on simple or branched sporophores more clearly differentiated than those of *A. longissima*. Only one spore was produced on each simple sporophore or on each branch. The spores germinated within a very few hours in water or on malt agar.

Thus, save for the absence of the separating cell, these fungi fit the generic characters for *Anguillospora* as established by Ingold. Rather than create a new genus on what seems to be only a species category, especially in view of the fact that Ingold himself (1949) has added a species without a separation cell to this genus, it is proposed that the genus *Anguillospora* be expanded to include these forms.

**Anguillospora** Ing.

Submerged aquatic fungi with branched, septate mycelium. Aleuriospores terminal, eel-like, septate, colorless, either separating from the aleuriophore by the breakdown of a separating cell or by a disarticulation and rounding off process at a septum at the end of the aleuriophore.

**Anguillospora pseudolongissima** n. sp. (Figs. 1 T, 3 A)

Submerged aquatic fungus with branched, septate mycelium, colorless. Aleuriophores branched or sometimes simple, colorless, 50–150 mu long, 3.5–4.5 mu broad. Aleuriospores terminal, colorless, sigmoid or falcate, scolecosporus, 50–100 mu long, 4.6–6 mu broad in the middle and tapering to 3–5 mu at the tips, 5–8 celled. Aleuriospores shed by a gradual disarticulation and rounding off process at one of the septa at the end of the aleuriophores.

Hab. On decaying and submerged leaves of *Salix* sp. in a creek near Bishop, Mono County, California.

*Anguillospora pseudolongissima* sp. nov.

Fungus aquaticus submersus, a mycelio ramoso septato, sine colore. Aleuriophorae sine colore, ramosae vel subinde simplices, 50–150 mu longitudine, 3.5–4.5 mu latitudine. Aleuriosporae acrogena, sine colore, sigmoideae vel falcatae, scolecosporae, 50–100 mu longitudine, medio 4.5–6 mu latitudine, utrinque ad 3–4 mu attenuatae, 5–8 cellulatae. Aleuriosporae a disarticulatione gradata parietis et turgescente cellularum contra septum aliquem apices aleuriophore.

Hab. In foliis submersis putrescentibusque *Salicis* sp. in rivulo prope Bishop, Comitate Mono, California.

For both *Anguillospora longissima* and *A. pseudolongissima*, colonies, arising from single-spore isolations, have produced some secondary sporulating structures. The exact nature of these is as yet in doubt. In certain cultures of *A. longissima* black pycnidia, 75–100 × 90–120 mu, of an irregular but globose shape, were found. The pycnidiospores formed were colorless oblong bodies measuring 2–2.5 × 3–3.5 mu. In certain cultures of *A. pseudolongissima* colorless phialides and phialospores were produced (Fig. 3 A). The phialides were flask-shaped; the venter at its widest diameter was about 4 mu and narrowed to about 1.5 mu at the neck. The phialides, when first formed, were without the neck-like portion. As the development proceeded a small protuberance would be formed which gradually elongated until an oblong structure, 2–2.5 × 6–6.5 mu, was produced above a narrow constriction which formed the neck. The wall at the apex of the oblong structure gave away and an oblong phialospore was extruded abruptly into the water. After the release of the first phialospore had taken place, another began its development in the bottom of the tube formed by the wall of the tip of the phialide after the release of the first phialospore.

It was thought that the phialospores and pycnidiospores were spermatia. However, matings between the two species and between different single-spore isolations of each species collected from several localities also proved unsuccessful. All attempts to germinate the phialospores and pycnidiospores were also unsuccessful.

## ANGUILLOSPORA GIGANTEA n. sp.

This species (Figs. 1 K, 3 B–G) was found only during the summer and early fall months on submerged and decaying cottonwood leaves and twigs. It does not appear to be a common species, and while it has been collected many times during this survey, it has only been found in the one locality. The simple sporophores, up to 65 mu in length, grow out into the water at right-angles from the veinlets of the leaves, either scattered or in dense tufts. Differentiation between the mycelium and the sporophore on one hand and the sporophore and the spore on the other is very difficult; these structures gradually blend into one another.

The spore begins its development as a slight swelling of the sporophore tip; it enlarges from 2.5 mu near the base to 5–6 mu near the tip and forms the spore primordium. Very early in its development, the spore primordium is delimited by a transverse septum (Fig. 3 B). As the spore primordium elongates, with growth more or less restricted to the terminal portion, cross-walls are formed and a curvature of the spore is brought about by the activity of the growing tip. The curvature is not always restricted to one plane so that when the spore is mature it is more or less sigmoid but generally less so than the spore of *A. longissima.* The spore is composed of six to ten cells, varies in length from 150–750 mu or more and is 5–6 mu in width in the middle and tapers gradually to 2.5–3 mu at the tips. The spore is shed in the same manner as *A. pseudolongissima.* There is only one spore, clearly an aleuriospore, formed on each sporophore.

The fungus was isolated in pure, single-spore culture. On malt agar a dense colony was formed with a thick cottony aerial mycelium. Shortly after the colony was established a very pronounced dark red pigment appeared and as the colony aged became a deep reddish-purple. Microscopic examination showed that the walls of the older hyphae were colored a reddish-brown and that the agar itself was stained purple. The aerial hyphae were less pigmented and appeared light pink in color. This pigment has not been observed in nature.

Aleuriospores are not produced on agar. When, however, a narrow slice of the agar colony was placed in water, aleuriospores were formed in great numbers in twelve to twenty-four hours on aleuriophores that arose from the cut surfaces of the older portions of the colony. The spores produced in culture were similar in every way to those formed in nature, except that the spores were generally shorter (150–300 mu) than those formed on the natural substratum. In culture irregular sclerotium-like bodies, formed of thick-walled and heavily pigmented hyphal cells were developed. When the sclerotia were placed in water a loose sporodochium was formed on each and large numbers of spores produced. The aleuriospores germinated readily in water or on malt agar and germ-tubes were formed by any or all of the cells of the spore.

**Anguillospora gigantea** n. sp.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores simple, colorless, up to 65 mu long, 2.5 mu wide, bearing only one aleuriospore. Aleuriospores terminal, colorless, sigmoid or falcate, scolecosporus, 150–750 mu long, 5–6 mu broad in the middle and tapering gradually to 2.5–3 mu at the tips, 6–10 celled; shed by a disarticulation and rounding off process of one of the terminal septa of the aleuriophore.

Hab. On decaying and submerged leaves and twigs of *Populus* sp. in an irrigation ditch near Walnut Creek, Contra Costa County, California.

*Anguillospora gigantea* sp. nov.

Fungus aquaticus submersus, mycelio septato, sine colore. Aleuriophorae sine colore, simpliciae, ad 65 mu longitudine, 2.5 mu latitudine, sporam unicam ferens. Aleuriosporae acrogenae, sine colore, sigmoideae vel falcatae, scolecosporae, 150–750 mu longitudine, medio 5–6 mu latitudine utrinque attenuatae gradatim ad 2.5–3 mu, 6–10 cellulatae; a disarticulatione turgescenteque cellularum ad aliquem cellulam terminalem sporophorae contiguarum liberatae.

Hab. In foliis et ramulis submersis putrescentibusque *Populi sp.* in fossa irrigationis prope Walnut Creek, Comitate Contra Costa, California.

## LUNULOSPORA CURVULA Ing.

Ingold (1942) first described this beautiful fungus (Figs. 1 V, 4 A–I) as the type and only species in his new genus *Lunulospora*. It has been found throughout the year and throughout the state of California especially during the spring and summer months.

The sparingly branched or occasionally simple sporophores project from the petioles and larger veins of the rotting leaves into the water and attain a length of 75–250 mu. The sporophore may have two or three branches, and at the tip of each branch it may bear three or four spores in varying stages of development. Spore formation is initiated by the production of a clavate cell some 12–14 mu in length and 2–4 mu in width that is soon delimited from the sporophore by a basal septum (Fig. 4 A, B). Shortly after the clavate cell is cut off, another septum forms 2–6 mu above the first one (Fig. 4 C). The upper cell is the spore primordium and the lower or stalk-cell behaves like the separating cell of *Anguillospora longissima* when the spore is mature. The spore primordium elongates by means of apical growth. When the spore primordium has about doubled its length, a second growing point differentiates at the base of the spore primordium and to one side of the place where the stalk-cell joins the body of the spore (Fig. 4 E–G). Both growing points elongate by means of apical growth but not always in the same plane so that a sigmoid crescent, 65–90 mu in length and tapering to 0.5–1 mu at the tips, is the result. The spore, clearly an aleuriospore is unicellular. At maturity the stalk cell breaks down and the spore is released.

While the first spore is developing on the sporophore tip, a second and third spore are often produced alongside the first and truly terminal one. This may be repeated several times and the apex of the sporophore takes on a clavate or platform appearance and may reach a width of 8–10 mu and support as many as five or six spores in various stages of development.

The fungus has been isolated several times in single-spore, pure culture. On malt agar a rather dense white colony was produced with little aerial mycelium. As the cultures aged, the older regions became a dark olive green or greenish-black in a very irregular manner, and the cultures sectored readily. Aleuriospores are not formed on agar. Abundant spore formation, however, occurred in twelve to twenty-four hours from the surfaces of a narrow strip of the agar colony that had been placed in water. These aleuriospores and aleuriophores were morphologically similar in every way to those formed in nature. After the fungus has been in culture for a few weeks, it has a tendency to become sterile. At first the spores isolated from culture would germinate readily in water or on malt agar; later on the spores would not germinate and still later spore production was considerably reduced and finally ceased altogether.

**Lunulospora curvula** Ing., *Trans. Brit. Myc. Soc.* Vol. XXV, 404:1942.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores simple or sparingly branched, 75–250 mu long, 3–4 mu broad. First aleuriospore truly terminal in linear extension of the aleuriophore, subsequent spores on an expanded apex of the aleuriophore. Aleuriospores colorless, lunate, sigmoid, unicellular, 65–90 mu long, 5–6 mu broad at the point of attachment, tapering to 0.5–1 mu at the tips; attached to a stalk cell at a point along the convex surface; liberated by the dissolution of the stalk-cell.

## ARTICULOSPORA TETRACLADIA Ing.

This fungus (Figs. 1 P, 5 A–G), the type species of the genus, was originally collected and described by Ingold (1942). It has been found in California from late spring through early fall on a wide variety of submerged decaying angiosperm debris. It was not, however, found in abundance. It may have been overlooked due to the superficial resemblance of its spores to those of several other species, viz., *Lemonniera aquatica*, *L. cornuta*, and *Tricelophorus monosporus*. The short sporophores, hardly 40 mu in length, were more often than not hidden by the growth of diatoms and other microorganisms so that it was usually only the spores that were observed. It was collected more by accident than by design. The studies were made on pure cultures of the fungus obtained by single-spore isolations.

On malt agar the colony consisted of a dense buff colored mycelial mat with a thick white or greyish aerial mycelium in large scattered tufts. Spores were formed only when a piece of the colony was placed in water.

The spore primordium, the first formed branch of the spore, is initiated by the cutting off by a septum of a terminal portion of a sporophore or a branch (Fig. 5 B, D). From the apex of the spore primordium the second branch of the spore is initiated much like the "bud" of a yeast cell (Fig. 5 B, C). The second branch, separated from the first by an isthmus and then by a septum is in the beginning on a straight line with the first. Close to the point of origin of the second branch and slightly to one side a new cell is budded out on the first branch (Fig. 5 D). As the third branch develops it displaces the second to one side so that at this stage the spore resembles a "Y." While the elongation of the second and third branches proceeds, the fourth is initiated in the same manner as the other two and more or less between the second and third branches (Fig. 5 E). The fourth branch in its development displaces to one side the third. Thus the mature spore consists of four divergent branches of which the second, third and fourth are separated from the first by narrow isthmuses and usually a septum as well. Ordinarily the branches become once or twice septate, particularly the first and second, before the spore is shed.

Usually, while the first spore is developing, a new spore is initiated in a bud-like fashion beside the original one; the process of development of the second spore is in no way different from the first. This process may be repeated indefinitely. Often, in culture, the second or third spore "bud" may develop into a lateral branch of the sporophore and become several cells in length, then the terminal cell becomes the spore primordium. The spores are liberated by disarticulation at the basal septum (Fig. 5 C, G). The spores are clearly aleuriospores.

**Articulospora tetracladia** Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 327: 1942.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores simple or sparingly branched, colorless, up to 40 mu long, 3–4 mu wide. Aleuriospores terminal, colorless, composed of four divergent branches; the first branch 17–25 mu long, 3–5 mu wide, 2–3 celled; the other three branches, of more or less equal length, 20–50 mu long, 3–4 mu wide, tapering to a narrow point, each separated from the first branch by a narrow isthmus 1.5 mu wide. The four branches arise in succession. Aleuriospores produced in succession from the tips of the aleuriophore and its branches but not basipetally.

### ARTICULOSPORA MONILIFORMA n. sp.

In the spring of 1947 in Calaveras County and again in the summer of 1949 in Sonoma County a different species of *Articulospora* (Figs. 1 N, 9 A–G) was found on submerged and decaying alder and willow leaves. This species was not very abundant on the leaves and has been collected only a few times. It is quite possible that *A. moniliforma* was overlooked for the same reasons that *A. tetracladia* was. The branched sporophores, often quite short and at most hardly exceeding 50 mu in length, were generally obscured by the growth of diatoms and other microorganisms. The fungus was successfully isolated several times in single-spore, pure culture and all observations were made on pure culture material.

On malt agar the fungus formed a dense, compact, dull orange colony with no cottony aerial mycelium. The surface growth consisted of a firm crust or a series of irregular small crusts of densely packed, intertwined globose hyphal cells filled with oil globules and small granules that apparently gave the colony its characteristic color. Spores were produced only when bits of the colony were placed in water. The spores and sporophores were identical with those found in nature. The spores followed the same basic pattern of development as *A. tetracladia*, but the sporophore and spore morphology were different.

The main axis of the sporophore is little differentiated from the vegetative hyphae. The distal portion of the axis and all of the lateral branches are composed of conspicuously clavate cells 10–15 mu in length and 5–6 mu in width at the distal ends and taper to 2.5 mu at the point of contact with the cells below them. Occasionally the individual cells are globose at both ends with a relatively narrow isthmus between the swollen portions.

The formation of the aleuriospores and the sequence of development of the branches are like those of *A. tetracladia*. The aleuriospores, however, are markedly smaller than those of either *A. tetracladia* or *A. inflata*. All four of the branches of *A. moniliforma* are more nearly alike in size and shape than are those of *A. tetracladia*. While the second, third and fourth branches of *A. tetracladia* are somewhat obclavate and are separated from the first formed one by narrow isthmuses, the first formed branch of *A. moniliforma* is conspicuously clavate and the other three are equally conspicuously obclavate. The proposed specific epithet was suggested by the pronounced swelling of the cells of the branches of the aleuriophore and of the unicellular branches of the aleuriospores which gives to the whole sporulating apparatus a beaded appearance.

**Articulospora moniliforma** n. sp.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores branched, colorless; lower unbranched portion 25–30 mu long, 2–2.5 mu broad; upper branched portion composed of clavate cells, 10–15 mu long, 5–6 mu wide tapering to 2.5 mu at the base. Aleuriospores terminal, colorless, composed of four divergent branches; first formed branch clavate, 13–16 mu long, 2.5–4 mu wide at greatest width; second, third, and fourth branches obclavate, 10–16 mu long, 3–4 mu wide, tapering to 1.5 mu at the tips, separated from the first branch by narrow isthmuses. The four branches arise in succession. Aleuriospores produced in succession at or near the tips of the aleuriophores but not basipetally.

Hab. On submerged and decaying leaves of *Salix* and *Alnus* spp. Stanislaus River, Calaveras County, California.

*Articulospora moniliforma* sp. nov.

Fungus aquaticus submersus, a mycelio ramoso, septato, sine colore. Aleuriophorae ramosae, sine colore, infra simplices, 25–30 mu longitudine, 2–2.5 mu latitudine, pars superiora aleuriophorae ramosae, compositae a cellulis clavatis, 10–15 mu longitudine, 5–6 mu latitudine ad basis attenuatis ad 2.5 mu. Aleuriosporae acrogenae, sine colore, a radiis divergentibus, radio primario clavato, 13–16 mu longitudine, 2.5–4 mu latitudine maxima, radiis certeris obclavatis 10–16 mu longitudine, 3–4 mu latitudine, utrinque attenuatis ad 1.5 mu a conjunctis cum radio primario constrictis, radiis quattuor ex ordine evolutis. Aleuriosporae ad apices ramulorum aleuriophorae prope limdem locim deinceps evolutae.

Hab. In foliis submersus putrescentibusque *Salicis* sp. et *Alni* sp. flumine Stanislaus, Comitate Calaveras, California.

TETRACLADIUM MARCHALIANUM De Wild. and T. SETIGERUM (Grove) Ing.

*Tetracladium marchalianum* De Wild. (Fig. 1 F) and *T. setigerum* (Grove) Ing. (Fig. 1 G) are probably the most common aquatic Hyphomycetes found in California. They are frequently found together on the same substratum in large numbers and in addition to a wide variety of angiosperm debris may be found on such substrata as *Marsilia* and decomposing *Isoetes*.

**Tetracladium marchalianum** De Wild. *Ann. Soc. Belge Microsc.*, Vol. XVII, 34:1893.

*Cerasterias raphidioides* Reinsch var. *inaequale*, *Notarisia*, Vol. III, 512:1888.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores simple or branched, bearing one to several aleuriospores at the tips in various stages of development. Aleuriospores consisting of four divergent branches up to 25 mu long, 2–3 mu wide at the base, tapering gradually to a point, and two knobs, more or less spherical or oblong, one- or two-celled, 2.5–5 mu broad and up to 6 mu long. One of the knobs is situated in the axil of the four branches and the other, usually the smaller, some distance out on a branch on the upper surface.

**Tetracladium setigerum** (Grove) Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 369:1942.

*Cerasterias raphidioides* Reinsch var. *incrassata*, *Notarisia*, Vol. III, 512:1888.

*Tridentaria setigera* Grove, *J. Bot.*, Vol. L, 16:1912.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores simple or branched, bearing one to several aleuriospores at the tips in various stages of development. Aleuriospores consisting of four divergent branches up to 35 mu long, 3 mu broad at the base, tapering to about 1 mu at the tips, and three knobs, fusiform-elliptical, 13–15 mu long, 2.5–3 mu wide, two- to three-celled. Two of the knobs situated in the axil of the branches and the other some distance out on the upper surface of one of the arms.

### TRICLADIUM SPLENDENS Ing.

This species (Figs. 1 U, 7 A–G) and type of the genus was found by Ingold and described by him in 1942. Though the fungus is a common one in England, it has been collected only four times in California and appears to be one of the rarer species in this locality.

The sporophores are little differentiated from the vegetative hyphae and are up to 65–75 mu in length. The spore primordium is formed when the terminal, clavate portion of a sporophore is delimited by a transverse septum (Fig. 7 A). The spore primordium increases in size by apical growth and forms the curved main axis of the spore. When the spore primordium is at the two- or three-celled stage, a lateral branch is initiated just below one of the septa (Fig. 7 C). The branch, at first similar to the "bud" of a yeast cell, enlarges laterally and elongates by apical growth more or less perpendicular to the main axis and tapers gradually to a point. The lateral branch, 32–60 mu in length and 5 mu broad near the base, is separated from the main axis of the spore by a narrow isthmus less than 2 mu in width. Not long after the initiation of the first lateral, a second branch is formed in the same manner as the first and usually from the next cell of the main axis (Fig. 7 E). The two lateral branches, though both originating on the convex side of the main axis, are not in the same plane and are somewhat divergent. The lateral branches usually become two- or three-celled. The mature spore, then, consists of a main axis that is more or less curved and two divergent branches separated from each other by a linear distance of some 15–20 mu, and each branch is separated from the main axis by a narrow isthmus. The spore, an aleuriospore, is shed by the disarticulation of the first formed septum usually and by the rapid rounding off of the cells on either side. Only one spore is produced on an aleuriophore or on each branch.

*Tricladium splendens* was isolated several times in pure, single-spore culture. The spores germinated readily in water and on malt agar; germ-tubes were generally produced from the tips of the branches and from both ends of the main axis though frequently other cells cooperated. On agar, almost from the first, a dense brownish-black colony was developed with a narrow white border; the colony was frequently inconspicuously zonate. Spores were not formed on agar but when a slice of the colony was placed in water, spores were produced in fair abundance in twenty-four to thirty-six hours. The majority of spores, in culture, agreed with those found in nature. Sometimes, however, large numbers of abnormal spores were developed, i.e., spores with only one branch so that a "Y"-shaped object resulted or spores without any branches. The abnormal spores, when cultured, produced colonies indistinguishable from those of normal spores and when placed in water the spores obtained behaved like those of the original isolates.

**Tricladium splendens** Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 385:1942.

Submerged aquatic fungus with branched, septate, colorless hyphae. Aleuriophores colorless, usually simple, 30–74 mu long, 3–4 mu wide. Aleuriospores terminal, colorless, consisting of an elongated curved main axis, 2–5 septate, 50–100 mu long, 5–6 mu broad, tapering to 3 mu at the tips, and two divergent branches arising from the convex side of the axis in different planes. Branches 15–20 mu apart, 32–60 mu long, 5 mu wide near the base and tapering to 1–2 mu at the tips, each separated from the main axis by a narrow isthmus less than 2 mu wide. Aleuriospores shed by disarticulation and rounding off of the cells on either side of one of the lower septa. Only one aleuriospore is produced on the aleuriophore or its branches.

## TRICLADIUM ANGULATUM Ing.

The second species of the genus (Figs. 1 B, 7 H–N), first described in 1942 by Ingold, was collected throughout the year in California. It was most frequently found from February through July and less commonly at other times. It is a very common fungus and often forms miniature forests of sporophores and spores over the surface of the substratum.

The sporophores range from simple ones to those with four or five branches and even the simple ones, after a time, become branched. The first formed spore, either on the main axis of the sporophore or on a branch, is truly terminal. A clavate extension of the sporophore is cut off by a transverse septum some 30–40 mu back from the tip and becomes the spore primordium (Fig. 7 H); it may at this time be already slightly curved or even sigmoid. Shortly afterwards a second septum is formed which cuts the primordium roughly in half. While the primordium continues to elongate by apical growth, an arm or branch is formed on the convex side of the spore axis and usually just below this second septum. Since this branch has a wide-angle base, the already curved spore axis is sharply bent at this point (Fig. 7 J–K). As development continues, another transverse septum is formed above the second, and just below this septum a second branch is initiated. The second branch, usually in a different plane from the first, has the same effect on the main axis as the first branch (Fig. 7 L). Thus the main axis of the spore is scorpioid and has two arms, not in the same plane, attached by a wide base (Fig. 7 M). The spore is released in the same fashion as *T. splendens*.

While the first spore is developing, a new clavate extension of the sporophore forms alongside it. The course of events followed during the maturation of the second spore is like that of the first. This process may be repeated several times so that at any one time, on any one sporophore, a number of spores in various stages of maturation may be found. The sporophore during this process takes on the same clavate or platform appearance of *Lunulospora curvula*. The spores are clearly aleuriospores.

The fungus has been isolated in pure, single-spore culture many times. The spores germinate readily in water or on malt agar. Germ-tubes were produced from the tips of the branches and the extremes of the main axis. A compact, creamy-white colony with no aerial mycelium was formed on agar. Spores were formed only when slices of the colony were placed in water; spore formation occurred in about twelve hours. Abnormal spores with only one branch, or no branches at all were occasionally formed in culture but germinated and formed colonies like the normal ones.

**Tricladium angulatum** Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 389:1942.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores colorless, simple to sparingly branched, 60–100 mu long, 3 mu wide. Aleuriospores terminal, colorless, branched, each consisting of a main axis, 45–60 mu long, 4–5 mu wide, tapering to about 2.5 mu at the tips and bent into an obtuse angle at the point of juncture of each branch. The two branches are not in the same plane. 25–35 mu long, 6 mu broad at the base and tapering to 2.5 mu at the tips and inserted on the main axis some distance apart. Aleuriospores produced in succession but not basipetally and shed by the disarticulation of the basal septum.

## TRICLADIUM GRACILE Ing.

Though this species (Figs. 1 M, 8 A–E) is described by Ingold (1942) as being common in Britain, it is one of the rarer species in California. It was found only a few times during the winter and spring months and never in abundance.

The development of the spore, an aleuriospore, is essentially like that of *T. angulatum* and to a lesser extent like *T. splendens.* Though agreeing with the other species in generalities, there are some specific differences and similarities between *T. gracile* on the one hand and *T. splendens* and *T. angulatum* on the other. There is only one aleuriospore on the aleuriophore as in *T. splendens.* The lateral branches of the spore are inserted on the scorpioid main axis by a broad base as in *T. angulatum.* The lateral branches are either equal in width throughout except at the base or only slightly tapering. The aleuriospores are very much larger than they are in either of the other two species.

*Tricladium gracile* has been isolated several times in single-spore, pure culture. On malt agar the fungus formed a dense, compact mycelial mat that was at first colorless but soon became a very dark greyish-brown with a light brownish aerial mycelium. The colonies were occasionally zonate. Though no spores were formed on agar, spores were formed in large numbers twelve hours after the colony was placed in water.

In some of the two-day-old hanging-drop cultures there was observed some small clusters of phialides grouped at the terminal regions of old aleuriophores or newly produced determinate hyphae; in each case a phialide was terminal (Fig. 8 E). The phialides and phialospores were similar in appearance and identical in behavior to those found in *Anguillospora pseudolongissima.* All attempts to germinate the phialospores failed. It was thought that they might be spermatia which might function when mated with the complementary strain. Using all of the available isolations in mating experiments, negative results were obtained in every case.

**Tricladium gracile** Ing., *Trans. Brit. Myc. Soc.*, Vol. XXVII, 38: 1944.

Submerged aquatic fungus with septate, branched, colorless mycelium. Aleuriophores simple, colorless, 75 mu long, 2.5 mu broad, bearing one aleuriospore. Aleuriospores colorless, septate, terminal, each consisting of a scorpioid main axis and two lateral branches situated at different levels on the main axis and usually in different planes; main axis 125–200 mu long, 5–6 mu broad between the lateral branches and tapering to 2.5 mu at the base and 1.5 mu at the apex, bent into a broad angle at the point of juncture of each branch; branches straight, generally even, 50–100 mu long, 1.5 mu broad, situated on the main axis 12–30 mu apart. Aleuriospore shed by disarticulation at the basal septum.

## TRICELOPHORUS MONOSPORUS Ing.

Originally described by Ingold (1943), this remarkable fungus (Figs. 1 H, 6 A–G) was found most commonly in California during the spring, summer and fall months on submerged and decaying angiosperm debris of all sorts. Though generally uncommon, it was found to occur in great abundance in certain localities and was sometimes the dominant fungus species.

The sporophores, little differentiated from the vegetative hyphae, are usually simple but may be branched once or twice. They vary in length from 20–150 mu and are between 1.5–2 mu in diameter. The initiation of the spore is first apparent in the formation of a small sub-spherical or oval swelling at the tip of the sporophore (Fig. 6 A). The swelling, the spore primordium, is soon delimited from the sporophore by a transverse septum. When the spore primordium becomes obclavate in shape, the beak-like terminal portion is cut off by a cross-wall from the subspherical basal cell (Fig. 6 B). The basal cell, 3.5 mu in width and 4–5 mu in length, undergoes no further increase in size. The terminal cell elongates by apical growth and reaches a length of 30–40 mu and tapers from about 3 mu at the base to about 1.5 mu at the tip. The terminal cell forms one of the four divergent branches of the spore (Fig. 6 D–G). While the terminal cell is still but little elongated, a small bud-like swelling, similar in appearance to the bud of a yeast cell, is formed on the equator or slightly below the equator of the basal cell of the spore primordium (Fig. 6 C).

By enlargement and terminal elongation, the bud becomes one of the three downward-directed branches of the spore. Shortly after the first branch is initiated and its elongation begun, a second bud is formed some 120 degrees away and in the same plane as the first (Fig. 6 D). A third downward-directed branch is initiated last in the same manner as the other two. Shortly after the elongation of the last formed branch is completed, the spore, an aleuriospore, is discharged by the disarticulation and rounding off of the cells on either side of the basal septum. Generally there are several spores produced on the sporophore, though in each case there is a short period of terminal growth of the sporophore following the release of each spore.

The fungus has been isolated in single-spore, pure culture many times. The aleuriospores germinated readily in water and on malt agar. Germ-tubes were formed from the tips of the divergent branches. On malt agar it grew very slowly, the colony at the end of four weeks was scarcely two centimeters in diameter. The colony was compact with no aerial mycelium. The older hyphae took on a dark brown color that was masked in the center of the colony by an ochraceous powdery layer that on examination proved to be spores. These aerial spores were similar in every way to those formed in nature and to those formed when the agar colony was placed in water.

**Tricelophorus monosporus** Ing., *Trans. Brit. Myc. Soc.*, Vol. XXVI, 148:1943.

Submerged aquatic fungus with septate, branched, colorless mycelium. Aleuriophores colorless, simple or sparingly branched, 20–150 mu long, 1.5–2 mu in diameter. Aleuriospores colorless, terminal, branched, consisting of a main axis and three downward-directed branches arising from a limoniform basal cell; main axis continuous with the aleuriophore, divided into two cells, the basal cell limoniform, 4–6 mu long, 3–3.5 mu wide, the terminal cell tapering from 3–3.5 mu wide to 1–1.5 at the tip, 30–40 mu long. The divergent branches 120 degrees apart arising from the equator of the limoniform cell, 25–30 mu long, 2–2.5 mu broad and tapering to about 1–1.5 mu at the tips, separated from the basal cell by abrupt isthmuses of about 1 mu in diameter. Aleuriospores shed by disarticulation at a basal septum.

## CLAVARIOPSIS AQUATICA De Wild.

This beautiful fungus (Fig. 1 R) was first collected and described by De Wildeman in 1895. It apparently escaped further notice until Ingold (1942) collected and figured it. As Ingold remarked, this fungus is extremely common and, excepting possibly *Anguillospora longissima* and *Tetracladium marchalianum*, it proved to be the most common aquatic Hyphomycete found in California. It was found throughout the year in great abundance on all sorts of angiosperm debris. Our fungus does not differ in any respect from that originally described by De Wildeman or from the organism figured by Ingold. Though De Wildeman was unable to secure the fungus in culture, Ingold was successful. He found that many isolates of the fungus produced pycnidia and sclerotia and a series of intergrading types of these structures. His attempts to germinate the minute oval pycnidiospores met with failure. Many of the California single-spore isolates also formed pycnidia and sclerotia. Here, as well, all attempts to germinate the pycnidiospores have failed. Perhaps the pycnidiospores, as perhaps those of *Anguillospora longissima*, are actually spermatia rather than propagating units, however, this aspect was not attacked. Many of the sclerotia, however, when placed in water produced sporophores and spores like those found in nature.

**Clavariopsis aquatica** De Wild., *Ann. Soc. Belge Microsc.*, Vol. XIX, 197:1895.

Submerged aquatic fungus with septate, branched, colorless mycelium. Aleuriophores colorless, simple, 50–200 mu long, 2–3 mu broad. Aleuriospores terminal, colorless, consisting of a clavate two-celled main axis, 35–45 mu long, 11–15 mu broad at the apex and tapering downward to 2.5–3.5 mu at the base, and three divergent branches, 40–80 mu long, 2–2.5 mu broad, even, arising equidistant from each other from the truncate apex. Aleuriospores shed by disarticulation at the basal septum, borne in succession but not basipetally.

## TETRACHAETUM ELEGANS Ing.

Ingold collected and described this organism (Figs. 1 I, 10 A–F), the type and only species of the genus, in 1942. Though it seems to be one of the common species in England, it is uncommon in California. It was found throughout the year but more often during the spring and summer months.

The sporophores of this fungus are simple, straight, 50–150 mu in length and 2.5–3.5 mu in diameter. The first indication of spore formation is the appearance of a transverse septum in the sporophore some 100 mu back from the narrowly clavate tip of the sporophore (Fig. 10 A–B). The growth in length of the spore primordium is by apical elongation. As maturation proceeds, a relatively large swelling appears on one side of the spore primordium a few microns back from the tip. The swelling causes the tip to be bent to one side (Fig. 10 C); the tip then continues to grow in this new direction. The swelling, now on the convex side, develops into two new growing points of equal size, side by side, on the same level, which make an angle of about 120 degrees with each other and with the tip of the spore (Fig. 10 D). These three growing points continue their apical growth at about the same rate with the spore tip slightly in advance until a tetraradiate spore is produced with a main axis, divided in half, and two branches and all parts of about the same length (Fig. 10 E–F).

Shortly after the initiation of the two secondary growing points a new transverse septum is formed about 5 mu above or below the septum that originally delimited the spore primordium (Fig. 10 E). This cell behaves exactly like the previously described separating cell of *Anguillospora longissima*. When the spore is mature, this cell breaks down and the spore floats away. For a brief period thereafter, a short collar may be seen remaining at the base of the liberated spore, an aleuriospore, and the tip of the aleuriophore (Fig. 10 F). When the spore is shed the spore-producing capacity of the aleuriophore is at an end.

The fungus has been isolated in pure, single-spore culture. The spores germinated readily in water or on malt agar. A number of germ-tubes were produced, usually from either end of the main axis and from the tips of the branches or occasionally several of the cells of the body of the spore cooperated. On malt agar there was formed a dense, creamy-white mycelium with or without a fluffy aerial growth. Spores were produced in culture only when a slice of the agar colony was placed in water. Spore formation was exceedingly abundant under these conditions. The aleuriospores and aleuriophores were identical in every way to those formed in nature.

**Tetrachaetum elegans** Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 337:1942.

Submerged aquatic fungus with septate, branched, colorless mycelium. Aleuriophores simple, colorless, 50–150 mu in length, 2.5–3.5 mu broad, each bearing one aleuriospore. Aleuriospores terminal, colorless, each consisting of a main axis 200–300 mu long, 1.5–2.5 mu wide, 4–6 celled, and two lateral, divergent branches, 100–150 mu long, 1.5–2.5 mu broad, situated side by side midway along the main axis. Aleuriospores released by the breakdown of separating cells 5–6 mu in length at the end of the aleuriophore.

## CAMPYLOSPORA CHAETOCLADIA n. gen., n. sp.

In November of 1948 on skeletonized maple leaves from a stream in Sonoma County and again in April of 1949 on a leaf too decomposed to identify from a melting snow freshet at Mineral, near Mount Lassen National Park, California, a most unusual and interesting fungus was collected (Figs. 1 Q, 11 A–M). The mycelium, like that of all the other fungi in this aquatic group, ramified throughout the secondary and primary veins of the leaves and only the sporophores and spores were visible.

The sporophores are very short, 10–20 mu in length and 2–2.5 mu in diameter; the sporophores, unbranched, appear to be no different from the vegetative hyphae. A short clavate swelling, some 10 mu in length, appearing at the tip of the sporophore, is the first indication of the spore primordium (Fig. 11 B). The clavate tip soon becomes conspicuously pyriform at which time the delimiting septum appears between the spore primordium and the sporophore (Fig. 11 C). Further enlargement of the spore primordium is in a lateral direction so that it soon resembles very closely the "crozier" apparatus of the Ascomycetes (Fig. 11 D). A septum then forms which divides the "crozier" into two cells, a basal cell and a terminal cell which are, as far as position goes, actually side by side (Fig. 11 E). The terminal cell then enlarges downward so that it appears pendent, while the basal cell enlarges upward and away from the terminal cell and becomes somewhat triangular in shape (Fig. 11 F). Four new growing points now appear almost simultaneously, one at each end of the pendent terminal cell, one at the uppermost and outermost point of the basal cell and the fourth on the basal-cell side of the septum that originally divided the spore primordium in half (Fig. 11 G–H).

The method of growth of these growing points is quite different from that which pertains in all the other aquatic Hyphomycetes investigated. Instead of growing out in a straight, perpendicular line, each of the growing points produces an appendage that is bent into a tight arc and almost the entire elongation of the appendages takes place in this position (Fig. 11 I–J). About two or two and one half hours before the spore is shed the appendages begin to straighten out (Fig. 11 K). When the straightening process is completed, the spore, an aleuriospore, is set free by the disarticulation of the basal septum (Fig. 11 L).

The aleuriospore is a multicellular structure. Each of the appendages, which superficially resemble the appendages on the cleistothecium of *Phyllactinia*, is set off from the main body of the spore by a transverse septum. The pedent portion that bears an appendage at each end is divided by one or more transverse septa exclusive of those which delimited the appendages; the pendent portion is actually a branch of the spore attached more or less transversely to the main body of the spore by a narrow isthmus. The large triangular basal cell is sometimes divided by one or more cross-walls so that one of the appendages arising from this "cell" appears to be at the end of a short branch (Fig. 11 L). The mature aleuriospore of this fungus, then, is an asymmetrical, multicellular branched structure with four unicellular divergent appendages. When the spore is shed, a second one is formed at the end of the sporophore following a slight elongation of the terminal portion of the sporophore slightly to one side of the site of the first spore (Fig. 11 M). Aleuriospores are produced in succession but not basipetally.

A number of single-spore, pure cultures were obtained from the material collected in Sonoma County. On malt agar an isabelline mycelium was produced with a large amount of fluffy greyish aerial mycelium. Occasionally rather closely compacted knots of hyphae were formed about 0.5 mm. in diameter in the aerial mycelium. Spores were not formed on agar. Even when slices of the agar colony were placed in water only a few spores were formed but similar in appearance to those found in nature. When these spores were planted on agar no germination occurred. Attempts to germinate these spores in hanging-drops also failed. It was found that after being in culture for about three weeks those few cultures that did produce spores no longer did so.

If text-figure 1, #18 of Ingold's paper on the aquatic Hyphomycetes (1942) is examined, it will be noticed that there is a striking similarity between this figure and the fungus just described and figured. Ingold listed that spore as one of unknown identity. While no claim is being made that these two are identical, it seems, on the basis of the structure of the spore Ingold figured, that it may very well fit into the same genus as the fungus here described. Ingold's figure shows an asymmetrical, multicellular spore with four divergent appendages and seems to have the main body of the spore branched as well. Until developmental studies can be made on that organism, the issue will, of course, be in doubt.

Since our fungus resembles no known described organism, it is proposed that it be made the type of a new genus, *Campylospora.* The name is suggested by the bent or "crozier-like" form of the spore primordium and the fact that the appendages of the spore are also bent into an arc during the course of their development.

**Campylospora** n. gen.

Submerged aquatic fungi with branched, septate, mycelium. Aleuriospores septate, colorless, asymmetric, consisting of a basal cell with two divergent appendages and a lateral branch with two divergent appendages.

**Campylospora chaetocladia** n. sp.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores colorless, unbranched, 10–20 mu long, 2–2.5 mu broad. Aleuriospores colorless, terminal, multicellular, each consisting of a basal cell 8.5–12 mu wide, 10–14 mu long, with two divergent appendages of approximately the same length, 35–50 mu long, 6–3 mu wide at the point of attachment to the basal cell and tapering to about 1.5 mu at the tips; and a lateral branch, 10–25 mu long attached perpendicularly to the transverse axis of the aleuriospore and bearing at each end an appendage similar in appearance to those on the basal cell. Aleuriospores produced in succession but not basipetally.

Hab. On decaying submerged leaves of *Acer* sp. in a stream in Sonoma County, California.

*Campylospora* gen. nov.

Fungi submersi aquatici a mycelio ramoso, septato, sine colore. Aleuriosporae setatae, sine colore, asymmetricae, a cellulo basale cum duo radiis divergentibus et ramulo laterale cum duo radiis divergentibus, composita.

*Campylospora chaetocladia* sp. nov.

Fungus aquaticus submersus a mycelio ramoso, septato, sine colore. Aleuriophorae sine colore, breves, simplices, 10–20 mu longitudine, 2–2.5 mu latitudine. Aleuriosporae sine colore, multicellulares, compositae a cellulo basale 8.5–12 mu latitudine, 10–14 mu longitudine, cum duo radiis subaequalis divergentibus in diversis angulis, 35–50 mu longitudine, 6–3 mu latitudine ad punctum a cellula basale affixum ad cacuminem ad 1.5 mu attenuata, et ramulo laterale, 10–25 mu longitudine in perpendiculum ad axem transversalem aleuriosporae affixus, ad apices alteruter radio ad eos cellulae basalae simile, ferens. Sporae deinceps evolutae, evolutio a elongatine paullo sporophorae subsecuta essens.

Hab. In foliis submersis putrescentibusque *Acer* sp. in rivulo, Comitate Sonoma, California.

## FLAGELLOSPORA CURVULA Ing.

*Flagellospora curvula* (Fig. 1 D, 12 A–F), the type of the genus, was collected and described by Ingold in 1942. Though common enough in England, it was collected only twice in California; both collections were made during April of 1949. It may be much more common than it appears to be. It was cultured more by accident than by design since the spores that were isolated were thought to be those of *Anguillospora longissima.*

In spite of the gross similarity that exists between the spores of *A. longissima* and *F. curvula*, the fungi are quite different in at least one important respect and several minor ones. On malt agar *F. curvula* makes a dense light-brown colony with a few wisps of aerial mycelium in the form of erect cords near the point of inoculation. Conidia are produced only when a slice of the colony is placed in water. It is assumed that these spores are similar to those formed in nature; they are in complete agreement with Ingold's drawings and photographs. The sporophores are relatively simple and possess a short unbranched basal portion, 50–75 mu in length and 2.5–3 mu in diameter, which bears at the tip a number of short branches. The branches either bear phialides or are themselves phialides. The phialides are somewhat clavate, 18–25 mu in length and about 3–4 mu in diameter near the apex and taper to 2–2.5 mu at the base. From the tips of the phialides are produced in succession sigmoid or crescent shaped non-septate conidia, 100–150 mu in length and 2–2.5 mu broad at the widest point and taper gradually to 1–1.5 mu at the ends. These conidia germinate well in water as Ingold has pointed out. It is, however, only a relatively small precentage that will grow well when planted on malt or prune agar.

Since *F. curvula* produces true conidia in the form of phialospores it is clear that Ingold was justified in excluding it from the genus *Anguillospora* on the grounds that the latter is founded on a fungus characterized by aleuriospores.

**Flagellospora curvula** Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 402:1942.

Submerged aquatic fungus with septate, branched, colorless mycelium. Conidiophores colorless, branched, bearing a number of phialides. Phialides clavate, 18–25 mu long, 3–4 mu broad near the apex, tapering downward to 2–2.5 mu at the base. Conidia colorless, sigmoid or lunate, non-septate, 100–150 mu in length, 2–2.5 mu broad in the middle and tapering to 1–1.5 mu at the tips; produced in basipetal succession on the phialides.

### FLAGELLOSPORA PENICILLIOIDES Ing.

The second species in the genus *Flagellospora* (Figs. 1 E, 12 G–K) was collected and described by Ingold (1944) in England. It has been found several times in California during the spring, summer and fall months of the year. It has been found principally on decaying and submerged willow leaves and on the leaves, twigs and samaras of maple.

The conidiophores are perhaps the most conspicuous feature of this species. They are well developed, much branched as a rule and are strikingly similar in structure to those found in the genus *Penicillium*. They frequently attain a length of 200 mu or more. The branches of the conidiophore terminate in clusters of six to eight bottle-shaped phialides. The phialides are 15–20 mu in length and 2.5–3 mu broad at the widest point and taper slightly both upward to about 1 mu and downward to about 1.5–2 mu at the base. From the tips of the phialides conidia are produced in basipetal succession.

The conidium begins its development as a finger-like process from the tip of the phialide (Fig. 12 G–I). Subsequent development consists primarily of increase in diameter and in length. Growth in length is not all in one plane so that the mature conidium is more or less sigmoid or lunate in shape. When the conidium is mature, a cross-wall is quickly formed at the base and the conidium is quickly shed. Ordinarily the conidia are one-celled when shed; shortly after release, but before germination, they become more or less equally two-celled.

The conidia germinated readily in water or on malt or prune agars. On malt agar, colonies from single-spore isolations formed a dense mycelial mat with some scanty aerial growth, much of which was aggregated into mycelial cords. When these were examined microscopically it was found that the cells of these strands had somewhat thicker walls and more oleaginous contents than the other hyphae. The colony was at first white, but soon became a deep reddish-brown and the agar itself soon took on this color. Only when slices of the colony were placed in water were conidiophores and conidia produced in any numbers. Occasionally conidiophores and conidia would be produced from the cut surfaces in petri dish culture. Spore formation occurred in about twelve hours after the mycelium was placed in water; the conidia and conidiophores were similar to those found in nature and arose for the most part from the mycelial cords. The sclerotia, observed by Ingold, were not seen.

In spite of Ingold's doubts in the matter, the genus *Flagellospora* seems to be a perfectly satisfactory choice for this fungus. The conidia of *F. curvula* and *F. penicillioides* are very much alike, i.e., unicellular when shed, sigmoid or lunate, and borne on phialides. The principal difference between the conidia is one of size. The difference in conidiophore structure, which to Ingold was the chief point of doubt, is a difference in degree rather than in kind. Merely shorten the unbranched basal portion of the conidiophore of *F. penicillioides* from 200 mu to something like 25–50 mu and the conidiophore of *F. curvula* is very closely approximated. On the whole, the genus *Flagellospora* seems to be a very good place for this fungus.

**Flagellospora penicillioides** Ing., *Trans. Brit. Myc. Soc.*, Vol. XXVII, 41:1944.

Submerged aquatic fungus with septate, branched, colorless mycelium. Conidiophores colorless, penicillioid, main axis 100–200 mu long, 3.5–5 mu broad, bearing branches of several orders and each terminating in a cluster of 6–8 ampulliform phialides, 15–20 mu long, 2.5–3 mu broad. Conidia sigmoid or lunate, colorless, 35–45 mu long, 2.5–3 mu wide in the middle and tapering to 1.5–2 mu at the ends; produced in basipetal succession from the phialides. Conidia when shed become two-celled.

## HELISCUS AQUATICUS Ing.

When Ingold first described this species (Figs. 1 J, 13 A–I) in 1942 he referred to it as one of the rarer aquatic Hyphomycetes. This is also the case with *Heliscus aquaticus* in California; it was collected only once in October of 1947 on a submerged and decaying leaf of *Cornus* sp.

The colorless conidiophores, which may be simple or sparingly branched, terminate in phialides; the simple conidiophores bear only one phialide. A small spherical swelling at the tip of a phialide is the first indication of the spore primordium (Fig. 13 D). This soon becomes either roughly cylindrical or clavate. The cylindrical primordia remain more or less the same diameter throughout, about 4 mu, whereas the clavate primordia, 20–30 mu in length and 2–2.5 mu broad at the base, expand upwardly so that the apex may measure 5–6 mu. Frequently from the apex of the spore primordium three short, divergent and abruptly tapering processes or branches, 2–8 mu in length, arise simultaneously. Our fungus seems to be even more polymorphic than the organism described and figured by Ingold; many of the spores are without any protuberances at all. As soon as the spore is mature, a cleavage line forms between the spore and the phialide and the conidium is shed. A new spore primordium begins its development immediately after the first conidium is shed (Fig. 13 F–G). Ordinarily when the conidia are shed they are unicellular, but shortly before germination, a transverse septum appears roughly midway along the length of the conidium; two or even three such septa are frequently formed. The conidia germinate very quickly after release.

In addition to the large submerged conidia, it was observed that occasionally a phialide would produce a small oval "microconidium," 2–6 mu long and 1.5–3 mu wide, between successive macroconidia (Fig. 13 G–I); this was especially true in culture. The "microconidia" were of great variability, not only as to size but also in the ability to germinate. The larger ones with more or less homogeneous contents germinate as quickly as the macroconidia. The smaller ones, 2 × 1.5 mu, had a small refractile globule at each end of the spore and were not observed to germinate. How much of this behavior is a result of nutrition and other conditions is impossible to state at this time.

A number of pure, single-spore cultures were obtained from the original collection.

On malt agar this fungus produced a light brown mycelial mat with a fluffy cream colored aerial growth. In contrast with Ingold's collections, our fungus grew rather poorly on malt agar. When a slice of the colony was placed in water conidia were produced in great numbers. These conidia differed from those observed in nature merely in the higher proportion of conidia without protuberances.

When the cultures aged, conidia were produced aerially in two ways. In certain cases conidiophores or even just phialides arose on the aerial hyphae and formed conidia. On much older cultures, six to eight weeks, sclerotial bodies were formed in the agar. The sclerotia were composed of thick-walled, densely pigmented and tightly packed globose cells. From the sclerotia conidiophores arose in sufficient numbers to form a rather loosely organized sporodochium. It is interesting to note that almost without exception the aerial conidia were without protuberances; at most they displayed only some small irregularity of form at the terminal ends (Fig. 13 A). It is also interesting to note that a large number of the aerial conidia were composed of many more than two cells each.

Chlamydospores were frequently found in the older cultures. In general they were spherical, 10 mu in diameter, and terminal on relatively short hyphal stalks. Occasionally they were intercalary or in short chains. The wall was smooth and yellow-brown in color and relatively thick. The contents were conspicuously oleaginous in character (Fig. 13 B). So far attempts to germinate these chlamydospores have failed. It is likely, however, that these spores serve as a hold-over mechanism during dry periods.

As Ingold (1942) has pointed out, *Heliscus aquaticus* resembles very closely *H. lugdunensis* Sacc. & Therry (Saccardo, 1880) which was found growing on pine bark. This similarity is expressed both in the general shape of the conidia, i.e., clove-shaped, and in the formation of sporodochia, though for *H. aquaticus* the sporodochium-formation seems to be a function of the cultural conditions and has not been observed in nature. It is also probable, from the published figures, that the conidia of *H. lugdunensis*, though no developmental details were given, are produced on phialides. In the light of the aquatic habitat and the high proportion of two-celled spores produced in nature and in the short instead of the elongated terminal protuberances, it seems reasonable to maintain *H. aquaticus* as a species distinct from *H. lugdunensis*. The recent paper by M. and Mme. Fernand Moreau (1949) seems to support this idea though these investigators were convinced that they were dealing with *H. lugdunensis*. It is quite clear from their figures and descriptions that their fungus and the California specimen are the same. It is also more than likely that the polymorphism of the spores, observed by Ingold, Moreau and myself, is largely a function of cultural conditions.

**Heliscus aquaticus** Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 367:1942.

Submerged aquatic fungus with branched, septate, colorless mycelium. Conidiophores colorless, short, simple to sparingly branched, 50 mu long, 2.5–3 mu broad, bearing one or more phialides 25–40 mu long, 3.5 mu wide at the base and tapering gradually upwards to 1–1.5 mu. Submerged macroconidia, colorless, cylindrical or clavate, 20–30 mu long, 5–6 mu broad at the apex, two celled, usually bearing at the apex a corona composed of three short, abruptly tapering, divergent protuberances, 2–8 mu long. Submerged microconidia, colorless, oval, 2–6 mu long, 1.5–3 mu wide, produced on the same conidiophores with and alternating with the macroconidia. Aerial conidia colorless, macro- and microconidia; macroconidia cylindrical, or clavate, 30–40 mu long, 5–6 mu broad, usually without terminal corona. Conidia produced in basipetal succession.

## ALATOSPORA ACUMINATA Ing.

Ingold collected and described this species (Figs. 1 C, 13 J–P) as the type of a new genus. Though common in England during the winter and spring months, it was only found during the spring and summer months in California. It was never found in great quantity and then only on skeletonized leaves. Since the conidia are relatively delicate in structure, it is quite possible that the organism was overlooked more often than not.

The short conidiophores, 10–20 mu in length and 2.5 mu in diameter, are generally simple but may be sparingly branched and bear one to several bottle-shaped phialides similar to those of *Flagellospora penicillioides*. A narrow, filiform extension from the apex of the phialide becomes the spore primordium (Fig. 13 J–K). When the spore primordium attains a length of some 20–30 mu it becomes somewhat clavate and begins to exhibit a slight curvature. As apical growth continues, this curvature becomes more and more marked so that eventually a wide angle bend, some 220 degrees, is formed (Fig. 13 L–N). At a stage when the curvature is well marked and a short distance back from the growing tip, two new growing points arise side by side on the convex side of the axis (Fig. 13 J). The growing points develop into two lateral, divergent branches, 18–25 mu in length and taper to very fine points (Fig. 13 O–P). When the unicellular conidium is mature, a transverse wall quickly forms between the conidium and the phialide and the conidium is released. As soon as the conidium is shed a new one begins to form at the apex of the phialide (Fig. 13 L–N).

While the form and development of the conidium of *Alatospora acuminata* is like that of the spore of *Tetrachaetum elegans*, these two species should be ranked in different genera since the spore of the first is a phialospore (conidium) and the spore of the second is an aleuriospore.

The species has been isolated several times in pure, single-spore culture. On malt agar the fungus formed a dense, tough brownish colony of septate, branched hyphae with no aerial mycelium. No conidia were formed on agar and when a slice of the colony was placed in water conidium production was very scanty and frequently lacking. After the cultures were more than a few weeks old, spores failed to form at all, even if they had once done so. Such conidia as were formed in culture, however, were identical to those found in nature.

**Alatospora acuminata** Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 381:1942.

Submerged aquatic fungus with branched, septate, colorless mycelium. Conidiophores colorless, 10–20 mu long, 2.5 mu broad, simple or sparingly branched, terminated by one or several ampulliform phialides, 15 mu long, 2.5 mu broad. Conidia unicellular, colorless, each consisting of a main axis, 38–45 mu long, bent in the middle, tapering from 2.5 mu in the middle to a fine point at each end, and two divergent, tapering branches 10–25 mu long arising at the same level on the convex side of the main axis. Conidia produced in basipetal succession on the phialides.

## LEMONNIERA AQUATICA De Wild.

In the same collections of algae made in the Botanical Garden at Nancy in which De Wildeman (1894) discovered *Tetracladium marchalianum* was also found this beautiful fungus, the type species of the genus. Ingold (1942) also found it and included it in his papers on the aquatic Hyphomycetes. It is extremely common in California; it was found throughout the year on a wide variety of submerged and decaying angiosperm debris. The morphology and developmental sequences of conidiophore and conidium agree exactly with the descriptions and figures of De Wildeman and Ingold.

*Lemonniera aquatica* (Fig. 1 O) was isolated many times in pure, single-spore culture. It grows slowly on malt agar but the majority of isolates exhibited the cultural characteristics described by Ingold. There are, however, two other cultural types. In the first, which otherwise agrees with Ingold's cultures, there is also a deep reddish-brown pigment, diffused out into the agar, as well as a sprinkling of brownish-black sclerotia, both on the surface and submerged in the agar. When a slice of this colony is placed in water conidiophores and conidia are produced scattered over the surface of the colony and from the sclerotia. In the second type of divergent colony there is little if any brownish pigment, either in the mycelium or diffused out into the agar. There is, however, a copious production of hard, irregular, black sclerotia over the surface of the agar. The sclerotia, often confluent, are roughly arranged in concentric rings about the point of inoculation. When slices of this type of colony are placed in water, conidiophore- and conidium-production is almost entirely limited to the sclerotia. Generally in all three types, when single spore inoculations are made, the parental type of colony is maintained. In some, however, there occurs a spontaneous sectoring out of any one or both of the other two types which indicates a heterocaryotic condition.

**Lemonniera aquatica** De Wild., *Ann. Soc. Belge Microsc.*, Vol. XVIII, 143:1894.

Submerged aquatic fungus with branched, septate, colorless mycelium. Conidiophores penicillioid, colorless, branched, 100–400 mu long, 4–6 mu broad, bearing at the tips of the branches a number of ampulliform phialides, 20–30 mu long, 5–7 mu broad at the widest point. Conidia colorless, each consisting of 4 more or less equal divergent branches, 50–120 mu long; one of the branches is in parallel continuation of the longitudinal axis of the phialide; conidia attached at the point of union of the four branches to the phialides. Conidia produced in basipetal succession.

## LEMONNIERA CORNUTA n. sp.

A second and distinct species of this genus (Figs. 1 S, 14 A–J) was found throughout the year on a wide variety of submerged and decaying angiosperm material. It is one of the more common aquatic Hyphomycetes, especially in the late summer and fall months, in California. It is frequently found growing with *L. aquatica.*

The conidiophores are very well developed, varying in length from 50 to 600 mu or more and 5–6 mu broad, and are similar in structure to the Asymmetrica-Divaricata grouping in the Penicillia. Each branch of the conidiophore terminates in a number of bottle-shaped phialides similar in structure to those of *L. aquatica.*

A small spherical swelling at the tip of a phialide is the first indication of conidium-formation (Fig. 14 B). The spherical swelling soon becomes quite flattened at the apex to form an inverted tetrahedron. The tetrahedron quickly resolves itself into four growing points that develop simultaneously and are situated almost at right angles to each other and transverse to the longitudinal axis of the phialide (Fig. 14 C–D). For a very short time the growing points grow in a straight line and in the same plane. Then one oppositely directed pair of growing points begin to grow in an upward direction and the other pair, 90° away, begin to grow downward (Fig. 14 E–H). When the conidium is fully grown, a transverse septum quickly forms between the phialide and the conidium and the release of the spore occurs. As soon as the conidium is shed another one begins its development from the apex of the phialide (Fig. 14 A–B). Ordinarily the branches of the conidium are non-septate when it is shed; soon afterwards one or more septations appear in each branch. The mature discharged conidium is a multicellular, tetraradiate structure in plan with each opposite pair of branches curved in opposite directions like two crescent moons back to back and at right angles to each other.

*L. cornuta* has been isolated in pure, single-spore culture several times. In general the colonies on malt agar resemble the majority of colonies of *L. aquatica,* i.e., a brown mycelial mat with isabelline aerial mycelium and myceliae cords composed of hyphae with inflated cells. Some of the colonies, on the other hand, developed roughly concentric rings of dark brown sclerotia that were similar in behavior to those found in *L. aquatica.* In culture conidia were obtained only when a slice of the colony was placed in water; in twenty-four hours large numbers of conidia were produced, not only from the ordinary conidiophores on the hyphae but from the sclerotia if present. The conidia and conidiophores were similar in all respects to those found in nature.

**Lemonniera cornuta** n. sp.

Submerged aquatic fungus with branched, septate, colorless mycelium. Conidiophores colorless, penicillioid, consisting of an unbranched basal portion, 50–600 mu long, 5–6 mu broad, terminating in a number of branches each bearing a number of ampulliform phialides, 20–30 mu long, 5–7 mu broad at the widest part. Conidia consisting of 4 divergent branches, usually septate, approximately equal in length, 30–45 mu long, 3–5 mu wide at the base and tapering to 2.5 mu at the tips; each pair of branches curved in opposite directions; inserted on the phialide at the point of divergence of the branches, the branches at right angles to the longitudinal axis of the phialide. Conidia produced in basipetal succession.

Hab. On submerged and decaying leaves and twigs of *Salix* sp. and *Quercus Kellogii* in Putah Creek, Napa County, California.

*Lemonniera cornuta* sp. nov.

Fungus aquaticus submersus, a mycelio septato, ramoso, sinecolore. Conidiophorae sine colore, habitii Penicillii, stirpe simplice, 50–600 mu longitudine, 5–6 mu latitudine, deliquescente in plurisibus ramulis, omnibus ferentibus phialides ampullaceous 20–30 mu longitudine, 5–7 mu latitudine maxima. Conidia dienceps e phialidibus evoluta. Conidia sine colore, radiis divergentibus, fere septatis, subaequallis, 30–40 mu longitudine, 3–6 mu latitudine basin, ad cacuminem ad 2.5 mu attenuatis; hoc par radiorum perpendiculare divergente, inflectum, ab altera pare; in phialidum ad punctum divergentiae radiorum affixis, radiis ad perpendiculum ad axem longitudinalum phialidis.

Hab. In foliis et ramulis submersis putrescentibusque *Salicis* sp. et *Querci Kellogii* in rivulo Putah, Comitate Napa, California.

## DISCUSSION

The fungi studied were limited to the moniliaceous, fresh-water forms, i.e., whatever the pigmentation of the mycelium, the spores and sporophores were colorless. No attempts were made to study any of the observed dematiaceous forms nor those Hyphomycetes in marine or brackish-water habitats. With one exception, *Dactylella aquatica*, all collections were made within the boundaries of the state of California.

California contains areas of great climatic diversity. These range from the Colorado-Mohave deserts with an annual rainfall of five inches or less to the Redwood Coastal Belt in the northwestern part of the state with an annual rainfall of 25 to 122 inches and to the timberline and true alpine areas with a mean temperature of 40° to 50° F. and an average rainfall of 50 to 70 inches. The bodies of fresh-water in the state are also highly variable. Rivers vary all the way from the navigable to the highly temporary ones in which the chief characteristics are a boiling yellow flood following a brief period of rain and a thin trickle or no water at all during the rest of the time. The same situation pertains to streams and creeks. Lakes are less variable but some are dry for prolonged periods. Many lakes, streams and ponds, especially in the southern portions of the state are quite alkaline and warm. Collections were made from as many geographical and climatic regions as possible with the following counties covered (Fig. 15):

Napa
Alameda
Contra Costa
Marin
Solano
Madera
San Joaquin
San Bernardino
Inyo
Mono
San Diego
Santa Barbara
Mendocino
Fresno
Glenn
Monterey
Tehama
Siskyou
San Mateo
Modoc
Sonoma
Del Norte
Tuolumne
Klamath (Oregon)
Shasta
Tulare
Los Angeles
Humbolt
Placer
Calaveras

With the exceptions of the collections made from creeks and ponds in the Mohave Desert (San Bernardino Co.), Death Valley (Inyo Co.), Shoshone (Inyo Co.) and Lone Pine (Inyo Co.) in which the alkalinity was too high, all collections revealed the presence of these fungi. It was also found that the same species occurring in the relatively warm streams of San Diego and Los Angeles Counties were also present in the melting snow freshets of Mount Lassen and in temporary and permanent streams, lakes and ponds everywhere. Far from being restricted either to North Temperate Europe or to Northeastern United States, they may very well be world wide in their distribution.

One of the most remarkable features of the aquatic Hyphomycetes is the bizarre and often spectacular shape of the spores. The majority of these fungi are characterized by branched spores, whereas only a few genera, *Margaretispora*, *Flagellospora*, *Anguillospora*, *Lunulospora* and *Dactylella*, are characterized by unbranched spores. Of this group, three of them, *Flagellospora*, *Anguillospora*, and *Lunulospora* are characterized by the production of elongate, sigmoid spores.

With such a high proportion of branched and elongate sigmoid spores represented in this group, it would seem that there is an advantage in possessing one or the other of these shapes. While it is easy to read more into a structure than is actually there, two feasible explanations present themselves without straining credibility too much: a, the coming to rest on a suitable substratum and b, the dispersal of the organism.

It is quite probable that the branched or sigmoid form is of great advantage in the anchoring of the spore to a suitable substratum, especially if the substratum is a decomposing or skeletonized leaf. The spore would submit readily to entanglement with the shreds of veinlets or with the remnants of the parenchyma still clinging to the veins. Ingold has extended this advantage downward to the sporophores themselves, i.e., the sporophores elevate the spores sufficiently to allow them to be carried away by the water currents without being trapped at the source. This is a very reasonable supposition and is probably quite true for the majority. However, if so, it would seem that this "purpose" is defeated in *Alatospora acuminata*, *Campylospora chaetocladia* and *Articulospora moniliform* with their very short sporophores.

The entanglement process seems to be materially aided by another factor exhibited by many of the species. This is the formation of appressoria very soon after the spore has come to rest; this factor is strikingly apparent in *Anguillospora longissima* and *Clavariopsis aquatica*, for in water cultures of these two species the spores form appressoria almost as soon as they have come in contact with the bottom of the culture dish and within a few minutes are firmly attached to the bottom of the dish.

In considering the advantage of the branched and sigmoid spores with respect to the ease with which they may be trapped on the substratum, it must be borne in mind that this advantage may be more apparent than real. The unbranched spores of *Dactylella aquatica* and the unbranched spore forms of *Heliscus aquaticus*, for example, germinate within a very few hours, as do all the spores in this group. The germ-tubes produced are quite capable of performing the same functions attributed to the branches of the branched spores, an observation that is borne out by the examination of any water culture of these fungi.

When one considers the problem of dispersal, one is reminded of the situation that exists in the saltwater Peridinaceae. Here there is a correlation between the length of the appendages and the density of the water. The warmer the water, and therefore less dense, the longer are the appendages of these peridinaceous organisms and the colder the water the shorter are the appendages. This is apparently a mechanism to maintain a resistance balance with the water that acts as an aid in floating. Thus one of the more important features of the branched and sigmoid form of the aquatic Hyphomycetes is the resistance that these shapes offers to the movement of water. As observed in water cultures, these spores float very efficiently and are doubtless carried long distances by the movement of water in the natural habitat.

Many of the California water courses are dry for the greater part of the year. During the early spring months, however, collections of suitable material from these temporary streams and ponds revealed the presence of many aquatic Hyphomycete species. There is, then, some sort of efficient "holding-over" mechanism. With sclerotia in several species and chlamydospores in at least one, this is not so surprising. When skeletonized leaves were collected, either from stream beds or ponds several months after the water had evaporated or from debris left behind by the floods, and placed in water, it was found that sporophores and spores were formed in large numbers in about forty-eight hours. The interesting fact was that it was *Anguillospora longissima* and not the sclerotial forming species that was the dominant and frequently the only species present. What the "holding-over" mechanisms are here is not yet known. It is assumed for want of other evidence that it is the thicker-walled, more densely pigmented hyphae, such as are formed in culture, that act to hold the organism over until favorable conditions return.

## ACKNOWLEDGMENTS

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**Fig. 1.** The aquatic Hyphomycetes found in California are represented as growing on a single, hypothetical substratum. The substratum is represented by the irregular line at the bottom.
**A.** *Anguillospora longissima* (Sacc. & Syd.) Ing. **B.** *Tricladium angulatum* Ing. **C.** *Alatospora acuminata* Ing. **D.** *Flagellospora curvula* Ing. **E.** *Flagellospora penicillioides* Ing. **F.** *Tetracladium marchalianum* De Wild. **G.** *Tetracladium setigerum* (Grove) Ing. **H.** *Tetracladium monosporus* Ing. **I.** *Tetrachaetum elegans* Ing. **J.** *Heliscus aquaticus* Ing. **K.** *Anguillospora gigantea* n. sp. **L.** *Dactylella aquatica* (Ing.) n. comb. **M.** *Tricladium gracile* Ing. **N.** *Articulospora moniliforma* n. sp. **O.** *Lemonniera aquatica* De Wild. **P.** *Articulospora tetracladia* Ing. **Q.** *Campylospora chaetocladia* n. sp. **R.** *Clavariopsis aquatica* De Wild. **S.** *Lemonniera cornuta* n. sp. **T.** *Anguillosporo pseudolongissima* n. sp. **U.** *Tricladium splendens* Ing. **V.** *Lunulospora curvula* Ing. × 400.

fig. 1

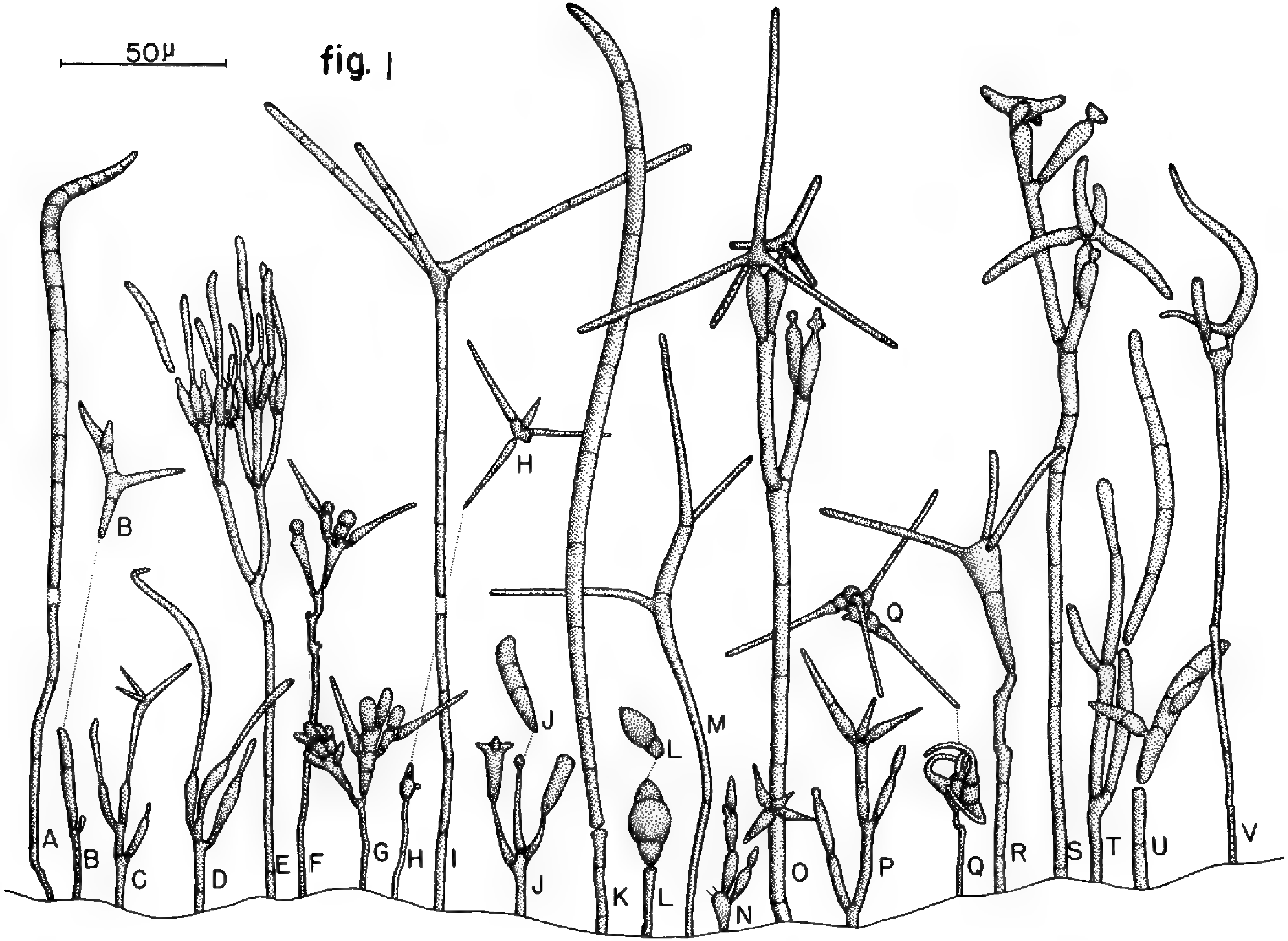
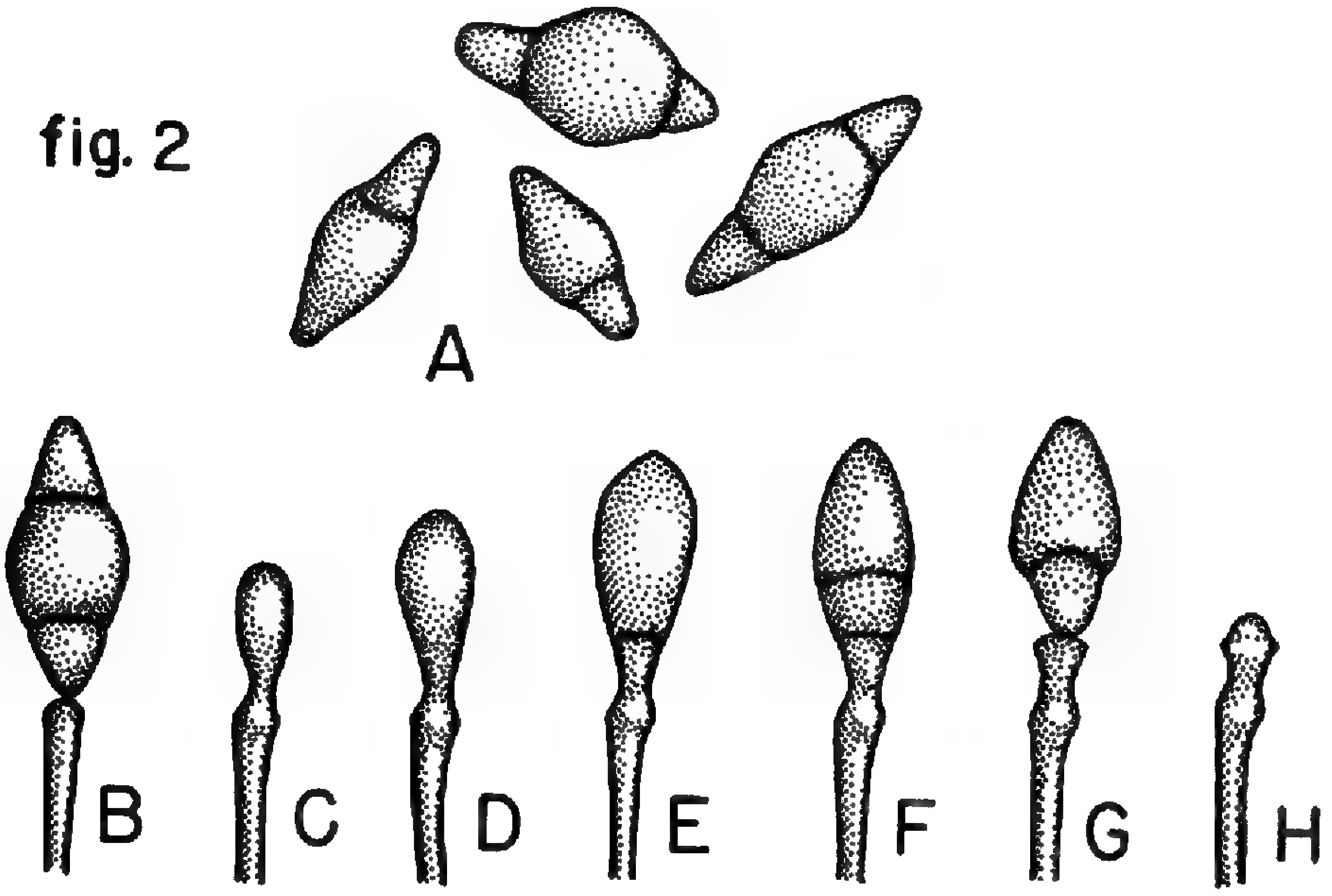


**Fig. 2. A–H.** *Dactylella aquatica* (Ing.) n. comb.

**A.** Mature aleuriospores. **B–H.** Stages in the development of an aleuriospore. **B.** Mature aleuriospore at the time of release. **C.** The spore primordium at 11:50 A.M. **D.** 1:15 P.M. **E.** 2:25 P.M. **F.** 3:15 P.M. **G.** The release of the mature aleuriospore at 4:10 P.M. **H.** The sporophore beginning to elongate prior to the formation of a new spore. From a hanging-drop culture of the fungus growing on a decayed leaf. × 700.

**Fig. 3. A.** *Anguillospora pseudolongissima* n. sp., showing the phialides and phialospores. **B–G.** Stages in the development of the aleuriospore of *Anguillospora gigantea* n. sp. **B.** An early stage in the development of the spore primordium. **C.** The spore primordium at 10:15 A.M. **G.** The mature aleuriospore at the time of release, 5:38 P.M. From hanging-drop, pure cultures. × 700.

fig. 2



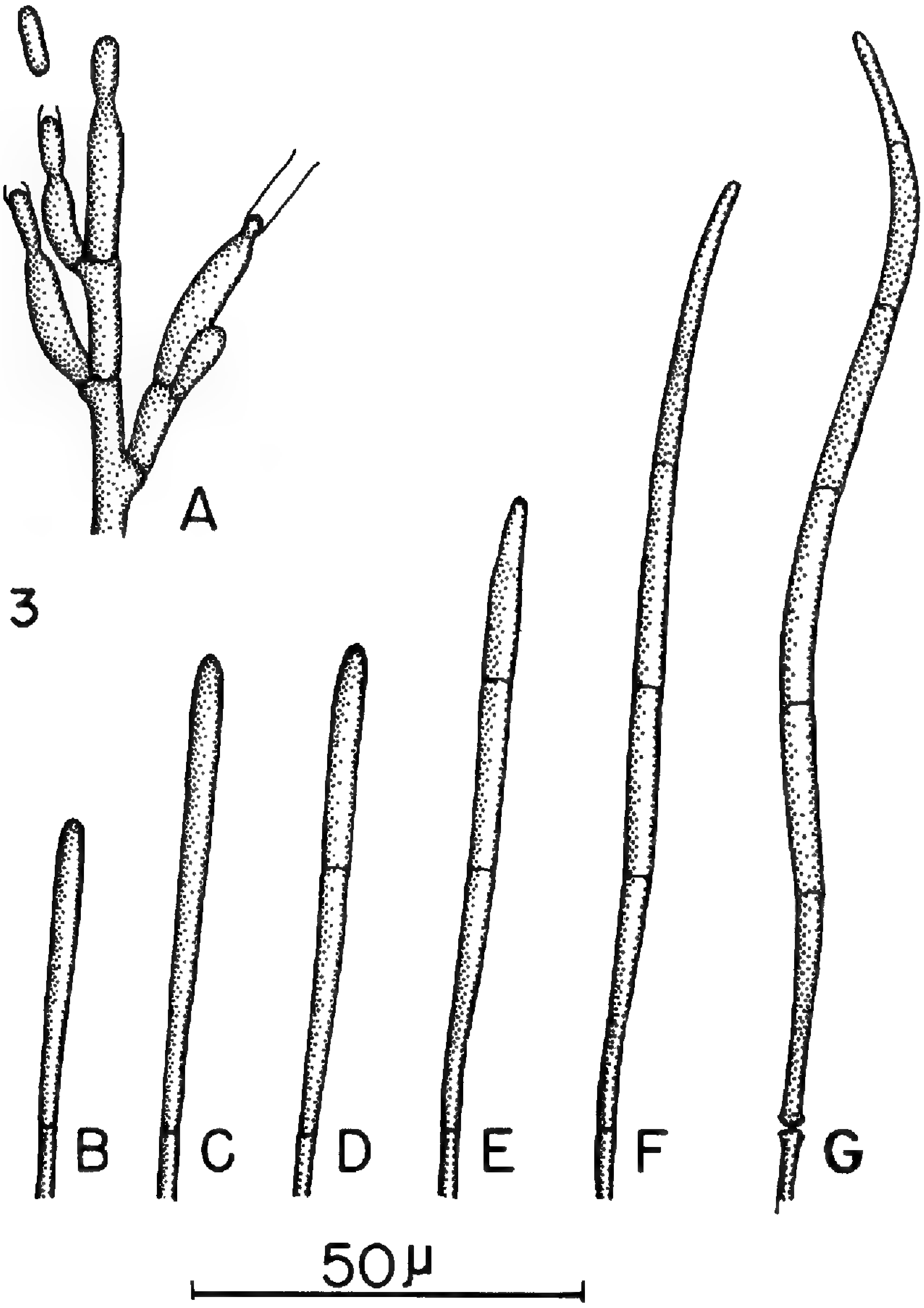


fig. 3

**Fig. 4. A–I.** *Lunulospora curvula* Ing., showing the development of the aleuriospores. **A.** A tip of a sporophore showing a half-matured aleuriospore and a young spore primordium at 10:15 A.M. **B.** The same spores at 11:00 A.M. **C.** 11:45 A.M., note the formation of the cross-wall that delimits the spore primordium. **D.** 12:25 P.M. **E.** The mature spore has been shed and the spore primordium shows a pronounced curvature at 1:10 P.M. **F.** 1:45 P.M. **G.** The initiation of a new spore primordium is well under way at the left of the expanded sporophore tip, 2:35 P.M. **H.** 3:30 P.M. **I.** The mature spore and the new spore primordium at 4:00 P.M. By 5:00 the mature spore had been shed and a new spore primordium initiated near that same spot. From hanging-drop, pure culture. × 560.

**Fig. 5. A–G.** *Articulospora tetracladia* Ing. showing the development of the aleuriospores. **A.** The spore primordium had appeared as a small spherical swelling at the tip of the lower left branch of the sporophore by 9:15 A.M. **B.** The cross-wall has formed at the base of the spore primordium, and the small swelling at the apex of the spore primordium is the beginning of the second branch of the spore, 11:35 A.M. **C.** The other spore, in this case a three-branched one, is in the process of being shed, 12:10 P.M. **D.** The third branch of the spore is just appearing, 2:10 P.M. **E.** By 3:45 P.M. the fourth branch of the spore has appeared. **F.** 5:00 P.M. **G.** The mature aleuriospore at the time of release, 6:10 P.M. From a hanging-drop, pure culture. × 560.

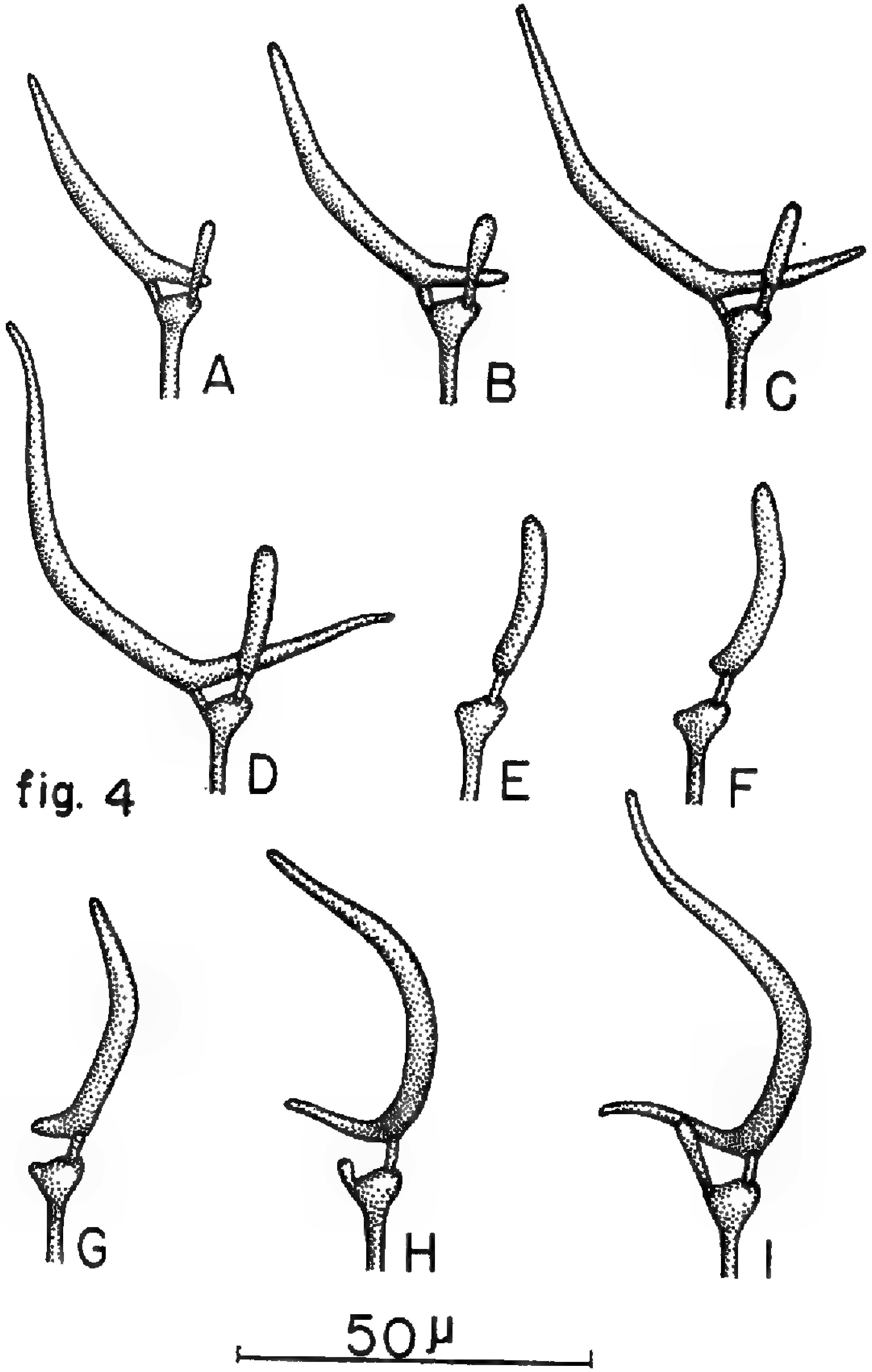


fig. 4

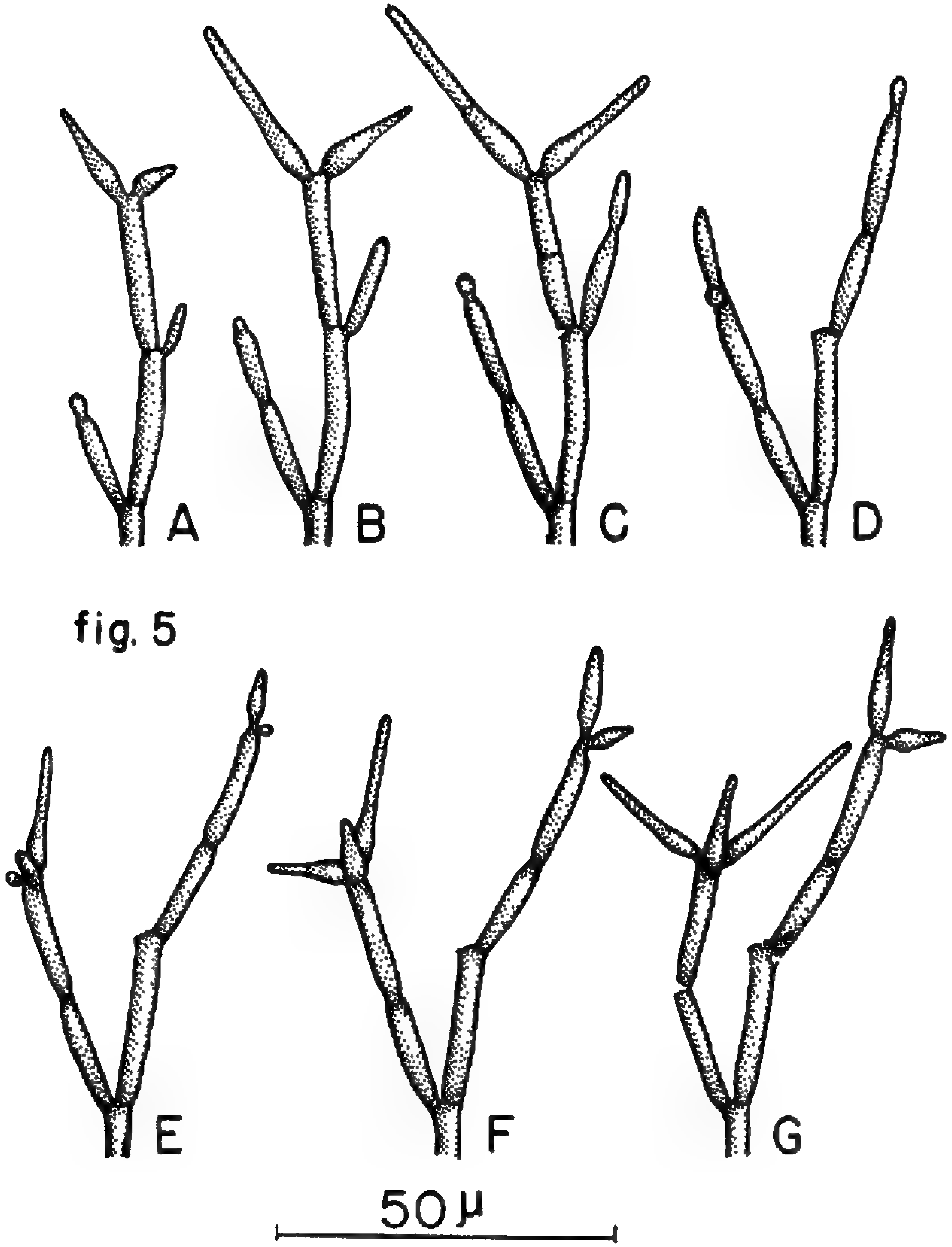


fig. 5

**Fig. 6. A–G.** *Tricelophorus monosporus* Ing., showing the development of an aleuriospore. **A.** The spore primordium has been delimited from the sporophore by a cross-wall, 12:30 P.M. **B.** The formation of the basal cell and the terminal cell; the latter will form one of the four divergent branches of the spore, 1:25 P.M. **C.** The initiation of the second branch, 1:50 P.M. **D.** 2:25 P.M. **E.** 4:00 P.M. **F.** The same spore at 6:30 P.M. **G.** The release of the mature aleuriospore took place at 6:50 P.M. From a hanging-drop, pure culture. × 560.

**Fig. 7. A–G.** *Tricladium splendens* Ing. **A.** The spore primordium with the delimiting septum at the base, 10:30 A.M. **B.** The spore primordium with its first transverse septum, 11:40 A.M. **C.** The first branch of the spore is visible as a "bud" 1:25 P.M. **D.** The spore primordium has elongated somewhat and a second transverse septum has appeared by 2:25 P.M. **E.** The second of the two divergent branches is visible 3:30 P.M. **F.** The same spore showing curvature of the axis at 5:30 P.M. **G.** Release of the aleuriospore at 6:35 P.M. From hanging-drop, pure culture. × 560.

**Fig. 7. H–N.** *Tricladium angulatum* Ing. **H.** The spore primordium with the delimiting septum at the base, 8:50 A.M. **I.** The first transverse septum, 10:00 A.M. **J.** The same spore showing the initiation of the first of two divergent branches and curvature of the axis, 11:05 A.M. **K.** 12:15 P.M. **L.** The second divergent branch has appeared, 1:15 P.M. **M.** The spore at 2:10 P.M. **N.** The mature aleuriospore at the time of release, 3:35 P.M. From hanging-drop, pure culture. × 560.

**Fig. 8. A–E.** *Tricladium gracile* Ing. **A.** The spore primordium already exhibited the curvature of the main axis and was delimited from the sporophore, 11:35 A.M. **B.** The initiation of the first branch is shown below the first transverse septum, 1:15 P.M. **C.** The second branch, 2:00 P.M. **D.** The mature aleuriospore at the time of release, 4:25 P.M. **E.** The phialides and phialospores of this species. From a hanging-drop, pure culture. × 500.

**Fig. 9. A–G.** *Articulospora moniliforma* n. sp., showing the development of the aleuriospores. **A.** A short section of the sporophore with one almost mature spore and to the right a spore primordium with the first branch fully developed and the second branch showing as a spherical swelling at the apex, 9:20 A.M. **B.** A bud has developed that will form a branch of the sporophore, 10:10 A.M. **C.** A two-branched spore has been discharged and the spore primoridum to the right of it has produced the third branch, 11:05 A.M. **D.** 12:00 noon. **E.** 1:10 P.M. **F.** 2:00 P.M. **G.** The mature spore has been released, 2:30 P.M. From a hanging-drop, pure culture. × 500.

fig. 6

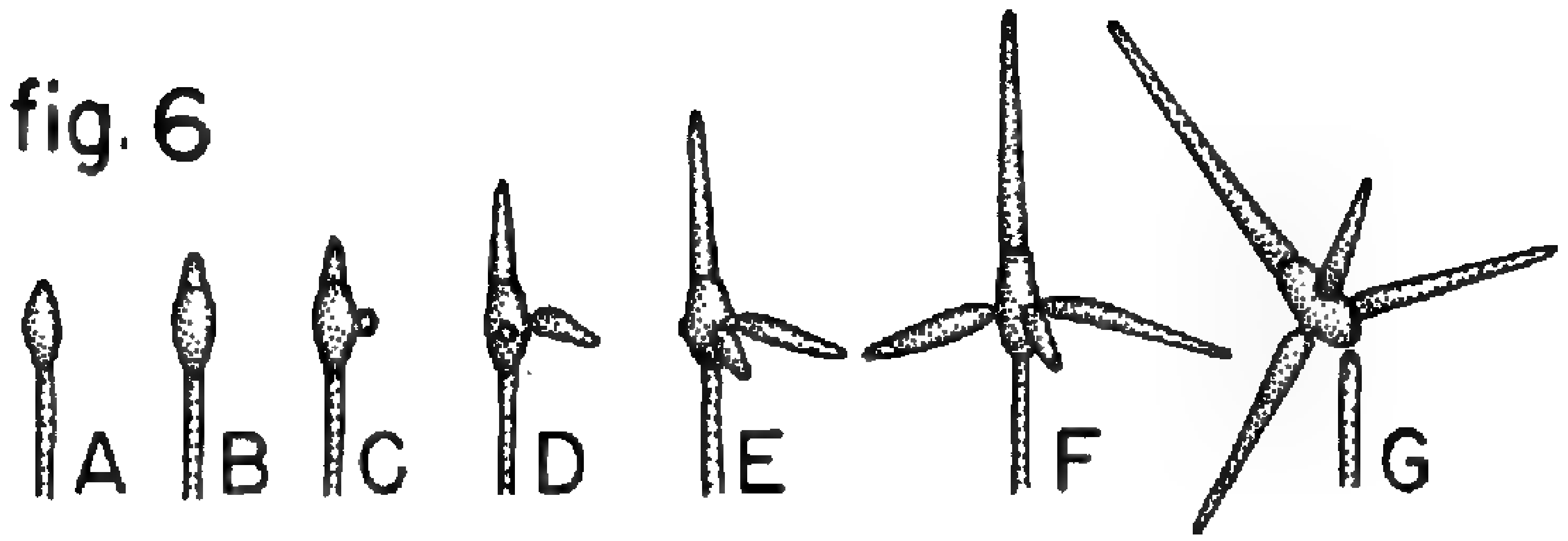
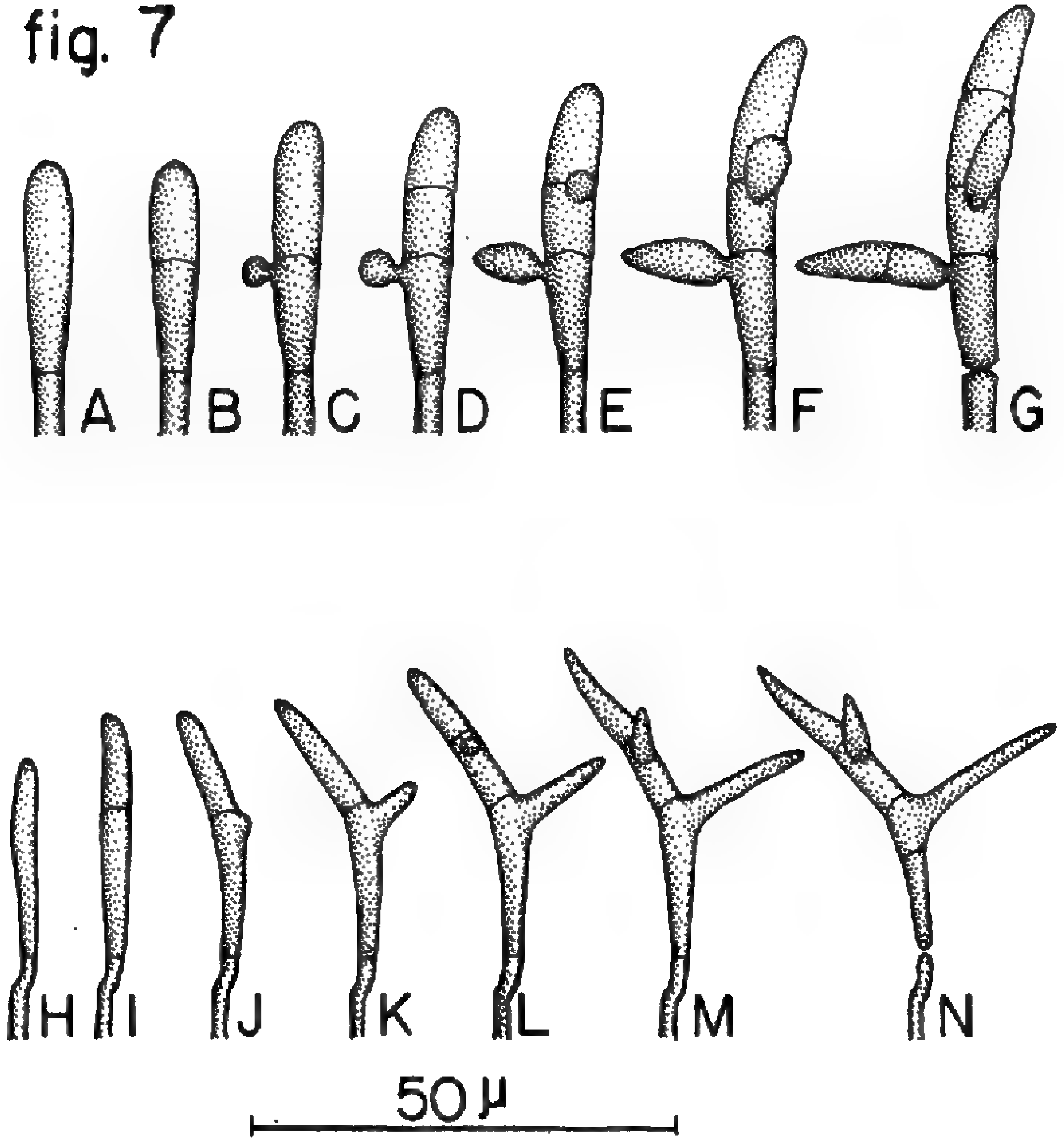


fig. 7



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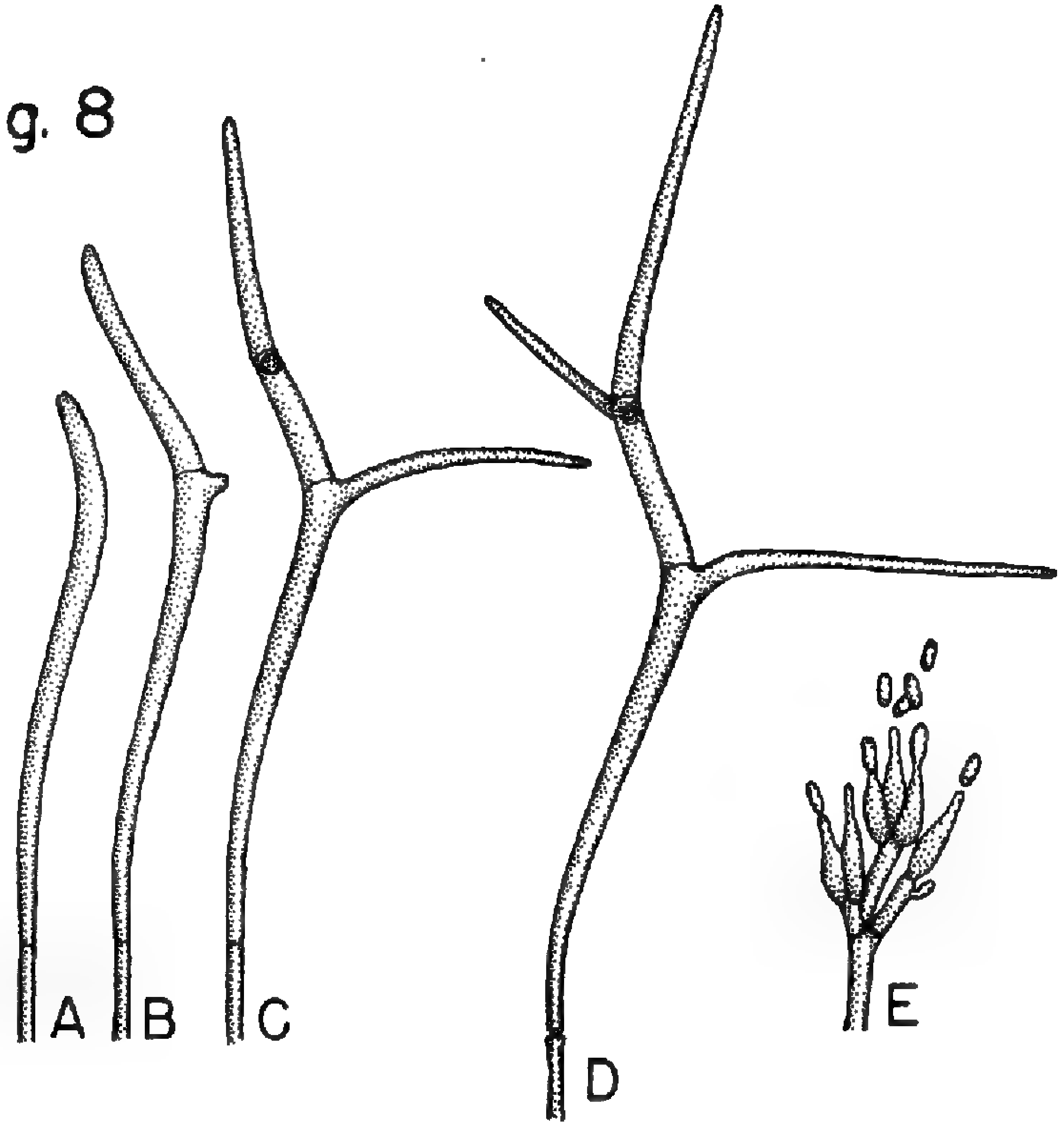


fig. 9

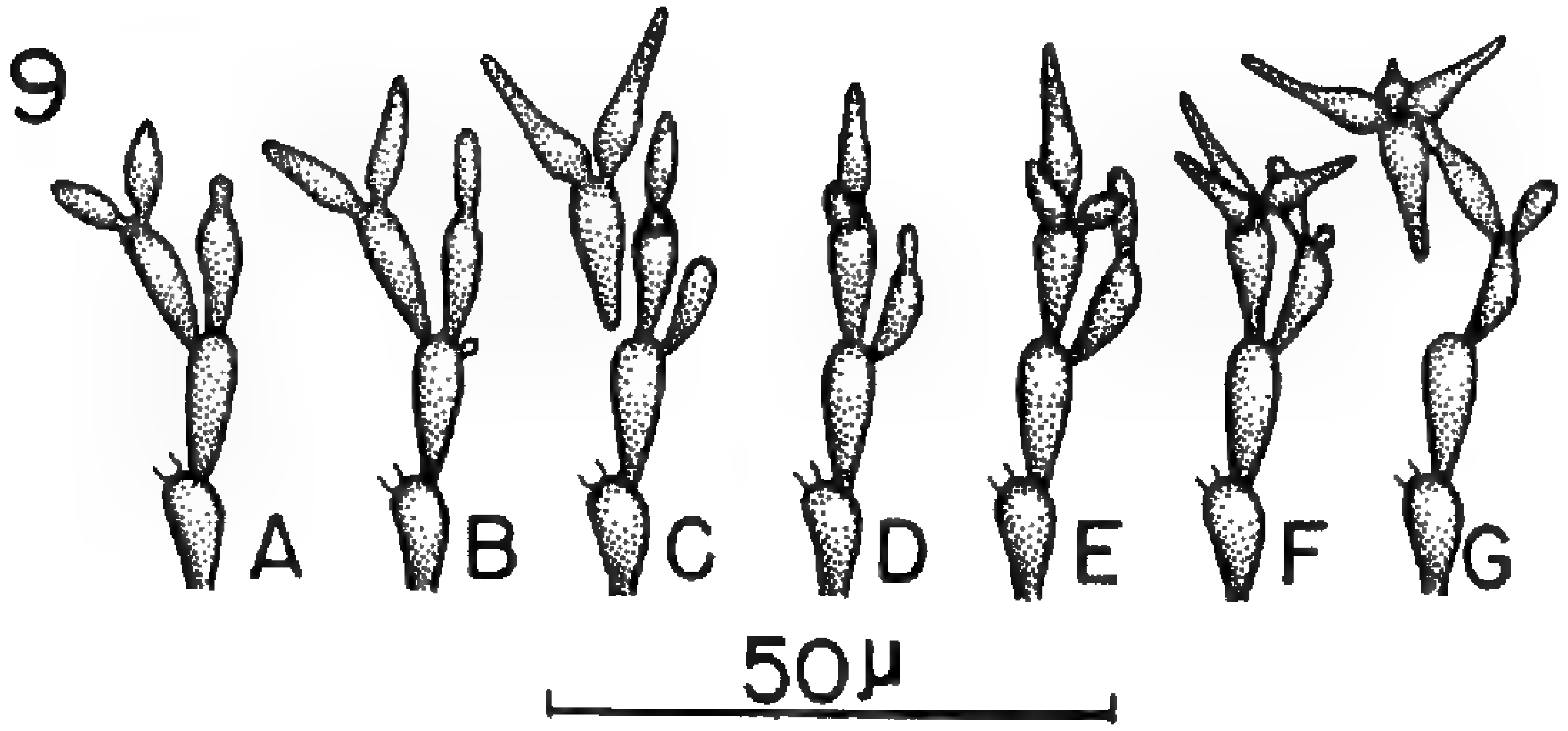


**Fig. 10. A–F.** *Tetrachaetum elegans* Ing., showing the development of an aleuriospore. **A.** The sporophore 10:40 A.M. **B.** The spore primordium has been formed by the cross-wall, 11:20 A.M. **C.** The spore primordium showing the origin of the new growing points 12:00 noon. **D.** 12:30 P.M. **E.** The same spore showing the formation of the separating cell, 1:30 P.M. **F.** Release of the mature aleuriospore at 4:05 P.M. From hanging-drop, pure culture. × 660.

**Fig. 11. A–M.** *Campylospora chaetocladia* n. sp. **A.** Mature, free-floating aleuriospores. **B–M.** Development of an aleuriospore. **B.** The aleuriophore, 11:20 A.M. **C.** The terminal swelling has been set off from the sporophore by a septum to form the spore primordium, 11:55 A.M. **D.** The "crozier" stage of the spore primordium, 1:20 P.M. **E.** The spore primordium is separated into a basal cell and a terminal cell by a cross-wall, 3:30 P.M. **F.** Upward enlargement of the basal cell and the downward enlargement of the terminal cell at 4:30 P.M. **G.** 5:25 P.M. **H.** The initiation of the four growing points that will develop into the four divergent appendages, 6:45 P.M. **I.** 8:00 P.M. **J.** 9:10 P.M. **K.** The curved appendages have begun to straighten out, 10:20 P.M. **L.** The mature aleuriospore was shed at 11:40 P.M. **M.** The initiation of a new spore primordium at the tip of the same sporophore, 1:10 A.M. From a hanging-drop culture of a fragment of decomposing maple leaf. × 660.

fig. 10

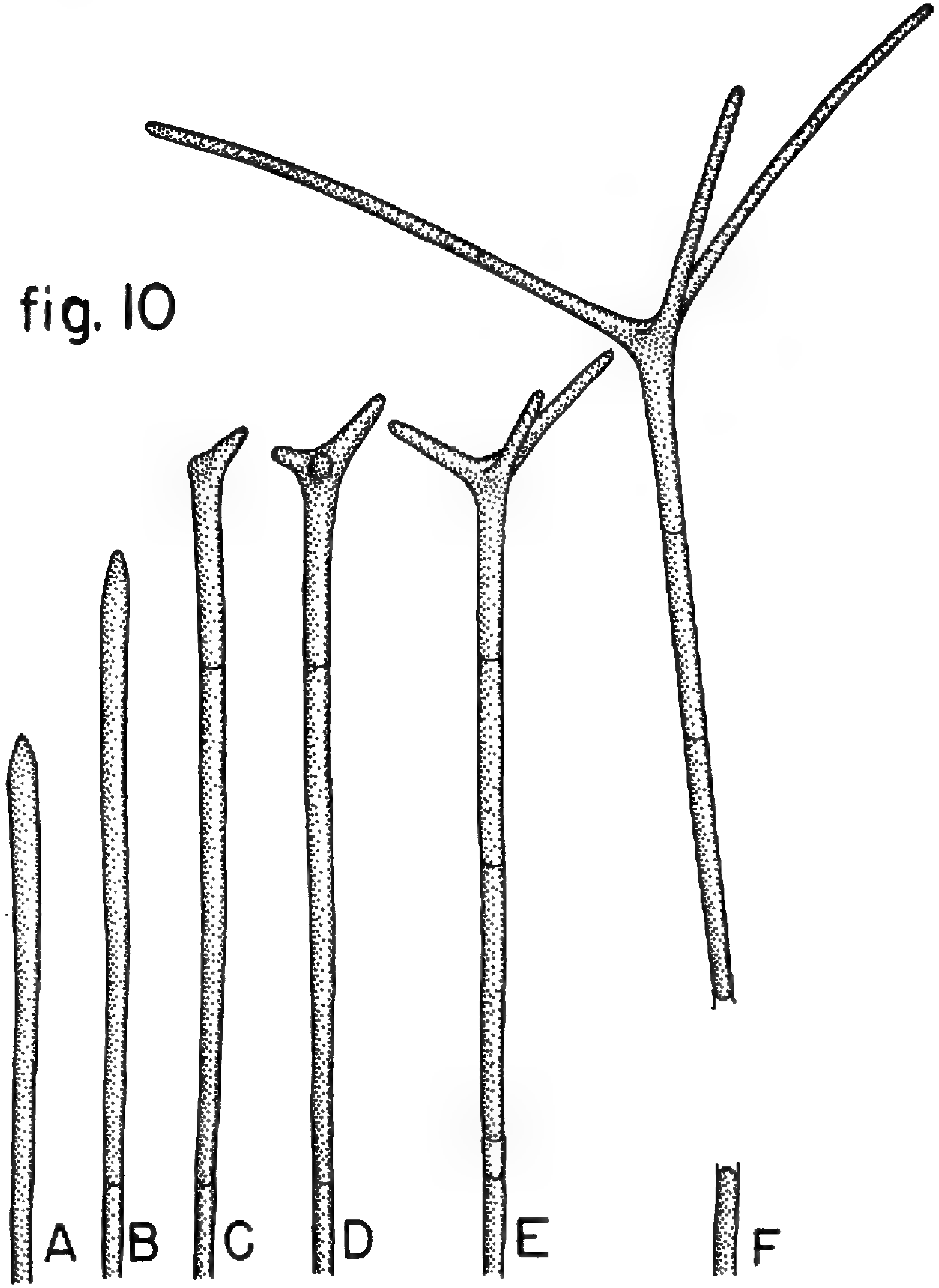


fig. 11

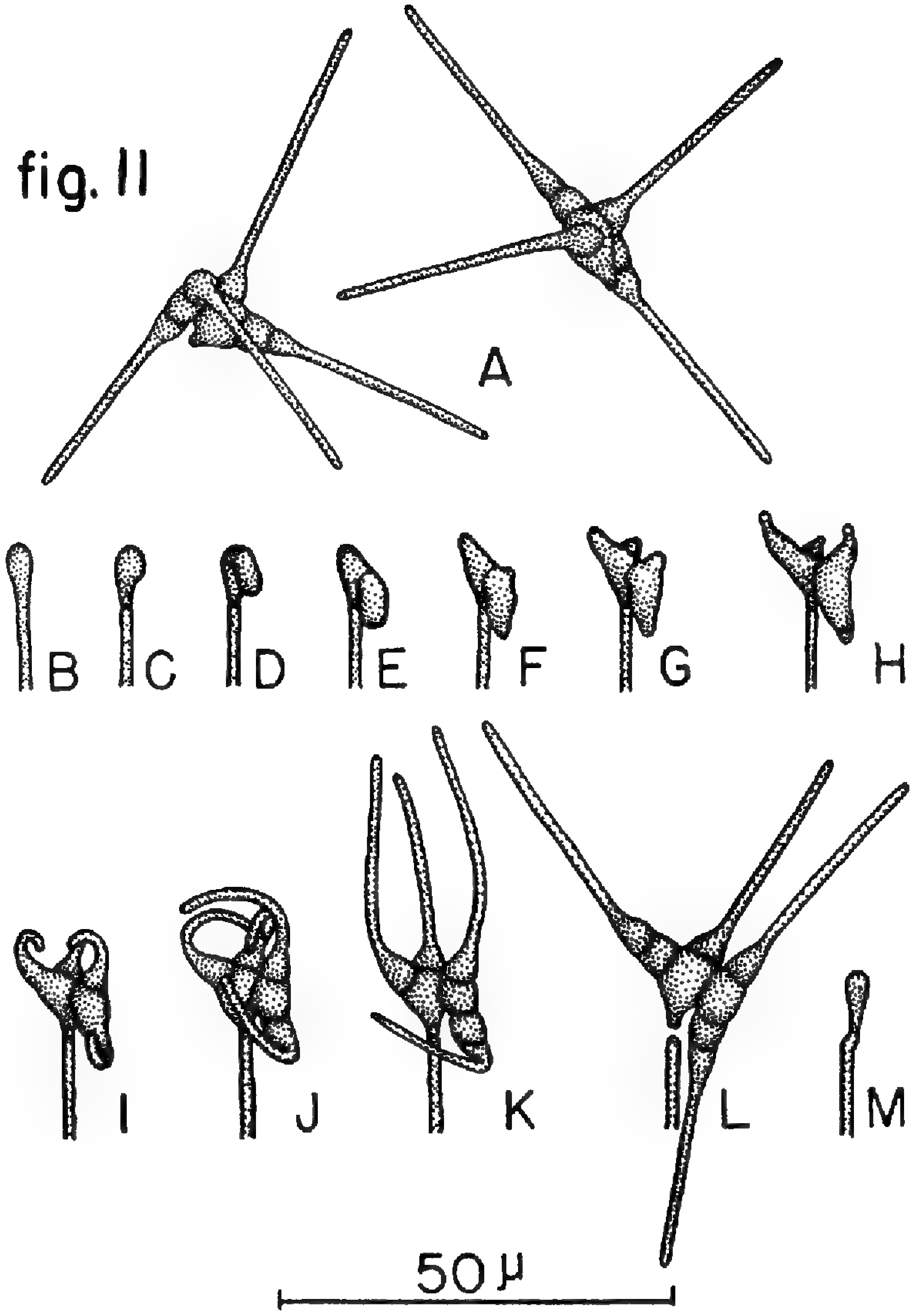


**Fig. 12. A–F.** *Flagellospora curvula* Ing., showing development of the conidia. **A.** The terminal and basal phialide of the conidiophore have begun the initiation of spore primordia, 11:35 A.M. **B.** 1:50 P.M. **C.** 3:20 P.M. **D.** The mature conidium has been shed from the middle phialide, 5:15 P.M. **E.** 8:05 P.M. **F.** By 10:10 P.M. the conidium has been shed from the terminal phialide and the conidium on the basal phialide is almost mature; note that a new primordium has appeared on the terminal and middle phialides. From a hanging-drop, pure culture. × 600.

**Fig. 12. G–K.** *Flagellospora penicillioides* Ing. **G–J.** Shows the development of a conidium beginning at 7:55 A.M. (G) and ending at a stage near maturity of the conidium at 11:50 A.M. (J). By 12:20 the conidium had been shed and a new one had made its appearance. **K.** The terminal portion of the conidiophore from which the developmental studies were made showing the method of branching and the clusters of phialides. From a hanging-drop, pure culture. × 600.

**Fig. 13. A–I.** *Heliscus aquaticus* Ing. **A.** Mature, aerial conidia. **B.** A chlamydospore showing the thick wall and the oily contents. **C.** A cluster of chlamydospores. **D–I.** Developmental stages in the formation of conidia. **D.** At 10:45 A.M. **E.** 11:50 A.M. **F.** 12:40 P.M. **G.** 1:15 P.M. **H.** 2:05 P.M. **I.** The phialide on the right has produced a microconidium, 2:45 P.M. From a hanging-drop, pure culture. × 600.

**Fig. 13. J–P.** *Alatospora acuminata* Ing., showing development of the conidia. **J.** Early stage of the spore primordium on the phialide to the right, 5:55 P.M. **K.** 7:50 P.M. **L.** The conidium has been shed from the left phialide; curvature of the spore axis is evident on the spore primordium to the right, 9:40 P.M. **M.** 10:45 P.M. **N.** The growing points which will form the two divergent branches have appeared, 11:45 P.M. **O.** 1:15 A.M. **P.** The conidium is near maturity, 2:30 A.M. From a hanging-drop culture of the fungus growing on a decayed leaf fragment. × 600.

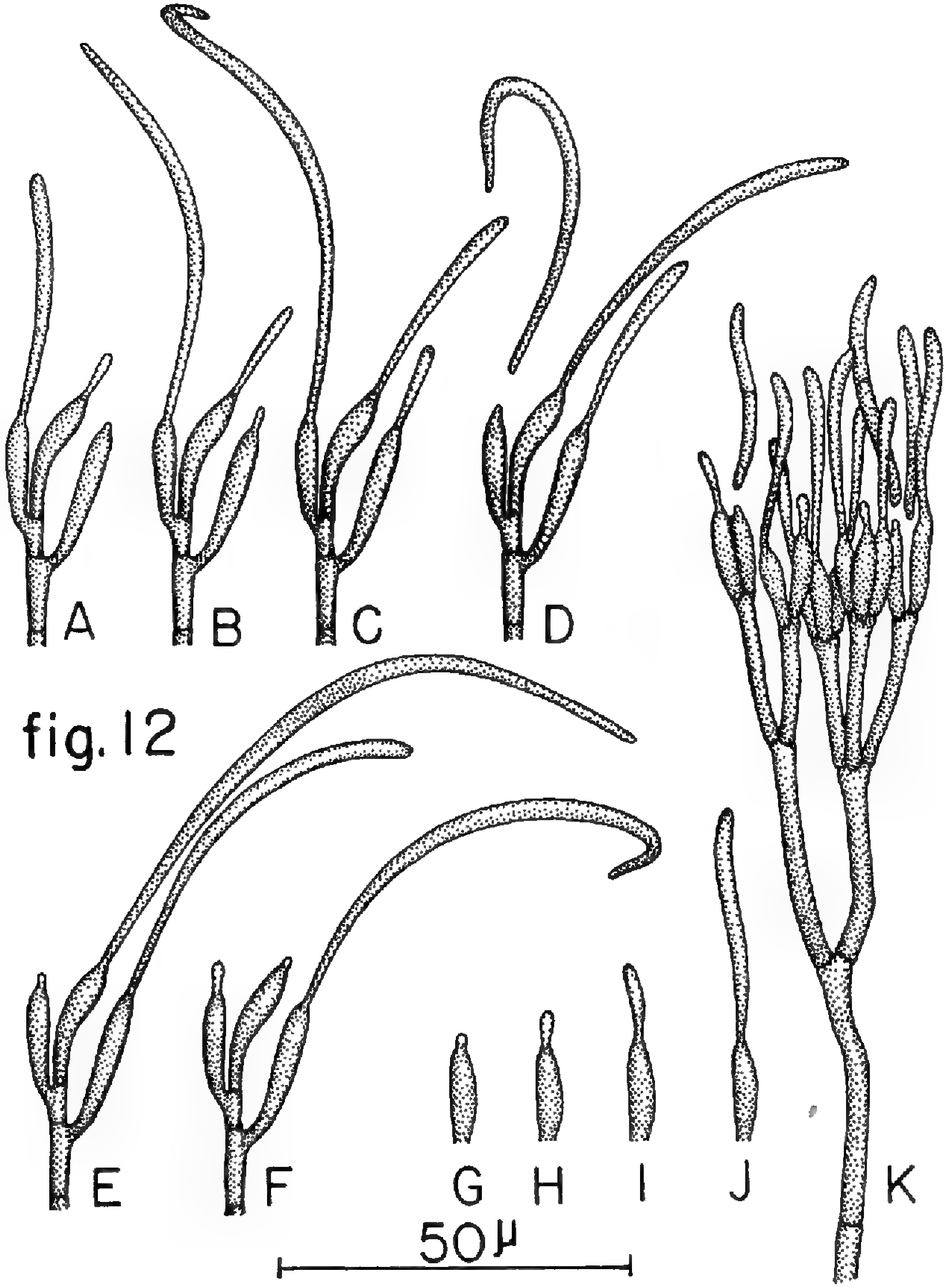


fig. 12

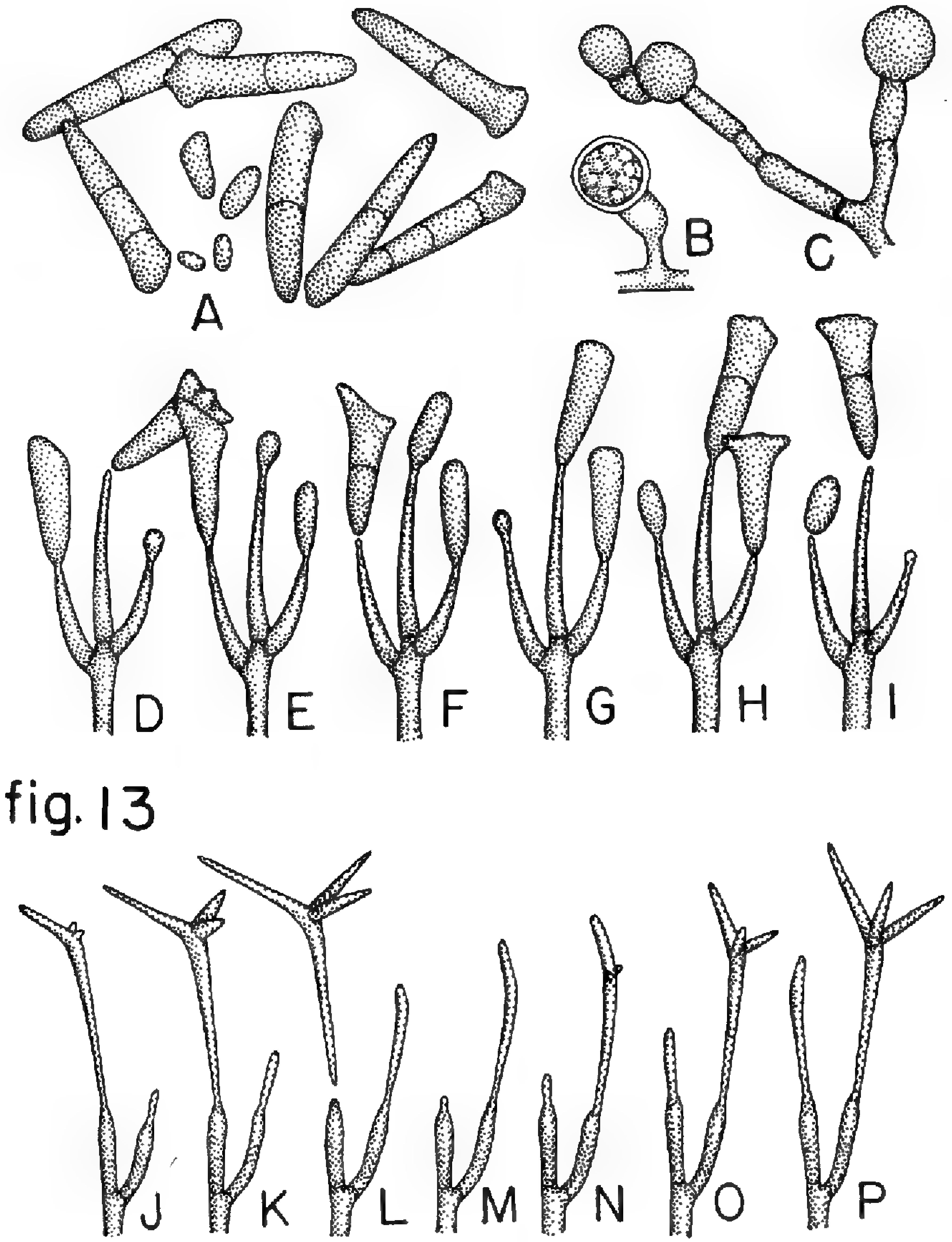
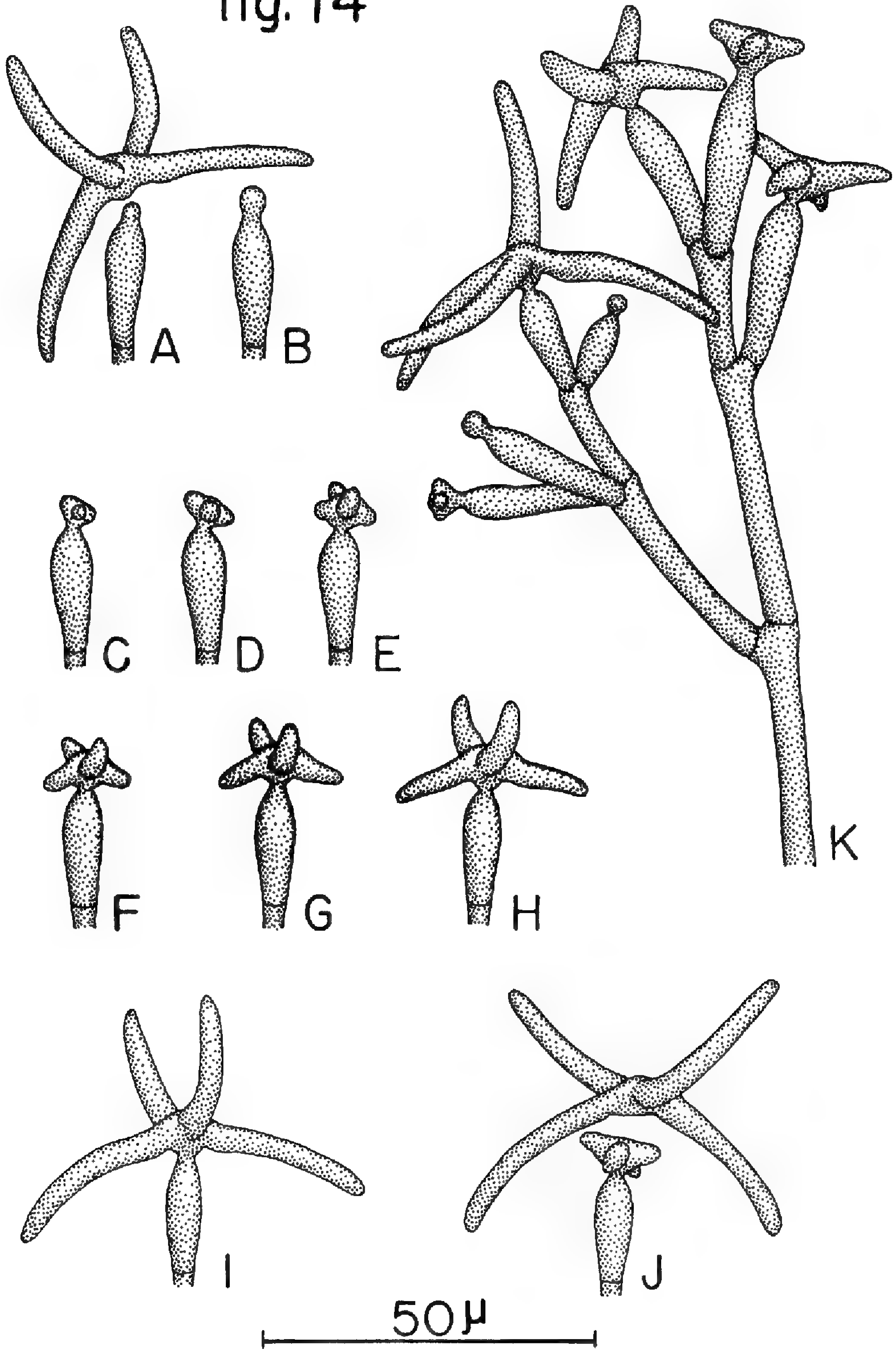


fig. 13

**Fig. 14. A–K.** *Lemonniera cornuta* n. sp. Stages in the development of a conidium. **A.** The mature conidium has been shed and the small spherical swelling at the tip of the phialide is the primordium of a new conidium, 2:30 P.M. **B.** The same primordium at 3:27 P.M. **C.** The spore primordium has assumed an inverted tetrahedron aspect with the four growing points already developed by 7:00 P.M. **D.** The same at 7:35 P.M. **E.** By 8:15 the growing points are short branches. **F.** 9:05 P.M. **G.** 10:30 P.M. **H.** 11:40 P.M. **I.** By 12:55 A.M. the conidium is almost mature. **J.** By 9:10 A.M. the conidium has been shed and a young spore has formed under it at the apex of the phialide. In still water the released conidium may remain for a long time at rest on top of the new conidium developing beneath it. **K.** The terminal portion of a conidiophore showing branching. From a hanging-drop, pure culture. × 740.

fig. 14



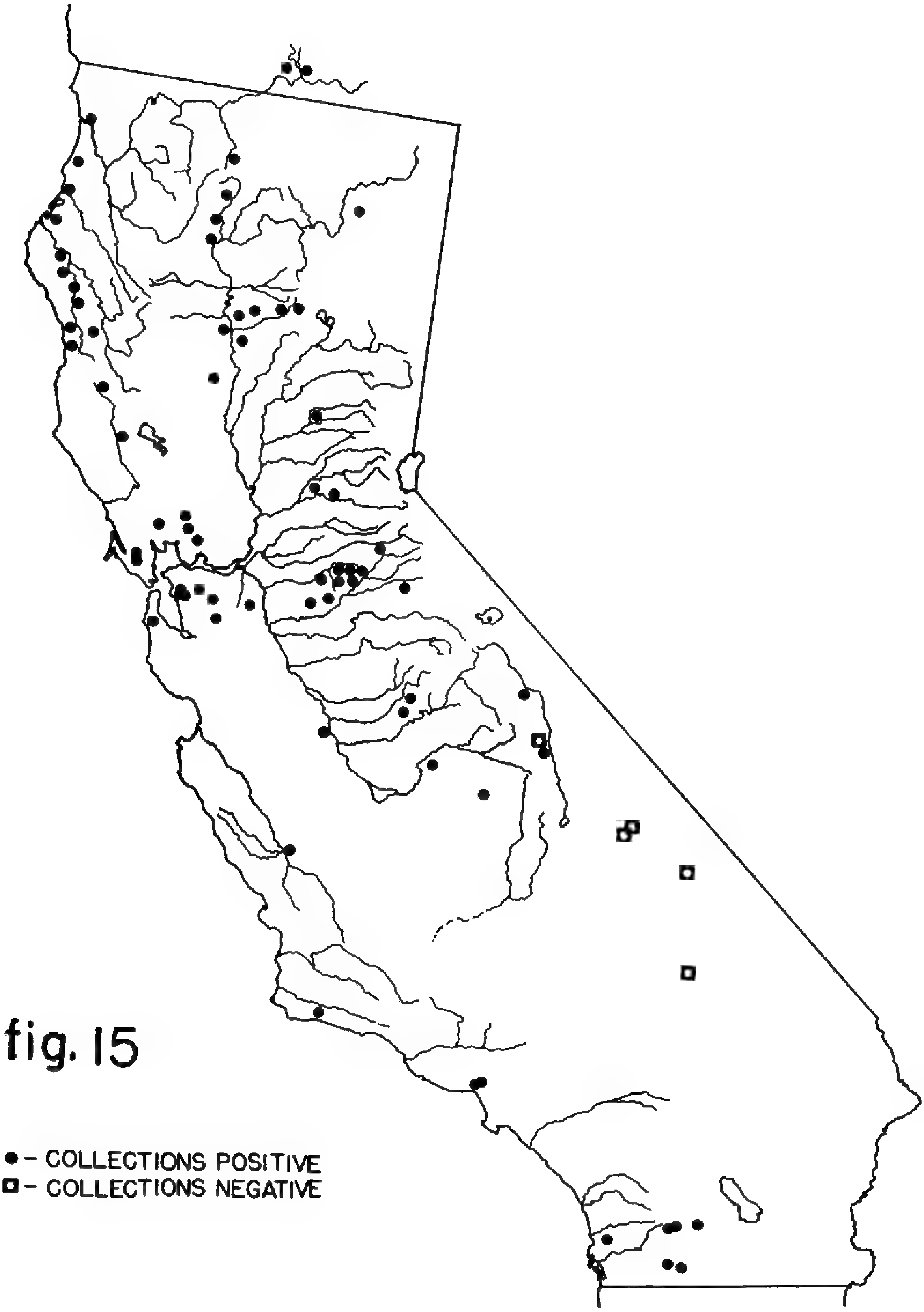


**Fig. 15.** An outline map of California showing the principal water courses, lakes, and those areas in which collections were made for aquatic Hyphomycetes.

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FARLOWIA

A JOURNAL OF CRYPTOGAMIC BOTANY

VOL. 4 JULY, 1955 NO. 4

# PROPOSAL FOR A SYSTEM OF BIOLOGICAL NOMENCLATURE, WITH SPECIAL REFERENCE TO MICROORGANISMS [1]

R. G. H. SIU [2] AND ELWYN T. REESE [3]

An absolute system of nomenclature, in which all of the characters employed for the identification of the organism are directly discernible from the name itself, is proposed.

Particularly in microbiology the use of the present system, as described by Briquet (1935), meets with many difficulties. There are the recurrent arguments over the concept of "major" and "minor" characters in delimiting the "species," the grouping and regrouping maneuvers of the "lumpers" and the "splitters," the persistence of *nomina nuda*, the multiplicity of synonyms and homonyms, the lack of fixity of names in taxonomic areas which have not been monographed and the continuous infusion of erroneous identifications into the literature. The question was entertained by Siu (1951) whether it is feasible to borrow some of the features of the simpler and more stable system of chemical nomenclature; or to modify certain numerical keys, such as those used by Davidson *et al.* (1942) and Nobles (1948) for the wood-rotting fungi into pronounceable words; and to formulate a more functional system of biological nomenclature.

In this paper, the principle of the suggested system is given with several examples in the *Fungi Imperfecti*. This will suffice as the basis for an evaluation of the *idea*. The final expression of the method will require intensive work by experienced and skilled taxonomists.

---

[1] The authors wish to express gratitude to Professors W. H. Weston, and the late W. L. White of Harvard University for their critical review of the manuscript.

[2] Farlow Library and Herbarium for Cryptogamic Botany, Harvard University, Cambridge, Mass.

[3] Pioneering Research Laboratories, U. S. Army Quartermaster Corps, Natick, Mass.

## GENERAL RULES FOR PROPOSED SYSTEM OF NOMENCLATURE

The name of the organism shall consist of two words, each of which contains nine letters, comprising three syllables. The succession of letters in each word shall be

**CVCCVCCVC**

where C represents a consonant and V a vowel. This arrangement provides a pronounceable series of letters.

Each letter shall represent one or a group of observable taxonomic characters. Since there are twenty-one consonants and five vowels, each character can be divided into twenty-one or into five divisions depending upon the position the representative letter occupies in the name. If there is doubt concerning the accuracy of determination of the character in question or if the available specimen does not allow for a study of that character, the consonant "X" or the vowel "O" shall be used. Upon acquisition of the requisite data, these tentative letters shall be replaced by the final ones.

If more or less than the 18 characters stipulated above are required, the individual words may be lengthened or shortened by employing the same pronounceable succession of letters. If deemed necessary, a trinomial may be invoked. As a final resort even numbers may be used between words, in which case each numbered position is capable of 10 subdivisions, with zero representing a doubtful character. The need for these modifications can be determined only after an intensive study of the proposed system.

It is suggested that the more readily observable characters or those separating the larger phylogenetic groups be represented among the first letters. Those characters observable with the greatest difficulties, those of a more mutable nature, and those of occasional appearance should be relegated toward the terminal positions in the name.

In the case of a binomial system it would be desirable to arrange the succession of characters, such that the first word generally indicates what is currently considered the genus and the second, the species.

## ILLUSTRATIVE EXAMPLES

It is believed that the proposed system can be applied to all organisms. The theoretical number of different names using 18 letters (12 of which are consonants and 6 vowels) is $20^{12} \times 4^{6}$ or 17,000,000,000,000,000,000. To illustrate the applicability of the system, five examples in the *Fungi Imperfecti* are given below. In this instance, the keys to the genera according to Clements and Shear (1931) are used. It is to be noted from the resulting characters (Table 1) that the first letter is used to separate fungi from other organisms. The second letter then divides the fungi into four large groups of which the *Fungi Imperfecti* is one. The examples have been developed with the thought that it will probably be necessary to develop new sets of characters for each of the four major groups of fungi, i.e. beginning with the third letter in the name.

The following five examples show how genera in the *Fungi Imperfecti* would be coded according to the information from Table 1.

| Present Name: | Illustrative New Name: |
|---|---|
| *Aspergillus* | **Fimmabbat** |
| *Gliocladium* | **Fimmapbam** |
| *Penicillium* | **Fimmapbat** |
| *Oedocephalum* | **Fimmebbat** |
| *Stilbum* | **Fismenbat** |

Thus *Penicillium* and *Oedocephalum* differ by only one character from *Aspergillus* while *Stilbum* differs in three characters. *Gliocladium* differs from *Penicillium* in one character. How closely related two genera are phylogenetically would be indicated by how far from the end of the coded word they differ in a particular character, thus the third letter represents divergence in families, *Stilbum* being in a different family than the other three genera.

As a further example, a *nomen nudum* may be considered. Accordingly, Weston's *Aglaiocephalum* (Weston, 1933) would assume the name, *Fimmetbak*.

## ADVANTAGES AND DISADVANTAGES OF PROPOSED SYSTEM

Two centuries of work have been based on the present binomial system. To suggest that this system be replaced by another requires a serious consideration of the resulting advantages and disadvantages. The difficulties inherent in the current system have been mentioned in the introductory paragraphs of this paper. The more significant advantages of the proposed system of nomenclature are:

1. Informative nature of names:

   The proposed name immediately provides the reader with a large amount of morphological and physiological information about the organisms. Phylogenetic relationships would also be readily apparent from the name. Thus, the degree of relationship would be indicated by how far from the first letter of the coded name a difference between the two names exists.

2. Fixity of names:

   Present rules permit many occasions for changes of names. It is not uncommon to find a dozen synonyms for the same organism. There is the question of historical priorities, for example. In the proposed scheme, once an organism is described, the name is not subject to change.

3. Clarity of tentative names:

   In the prevailing system, there is no way to know how "tentative" a tentative identification is. In the proposed system, the use of the letters "X" and "O" clearly identifies those characters in which doubt exists. The proposed system minimizes the tendency of some investigators to force a culture into a known species even though doubt exists as to the fitness of several characters.

4. *Nomina nuda*:

   Frequently names of organisms are mentioned in papers without accompanying descriptions. Since it is not possible to tell anything about the morphology and physiology from the name, these *nomina nuda* are of use only when they are later fortified with the proper descriptions. In many cases, the latter are not forthcoming and the meaningless names remain in the literature. If the proposed system of nomenclature is accepted, *nomina nuda* will be eliminated, for the mere presentation of the name itself provides considerable information about the organism. This has been exemplified earlier in this paper using Weston's *Aglaiocephalum.*

5. Objectivity:

   Subjectivity is reduced to a minimum in the proposed system. For example, the question of relative importance of characters does not come into play in the proposed system nearly as much as it does in the present system. This eliminates the perennial argument between the "lumper" and the "splitter" as to whether a given difference in character is of sufficient magnitude to create, say, a new "species." According to the proposed system, the difference is merely taken care of by the appropriate letter, without need of changing the entire name of the organism.

6. Functional simplicity:

   With its simple rules and freedom from historical priorities, the proposed system is much easier to follow than the present system particularly for the naming of new organisms. It is well within the grasp of the non-taxonomist, when the more typical organisms are concerned. Even the professional taxonomist is spared considerable time and effort by not being required to delve into the past literature with such intensity as required by the present system to make sure that the organism had not been previously named.

7. Reduction in number of synonyms, homonyms, and misidentifications:

   Given a correct observation of the characters in the laboratory, two independent workers will arrive at exactly the same name using the proposed method. This is not true with the present system. As discussed in "5" above, one individual may decide to coin a new name for the organism while the other investigator may decide to use the closest available name.

8. Flexibility for special purposes:

   (a) Names of organisms following the proposed system are readily adaptable to the IBM or punched card method of studying the correlation of characters. This opens up new scientific and industrial possibilities for the taxonomic researcher.

   (b) Individual, scientific or industrial groups interested in minor, specialized traits such as strain differences and genetic mutations may, for their own purposes, expand the prevailing name to include special characters. Such characters are not part of the accepted name, of course, but correspond more to the presently used strain numbers or varieties. If in the future, some of these traits do, in fact, represent important taxonomic features, they can be readily added to the prevailing name, without vitiating the earlier results.

   (c) Ease of handling herbarium specimens and filing library references is another advantage of the proposed system. The present scheme demands a knowledge of taxonomy on the part of a herbarium attendant and clerk, for frequently the organisms are filed according to families or phylogenetic groups. With the proposed system, ordinary alphabetical arrangement suffices.

As far as the authors can see, the proposed system is beset with no serious taxonomic difficulties, other than those inherent in any taxonomic endeavor. In this respect, it excels the present method. However, there are two disadvantages in the proposed scheme which must be considered. One is the seriousness of typographical errors. A mistake in a single letter may throw an organism into an entirely different class. The other is the difficulty in verbal presentation.

These disadvantages can be minimized by a careful choice of letters during the development of the basic keys, so that the more common species will have the more euphonious names. For this reason, the collaboration of phoneticists is clearly indicated. Furthermore, since not all of the letters possible for a given position will be used in the name, attention can be directed to the selection of letters which are as different as possible from each other in sound and appearance. It is believed that the difficulties of verbal presentation can be reduced to an acceptable level by such means. The seriousness of typographical errors, though decreased considerably, still remains and diligent proof-reading will be necessary. Actually this may not work out in practice to be as great as it may first appear, for usually the rest of the context will aid in the recognition of such errors. While one is tempted to prejudge the magnitude of such a source of error, probably it can be determined with accuracy only after the system has been developed and put into use for some time.

It may also be desirable that during the transition period, the present names are retained, followed by the proposed name in parenthesis. The use of dual names may be carried on until such a time that acquaintance with the new system becomes general.

## SUMMARY

An absolute system of biological nomenclature has been proposed as a replacement for the present one. In the new system, all of the characters that enter into the final identification of the organism are directly discernible from the name itself. It is hoped that this proposal will stimulate a healthy reexamination of the system of nomenclature used heretofore, and of the various means which can be employed to minimize its inherent difficulties. The proposal in this paper is humbly presented as one approach to the problem.

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TABLE 1. ILLUSTRATIVE KEY FOR LETTERS OF THE FIRST NAME ACCORDING TO PROPOSED SYSTEM OF NOMENCLATURE.

| Position of letter | Description of Character | | Letter |
|---|---|---|---|
| First | | | |
| | Plant phyla | | |
| | Spermatophyta | Gymnosperms | G |
| | | Angiosperms | H |
| | Pteridophyta | Ferns & allies | D |
| | Bryophyta | Mosses, etc. | M |
| | Thallophyta | | |
| | with chlorophyll | Algae | C |
| | without chlorophyll | | |
| | Filamentous | Fungi | F |
| | Nonfilamentous | Bacteria | B |
| | Fungi parasitic on Algae | Lichens | L |
| | Myxomycetes | | K |
| | Animal Phyla | | |
| | Protozoa | | P |

| Position of letter | Description of Character | | Letter |
|---|---|---|---|
| Second | | | |
| | Fungi | | |
| | Possessing a known sexual stage | | |
| | Mycelium coenocytic; sexual spores borne within a sporangium. | Phycomycetes | E |
| | Mycelium septate | | |
| | Sexual spores, borne in a sac, usually 8 spores per ascus. | Ascomycetes | A |
| | Sexual spores borne externally on a basidium, usually 4 spores per basidium. | Basidiomycetes | U |
| | Possessing no known sexual stage, or if known, then rare or infrequent | Fungi Imperfecti | I |
| Third | | | |
| | Conidia borne in pycnidia | | |
| | Pycnidia globoid, ostiolate or astomous | | |
| | Pycnidia brown to black, membranous to carbonaceous | Phomaceae | P |
| | Pycnidia bright colored; fleshy, gelatinous or waxy | Zythiaceae | Z |
| | Pycnidia dimidiate, more or less radiate or hysterioid. | Leptostromaceae | L |
| | Pycnidia apothecium-like or hysterioid, opening circularly or by a cleft or lobes | Discellaceae | B |
| | Conidia not borne in pycnidia | | |
| | Conidiophores borne on a more or less parenchymoid stroma | Melanconiaceae | G |
| | Conidiophores not on a stroma | | |
| | Hyphae in cottony masses | | |
| | Hyphae and spores hyaline or bright colored | Moniliaceae | M |
| | Hyphae and/or spores typically dark | Dematiaceae | D |
| | Hyphae compacted to form spore-body | | |
| | Spore-body sessile, globose to applanate (sporodochium) | Tuberculariaceae | T |
| | Spore-body stalked, capitate to cylindric (synnema) | Stilbaceae | S |
| | Conidia absent | Sterile Mycelia | K |
| Fourth | | | |
| | Conidia one-celled | (Amerosporae) | |
| | | Mucedineae | M |
| | | Dematieae | N |
| | Conidia two-celled | (Didymosporae) | |
| | | Mucedineae | T |
| | | Dematieae | G |
| | Conidia 3-many celled, septa transverse | (Phragmosporae) | |
| | | Mucedineae | B |
| | | Dematieae | C |

| Position of letter | Description of Character | | Letter |
|---|---|---|---|
| | Conidia 3-many celled, septa transverse & longitudinal | (Dictyosporae) | |
| | | Mucedineae | P |
| | | Dematieae | K |
| | Conidia filiform | (Scolecosporae) | |
| | | Mucedineae | S |
| | | Dematieae | L |
| | Conidia spirally twisted | (Helicosporae) | |
| | | Mucedineae | D |
| | | Dematieae | F |
| | Conidia forked, radiate or united | (Staurosporae) | |
| | | Mucedineae | R |
| | | Dematieae | V |
| Fifth | | | |
| | Hyphae very short or little different from the conidia | | |
| | Spores catenate | | I |
| | Spores not catenate | | U |
| | Hyphae elongate & distinct from conidia | | |
| | Spores catenate | | A |
| | Spores not catenate | | E |
| Sixth | | | |
| | Conidia exogenous | | |
| | Conidiophore simple, unbranched: | | |
| | Spores terminal | | G |
| | Spores typically pleurogenous | | L |
| | Conidiophore simple, branched: | | |
| | Branching irregular; spores terminal | | T |
| | Branching irregular; spores pleurogenous | | D |
| | Branching verticillate; spores terminal | | V |
| | Branching penicillate; spores terminal | | P |
| | Conidiophore inflated: | | |
| | Terminal swelling | | B |
| | Joints inflated | | J |
| | Conidiophore compound: | | |
| | Spore bearing portion simple, globose | | M |
| | Spore bearing portion simple, cylindric | | N |
| | Spore bearing portion branched | | S |
| | Conidia endogenous | | F |
| Seventh | | | |
| | Conidia globose to subglobose | | |
| | Smooth to somewhat rough | | B |
| | Very rough i.e. tuberculate, spiny, stellate | | D |
| | Conidia allantoid | | K |
| | Conidia elliptic to cylindric | | |
| | Smooth | | G |
| | Rough | | R |

| Position of letter | Description of Character | Letter |
|---|---|---|
| | Conidia fusoid | |
| | Smooth | M |
| | Rough | N |
| | Conidia ciliate | P |
| Eighth | | |
| | Parasitic on plants | E |
| | Parasitic on animals | I |
| | Saprophytic | A |
| | Some forms parasitic, some saprophytic | U |
| Ninth | | |
| | (Miscl. hodge-podge to catch various genera) | |
| | Spores held together by mucilaginous substance | M |
| | Sterile structures in spore bearing mass, spines, etc. | K |
| | Stroma present | L |
| | Subiculum present | S |
| | None of above | T |

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# ACTIVITY OF FUNGI ON OILS

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Plastic films, like other substances composed of organic materials, are subject to the degradative action of microorganisms. Under favorable conditions of moisture and temperature, microorganisms attack certain types of plasticizers although the plastic itself does not appear to be affected. Since the plasticizer is added to make the films flexible, microbial action results in a stiffening of the film (Harvey, 1949). Plasticizers vary in resistance from inert compounds such as tri-octyl-phosphate to extremely susceptible ones such as castor oil. For reasons of availability, cost or requirements of specific properties, it is frequently necessary to use plasticizers which are non-resistant. A study has been made in these laboratories of the breakdown of several homologous series of esters by the fungus *Aspergillus versicolor* and by the bacterium *Pseudomonas aeruginosa* (Stahl and Pessen, 1953). Results of tests conducted under the auspices of the National Defense Research Committee during World War II are summarized by Brown (1946). Most plasticizers are of the ester type. Those composed of naturally occurring oils and fatty acids (i.e. laurates, stearates, ricinoleates, etc.) are known to support microbial growth, while synthetic plasticizers of the phthalate and phosphate types are generally resistant. The present study was undertaken to determine the range of organisms capable of growing on typical plasticizers. It supplements a previous publication covering the activity of the same fungi on cotton and on wool (Reese, et al, 1950). The activities of some (358) of these organisms on coconut oil, methyl-acetyl-ricinoleate (or di-hexyl-sebacate) are being reported here.

Comparatively little information on fat utilization by fungi is available. Much more interest has been shown in fat *synthesis*. On the other hand degradative action by bacteria has been more fully covered. One of the best reviews is the 26 page chapter "Action of Microorganisms on Fat" by Jensen in his recent book (1945). Fats decompose slowly in the soil (Waksman, 1932). Fungi and aerobic bacteria are largely responsible. A comparative study of bacterial action on lipids (Castell and Garrard, 1941) showed *Pseudomonas aeruginosa*, *Alcaligenes viscosus*, and *Staphylococcus aureus* as possessing distinct lipolytic action. The factors affecting lipase production by two of these bacteria, *Alcaligenes viscosus* and *Pseudomonas aeruginosa,* were recently investigated (Cutchins, Doetsch, Pelczar, 1951). In the Actinomycetes, several of the antibiotic producing species of Streptomyces have been found to utilize animal and vegetable oils. Replacement of all of the carbohydrate by lipids did not decrease the yields of antibiotic produced (Perlman and Wagman, 1952). Fungi, especially Aspergilli and Penicillia, have frequently been observed growing on margarine and butter. Undoubtedly many of those fungi found on paints, meats and other complex substrata are obtaining their nutrient from the *fatty* constituents therein.

We are not concerned here with the mechanism of breakdown of the compounds under consideration. Indeed, the manner of attack does not appear to have been clearly established for various types of esters. Probably the action revolves around hydrolytic breakdown — lipases attacking glycerides such as coconut oil; esterases breaking down the simple esters. This aspect of the enzymic hydrolysis of fats and esters has been reviewed recently by Ammon and Jaarma (1950).

## METHODS

Cultures were set up in triplicate in 250 ml Erlenmeyer flasks containing 0.5g of coconut oil ("Moonstar," Procter and Gamble), di-hexyl sebacate (Hardesty Chemical Company) or methyl acetyl ricinoleate (P4, Baker Castor Oil Company) and 50 ml of nutrient solution (1.0 g $NH_4NO_3$; 1.36 g $KH_2PO_4$; 0.2 g $MgSO_4 7H_2O$; 0.1 g Difco yeast extract; 1000 ml distilled $H_2O$; pH adjusted to 6.4). The di-hexyl sebacate was purified by adsorption on activated silica, activated alumina and Fuller's earth. After autoclaving, the media were inoculated with a spore suspension, and placed on a reciprocal shaker at 30°C for 7 days. Dry weights of the mycelium produced were determined after filtering on sintered glass crucibles, extracting the residual oil with an excess of absolute ethanol and drying at 70°C. Results are based on the average dry weight of mycelium per flask.

## RESULTS

Results are presented in detail in the appendix. The data are summarized in Table 1 in which 5 categories of growth have been set up. The percentage of the strains falling into each category is shown as well as the total number of strains tested. Sebacate was distinctly inferior as a substratum. Over

TABLE 1. GROWTH OF FUNGI ON FATTY MATERIALS

| | Growth | | % of Strains Tested | | |
|---|---|---|---|---|---|
| Category | Wt/flask | as % wt. of oil | Coconut Oil | Ricinoleate | Sebacate |
| 0 | 0–10 mg | 0–2% | 5% | 10% | 40% |
| 1 | 11–100 | 3–20 | 39 | 57 | 58 |
| 2 | 101–200 | 21–40 | 31 | 29 | 1 |
| 3 | 201–300 | 41–60 | 22 | 4 | 0 |
| 4 | 301+ | 60+ | 3 | 0 | 0 |
| Number of strains tested | | | 358 | 309 | 82 |

95% of all strains tested showed less than 50 mg growth/flask (i.e. less than 10% conversion of oil to mycelium). No effort was made to determine the cause. The other ester, ricinoleate, was a fairly good substratum for 90% of the test organisms. The glyceride, coconut oil, was by far the best substratum of those tested in that 95% of the organisms were able to grow on it, and the per cent conversion of substratum to fungus tissue was greatest. While a few cases have been found where the amount of growth on ricinoleate exceeded that on coconut oil, the reverse is usually true.

The organisms falling at either extreme, i.e., no growth (group 0) or very good growth (groups 3,4) are listed in Tables 2 and 3. Much of the screening done has been on Aspergilli. The results indicate that members of the following groups are usually very active: *A. terreus*, *A. niger* (the *A.*

TABLE 2. ORGANISMS GROWING LITTLE OR NOT AT ALL UNDER CONDITIONS OF THE TEST (GROUP 0) †

| | | | |
|---|---|---|---|
| Acrostalagmus cinnabarinus | QM 320e | Colletotrichum sp. | QM 533 |
| Amblyosporium botrytis | QM 971 | Ctenomyces serratus | QM 256 |
| Aspergillus repens | QM 44c | Phialophora lagerbergii | QM 267 |
| Basidiomycete (conidial stage) | QM 592 | Pholiota adiposa | QM 512 |
| " " " | QM 870 | Polyporus sulfureus | QM 509 |
| Botryosporium pulchrum | QM 965 | Sepedonium sp. | QM 913 |
| Botryotrichum piluliferum | QM 991 | Stereum purpureum | QM 1014 |

TABLE 3. ORGANISMS GROWING BEST ON OILS (GROUPS 3, 4) †

| | | | |
|---|---|---|---|
| Alternaria tenuis | QM 73b | Beauveria bassiana | QM 972 |
| Aspergillus carbonarius | QM 331 | Brachysporium sp. | QM 70g |
| A. clavatus | QM 872 | Chaetomium globosum | QM 38f |
| A. fischeri | QM 865 | * Ch. spirale | QM 622 |
| A. flavus | QM 63c | Circinella sydowi | QM 629 |
| A. niger | QM 458 | * Cunninghamella bertholletiae | QM 1021 |
| A. niger mut. cinnamoneus | QM 326 | * C. blakesleeana | QM 631 |
| A. niger mut. schiemanni | QM 327 | * C. echinulata | QM 154f |
| A. ochraceus | QM 880 | Paecilomyces varioti | QM 823 |
| A. oryzae | QM 82i | Penicillium citrinum | QM 1a |
| A. parasiticus | QM 884 | Pestalotia royenae | QM 531 |
| A. phoenicis | QM 1005 | Pestalotia virgatula | QM 479 |
| A. sydowi | QM 31c | * Phomaceae | QM 13e |
| A. tamarii | QM 75b | * Phomaceae | QM 699 |
| * A. terreus | QM 72f | Phomaceae | QM 618 |
| * A. ustus | QM 891 | Phomaceae | QM 703 |
| A. ustus var. laevis | QM 893 | Phomaceae | QM 576 |
| A. versicolor | QM 432 | Rhizopus sp. | QM 1032 |
| A. violaceo-fuscus | QM 335 | * Septonema sp. | QM 818 |

* The asterisk indicates those organisms whose mycelial weight exceeded 60% of the initial weight of the coconut oil.

† See Table 1.

*luchuensis* series is only moderately active), *A. flavus-oryzae*, *A. fumigatus*, *A. clavatus*, *A. tamarii*, *A. versicolor*, *A. ustus*. Moderate activity is shown by *A. nidulans* group. Least activity is shown by members of the *A. repens*, and *A. wentii* groups. In the genus Chaetomium, as in the Aspergilli, the isolates of each species are quite uniform in activity. The relative activities of the several species are:

*Very active*: *Ch. globosum*, *Ch. spirale*, *Ch. mollipilium*

*Moderate activity*: *Ch. elatum*, *Ch. funicolum*, *Ch. cupreum*, *Ch. atrobrunneum*, *Ch. indicum*, *Ch. tortile*, *Ch. cochliodes*

*Weakly active*: *Ch. causiaeformis*, *Ch. velutinum*

*Cladosporium herbarum* isolates had medium to low activity on the oils used. This is odd since the isolates included two from sheepskin which Weston (1951) found to grow well on both animal and plant oils. *Cladosporium herbarum* and *Pullularia pullulans* are frequent causes of spotting of paints, yet neither fungus compares in activity with many others here tested on oils. This would indicate the difficulty of translating information obtained in shake flasks to other environmental conditions. Activity on the oils of paint, or of animal carcasses, evidently hinges on other factors.

Insect parasites appear to be very active consumers of oils. Thus, we find *Beauveria bassiana*, *Aspergillus parasiticus*, and *Aspergillus flavus*, in the very active group, but the common plant parasite *Botrytis cinerea*, on the other hand, has very little fat degrading ability. This observation is based on very few cases, and no generalization is intended.

The Phycomycetes vary in ability to metabolize oils. Best of the Phycomycetes tested are three species of Cunninghamella, *C. bertholletiae*, *C. blakesleeana*, *C. echinulata*. All three showed a mycelial weight equal to 65% of the initial weight of coconut oil, and to 20–40% of the initial ricinoleate. *Rhizopus spp.*, and *Circinella sydowi* are also very active, while *Absidia capillata* is rather weak. Of the Basidiomycetes tested, most appear to be relatively inactive, though this may be largely the result of the use of slow-growing vegetative inoculum. *Polyporus versicolor* had moderate activity on coconut oil.

## SUMMARY

Of the fungus isolates in the Quartermaster Culture Collection tested for their ability to grow on fatty materials: 95 percent grew on coconut oil, 90 percent on methyl acetyl ricinoleate and 60 percent on di-hexyl sebacate. Ability of fungi to hydrolyze extracellularly the ester linkage appears to be extremely widespread.

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## APPENDIX

| Organism | QM Number | Relative Activity * on Coconut Oil | Ricinoleate |
|---|---|---|---|
| **Absidia capillata** van Tieghem | 8b | 1 | 1 |
| **Absidia** sp. | 579 | 2 | |
| **Acremonium** sp. | 1b | 1 | |
| “ | 89c | 1 | 1 |
| “ | 581 | 1 | |
| “ | 582 | 1 | 1 |
| “ | 583 | 1 | |
| **Acrostalagmus cinnabarinus** Corda | 320e | 0 | 0 |
| **Aegerita** sp. | 566 | 2 | |
| **Alternaria oleracea** Milbrath | 280 | 1 | 1 |
| **Alternaria solani** (Ellis and Martin) Sorauer | 281 | 1 | |
| **Alternaria tenuis** Nees | 26a | 2 | 2 |
| “ | 73b | 3 | |
| “ | 85i | 1 | 1 |
| “ | 120m | 2 | |
| “ | 584 | 2 | 1 |
| “ | 585 | 1 | |
| “ | 586 | 2 | 2 |
| **Alternaria** sp. | 15a | 2 | |
| “ | 298 | 2 | |
| “ | 587 | 2 | |

* See table 1.

| Organism | QM Number | Relative Activity on | |
|---|---|---|---|
| | | Coconut Oil | Ricinoleate |
| **Amblyosporium botrytis** Fresenius | 971 | 1 | |
| **Arthrobotrys arthrobotryoides** (Berlese) Lindau | 669 | 1 | |
| “ | 1024 | 1 | |
| “ | 1025 | 1 | |
| **Arthrobotrys superba** Corda | 670 | 1 | |
| **Arthrobotrys superba** Corda var. **oligospora** Coemans | 671 | 1 | |
| **Aspergillus caespitosus** Raper and Thom | 961 | 1 | 2 |
| **Aspergillus carbonarius** (Bainier) Thom | 331 | 3 | 1 |
| **Aspergillus chevalieri** (Mangin) Thom and Church | 52b | 1 | 0 |
| “ | 64c | 1 | |
| “ | 112a | 1 | |
| “ | 312 | 1 | |
| **Aspergillus chevalieri** (Mangin) var. **intermedius** Thom and Raper | 58b | 1 | 0 |
| “ | 914 | 1 | |
| **Aspergillus clavatus** Desmazieres | 862 | 1 | 1 |
| “ | 872 | 3 | 1 |
| “ | 863 | 2 | |
| **Aspergillus echinulatus** (Delacr.) Thom and Church | 962 | 1 | 1 |
| **Aspergillus fischeri** Wehmer | 864 | 3 | 2 |
| “ | 865 | 3 | |
| “ | 866 | 2 | 2 |
| “ | 867 | 2 | |
| **Aspergillus flavipes** (Bainier and Sartory) Thom and Church | 24a | 1 | 1 |
| “ | 868 | 1 | 1 |
| “ | 869 | 1 | |
| **Aspergillus flavus** Link | 4m | 2 | 2 |
| “ | 10e | 3 | |
| “ | 63c | 3 | 3 |
| “ | 70a | 3 | |
| “ | 138f | 3 | |
| “ | 380 | 2 | |
| “ | 870 | 2 | |
| **Aspergillus flavus-oryzae** series | 871 | 3 | 2 |
| **Aspergillus foetidus** Thom and Raper | 328 | 2 | 1 |
| **Aspergillus fonsecaeus** Thom and Raper | 330 | 3 | 1 |
| **Aspergillus fumigatus** Fresenius | 6b | 2 | 2 |
| “ | 45h | 2 | 1 |
| “ | 445 | 2 | |
| “ | 497 | 2 | |
| **Aspergillus giganteus** Wehmer | 620 | 2 | 2 |
| **Aspergillus luchuensis** series | 102d | 1 | 1 |
| “ | 155e | 2 | |
| “ | 873 | 2 | |
| “ | 874 | 2 | |
| “ | 21e | | 1 |

| Organism | QM Number | Relative Activity on | |
|---|---|---|---|
| | | Coconut Oil | Ricinoleate |
| **Aspergillus montevidensis** Talice and MacKinnon | 401 | 1 | 1 |
| **Aspergillus nidulans** (Eidam) Winter | 25b | 2 | 2 |
| “ | 87c | 2 | 1 |
| “ | 875 | 1 | |
| “ | 876 | 1 | |
| **Aspergillus niger** van Tieghem | 458 | 3 | 2 |
| “ | 877 | 3 | 1 |
| “ | 878 | 3 | |
| **Aspergillus niger** mut. **cinnamomeus** (Schiemann) Thom and Raper | 326 | 3 | 2 |
| **Aspergillus niger** mut. **schiemanni** (Thom) Thom and Raper | 327 | 3 | 3 |
| **Aspergillus niger** series | 4j | 3 | |
| “ | 38b | 3 | |
| “ | 45d | 3 | |
| “ | 50c | 2 | |
| “ | 154a | 3 | |
| “ | 198b | 3 | |
| “ | 386 | 4 | |
| “ | 861 | 3 | 2 |
| **Aspergillus niveus** Blochwitz | 879 | 2 | 2 |
| **Aspergillus ochraceus** Wilhelm | 26b | 3 | 1 |
| “ | 58c | 2 | 1 |
| “ | 880 | 3 | 2 |
| **Aspergillus oryzae** (Ahlburg) Cohn | 22b | 3 | 2 |
| “ | 82i | 3 | 2 |
| **Aspergillus panamensis** Raper and Thom | 882 | 3 | 1 |
| **Aspergillus parasiticus** Speare | 883 | 3 | 3 |
| “ | 884 | 3 | 3 |
| **Aspergillus phoenicis** (Corda) Thom and Currie | 329 | 3 | 2 |
| “ | 1005 | 3 | 2 |
| **Aspergillus repens** (Corda) deBary | 44c | 0 | 0 |
| “ | 56f | 1 | 0 |
| “ | 59g | 1 | 1 |
| “ | 210 | 1 | 0 |
| “ | 360 | 1 | 0 |
| “ | 361 | 1 | 0 |
| “ | 364 | 0 | 0 |
| “ | 564 | 3 | 2 |
| **Aspergillus restrictus** G. Smith | 885 | 2 | 0 |
| **Aspergillus rugulosus** Thom and Raper | 886 | 1 | 1 |
| **Aspergillus sclerotiorum** Huber | 661 | 2 | 2 |
| **Aspergillus sydowi** (Bainier and Sartory) Thom and Church | 4d | 1 | 1 |
| “ | 31c | 3 | 1 |
| “ | 41a | 3 | 1 |
| “ | 54a | 1 | 1 |
| “ | 96a | 3 | 1 |
| “ | 103g | 3 | 1 |

| Organism | QM Number | Relative Activity on Coconut Oil | Relative Activity on Ricinoleate |
|---|---|---|---|
| **Aspergillus tamarii** Kita | 50b | 3 | 2 |
| " | 75b | 3 | 2 |
| " | 887 | 3 | 2 |
| " | 888 | 3 | 2 |
| **Aspergillus terreus** Thom | 72f | 4 | 2 |
| " | 82j | 3 | 2 |
| " | 91c | 3 | 1 |
| " | 106g | 4 | 2 |
| " | 442 | 3 | 2 |
| " | 889 | 3 | 2 |
| **Aspergillus unguis** Emile-Weil and Gaudin | 8f | 2 | 1 |
| " | 30b | 2 | 2 |
| " | 45e | 2 | 1 |
| " | 53c | 1 | 2 |
| " | 890 | 2 | 2 |
| **Aspergillus ustus** (Bainier) Thom and Church | 29c | 2 | 2 |
| " | 89d | 1 | 1 |
| " | 133f | 3 | 3 |
| " | 137d | 2 | 3 |
| " | 891 | 4 | 3 |
| " | 892 | 2 | 1 |
| **Aspergillus ustus** (Bainier) var. **laevis** Blochwitz | 24a-2 | 3 | 2 |
| " | 893 | 3 | 2 |
| **Aspergillus versicolor** (Vuillemin) Tiraboschi | 4g | 2 | 1 |
| " | 17d | 2 | 1 |
| " | 134c | 2 | 1 |
| " | 432 | 3 | 1 |
| " | 894 | 2 | 1 |
| **Aspergillus violaceo-fuscus** Gasperini | 335 | 3 | 1 |
| **Aspergillus wentii** Wehmer | 44a | 1 | 1 |
| Basidiomycete (Conidial stage) | 589 | 3 | 2 |
| " | 592 | 0 | 0 |
| " | 594 | 1 | 1 |
| " | 806 | 1 | 1 |
| " | 807 | 0 | 1 |
| **Beauveria bassiana** (Bals.) Vuill. | 972 | 3 | 2 |
| **Blakeslea trispora** Thaxter | 1019 | 1 | 1 |
| **Botryodiplodia theobromae** Patouillard | 78a | 1 | 1 |
| " | 145h | 2 | 1 |
| " | 166a | 2 | 1 |
| **Botryophialophora** sp. | 571 | 2 | 2 |
| **Botryosporium pulchrum** Corda | 907 | 1 | 0 |
| " | 965 | 0 | 0 |
| **Botryotrichum piluliferum** Sacc. & Marchal | 336 | 1 | 1 |
| " | 337 | 1 | 0 |
| " | 991 | 0 | 1 |
| **Botrytis cinerea** Persoon | 520 | 1 | 1 |
| **Botrytis** sp. | 344 | 1 | 1 |
| " | 578 | 1 | 0 |

| Organism | QM Number | Relative Activity on Coconut Oil | Relative Activity on Ricinoleate |
|---|---|---|---|
| **Brachysporium oosporum** (Corda) Saccardo | 665 | 2 | 2 |
| **Brachysporium** sp. | 38d | 3 | 2 |
| “ | 70g | 3 | 2 |
| “ | 595 | 1 | 1 |
| **Byssochlamys** sp. | 438 | 1 | 1 |
| **Cephaliophora tropica** Thaxter | 596 | 1 | 1 |
| **Cephalosporium** sp. | 107a | 1 | 1 |
| “ | 124h | 1 | 1 |
| “ | 127e | 1 | 2 |
| “ | 597 | 1 | 1 |
| “ | 598 | 1 | 1 |
| **Cephalothecium roseum** Corda | 599 | 1 | 1 |
| “ | 936 | 1 | 1 |
| **Chaetomium atrobrunneum** Ames | 626 | 2 | 2 |
| “ | 627 | 1 | 1 |
| “ | 952 | 1 | 1 |
| **Chaetomium causiaeformis** Ames | 949 | 1 | 1 |
| **Chaetomium cochliodes** Palliser | 604 | 1 | 1 |
| “ | 624 | 3 | 3 |
| **Chaetomium cupreum** Ames | 954 | 2 | 1 |
| **Chaetomium elatum** Kunze and Schmidt | 382 | 1 | 1 |
| “ | 605 | 1 | 1 |
| “ | 606 | 1 | 1 |
| **Chaetomium funicolum** Cooke | 33c | 2 | 1 |
| “ | 34d | 1 | 1 |
| “ | 35e | 1 | 1 |
| “ | 145k | 1 | 1 |
| “ | 155b | 1 | 1 |
| “ | 383 | 1 | 1 |
| “ | 607 | 1 | 1 |
| **Chaetomium globosum** Kunze | 32b | 3 | 2 |
| “ | 38f | 3 | 2 |
| “ | 85n | 3 | 1 |
| “ | 104a | 3 | 2 |
| “ | 459 | 3 | 3 |
| “ | 608 | 3 | 2 |
| **Chaetomium indicum** Corda | 46b | 1 | 1 |
| “ | 47c | 1 | 1 |
| “ | 156f | 2 | 1 |
| “ | 621 | 1 | 1 |
| **Chaetomium mollipilium** Ames | 1007 | 2 | 2 |
| “ | 1008 | 3 | 2 |
| **Chaetomium spirale** Zopf | 622 | 4 | 2 |
| **Chaetomium tortile** Bainier | 895 | 2 | 1 |
| **Chaetomium turgidopilosum** Ames | 948 | 2 | 1 |
| **Chaetomium velutinum** Ames | 623 | 1 | 1 |
| “ | 950 | 1 | 1 |
| “ | 951 | 1 | 1 |
| “ | 953 | 1 | 1 |
| **Chaetomium** n. sp. of Ames | 625 | 2 | 1 |
| **Circinella spinosa** van Tieghem and Le Monnier | 537 | 2 | 1 |

| Organism | QM Number | Relative Activity on | |
|---|---|---|---|
| | | Coconut Oil | Ricinoleate |
| **Circinella sydowi** Lendner | 629 | 3 | 1 |
| **Circinella** sp. | 902 | 2 | 1 |
| **Cladosporium herbarum** Link | 17b | 1 | 1 |
| “ | 52a | 2 | 1 |
| “ | 55b | 1 | 1 |
| “ | 71d | 2 | 1 |
| “ | 120g | 1 | 1 |
| “ | 121k | 2 | 2 |
| “ | 122e | 2 | 1 |
| “ | 279a | 1 | 0 |
| “ | 489 | 1 | 1 |
| “ | 1027 | 1 | 1 |
| “ | 1028 | 1 | 1 |
| **Cladosporium** sp. | 122c | 1 | 1 |
| “ | 146h | 1 | 1 |
| “ | 236 | 1 | 2 |
| “ | 279b | 1 | 1 |
| **Colletotrichum** sp. | 533 | 0 | 0 |
| **Collybia velutipes** (Curt.) Lond. | 1012 | 1 | 0 |
| **Coprinus sclerotigenus** Ellis and Everhart | 933 | 2 | 2 |
| **Corynespora** sp. | 569 | 0 | 0 |
| **Ctenomyces serratus** Eidam | 256 | 0 | 0 |
| **Ctenomyces** sp. | 199 | 0 | |
| “ | 287 | 2 | 1 |
| “ | 774 | 1 | 1 |
| “ | 845 | 1 | 1 |
| **Cunninghamella bertholletiae** Stadel | 1021 | 4 | 2 |
| **Cunninghamella blakesleeana** Lendner | 631 | 4 | 3 |
| **Cunninghamella echinulata** (Thaxter) Saccardo | 154f | 4 | 2 |
| **Cunninghamella elegans** Lendner | 634 | 2 | 1 |
| **Curvularia falcata** (Tehon) Boedijn | 77a | 1 | 1 |
| **Dactylium dendroides** (Bulliard) Fries | 508 | 2 | 1 |
| **Fusarium roseum** Link | 38g | 1 | 1 |
| **Humicola fuscoatra** Traaen | 580 | 1 | 1 |
| **Memnoniella echinata** (Rivolta) Galloway | 1c | 1 | 1 |
| **Mucor genevensis** Lendner | 549 | 1 | 1 |
| **Mucor heterosporus** Fischer | 615 | 2 | 1 |
| **Myrothecium verrucaria** (Alb. and Schw.) Ditmar ex Fries | 460 | 2 | 1 |
| **Paecilomyces varioti** Bainier | 822 | 2 | 1 |
| “ | 823 | 3 | 1 |
| “ | 824 | | 2 |
| **Penicillium capsulatum** Raper and Fennell | 2572 | 2 | 2 |
| **Penicillium chrysogenum** Thom | 943 | 2 | 1 |
| **Penicillium citrinum** Thom | 1a | 3 | 1 |
| **Penicillium duclauxi** Delacroix | 1078 | 2 | 1 |
| **Penicillium frequentans** Westling | 2497 | 2 | 1 |
| **Penicillium funiculosum** Thom | 443 | 2 | 2 |

| Organism | QM Number | Relative Activity on | |
|---|---|---|---|
| | | Coconut Oil | Ricinoleate |
| **Penicillium lilacinum** Thom | 4e | 2 | 2 |
| **Penicillium luteum** series | 474 | 2 | 1 |
| **Penicillium martensii** Biourge | 50a | 1 | 1 |
| **Penicillium palitans** Westling | 919 | 2 | 1 |
| **Penicillium pusillum** Smith | 137g | 1 | 1 |
| **Pestalotia bicolor** Ellis and Everhart | 664 | 3 | 2 |
| **Pestalotia dichaeta** Spegazzini | 698 | 2 | 2 |
| **Pestalotia palmarum** Cooke | 381 | 2 | 2 |
| **Pestalotia royenae** Guba | 531 | 3 | 2 |
| **Pestalotia virgatula** Klebahn | 478 | 2 | 2 |
| " | 479 | 3 | 2 |
| **Pestalotia** sp. | 2d | 3 | 2 |
| " | 119b | 2 | |
| " | 121L | 2 | 2 |
| " | 795 | 3 | 2 |
| " | 796 | 3 | |
| **Phialophora compacta** (Carrion) Binford, Hess & Emmons | 260 | 2 | 1 |
| **Phialophora fastigiata** (Lagerberg and Melin) Conant | 265 | 1 | 1 |
| **Phialophora jeanselmei** (Langeron) Emmons | 270 | 2 | 2 |
| **Phialophora lagerbergii** (Melin and Nannfeldt) Conant | 267 | 0 | 0 |
| **Phialophora pedrosoi** (Brumpt) Binford, Hess & Emmons | 259 | 1 | 1 |
| " | 261 | 1 | 1 |
| " | 262 | 2 | 1 |
| **Phialophora verrucosa** Medlar | 264 | 1 | 1 |
| " | 269 | 1 | 1 |
| **Phialophora** sp. | 645 | 1 | 1 |
| **Pholiota adiposa** Fr. | 512 | 0 | 0 |
| Phomaceae | 13e | 4 | 2 |
| " | 29b | 2 | 2 |
| " | 40c | 1 | 1 |
| " | 106d | 1 | 2 |
| " | 120k | 2 | 1 |
| " | 534 | 2 | 2 |
| " | 568 | 0 | |
| " | 576 | 3 | 2 |
| " | 603 | 2 | 2 |
| " | 618 | 3 | 1 |
| " | 699 | 4 | 3 |
| " | 701 | 2 | 3 |
| " | 702 | 1 | 1 |
| " | 703 | 3 | 3 |
| " | 704 | 2 | 2 |
| " | 798 | 2 | 2 |
| " | 799 | 2 | 1 |
| " | 804 | 2 | 1 |
| " | 830 | 2 | 1 |
| " | 831 | 1 | 1 |

| Organism | QM Number | Relative Activity on | |
|---|---|---|---|
| | | Coconut Oil | Ricinoleate |
| “ | 832 | 1 | 2 |
| “ | 896 | 2 | 2 |
| “ | 935 | 3 | 2 |
| **Phymatotrichum** sp. | 985 | 1 | 0 |
| **Polyporus sulfureus** (Bulliard) Fries | 509 | 0 | 0 |
| **Polyporus versicolor** (L.) Fr. | 1013 | 2 | 1 |
| **Pseudocoprinus** sp. | 801 | 1 | 1 |
| **Ptychogaster rubescens** Boud. | 1011 | 1 | 0 |
| **Pullularia pullulans** (deBary) Berkhout | 72c | 2 | 2 |
| “ | 279c | 1 | 1 |
| “ | 388 | 3 | 1 |
| “ | 802 | 2 | 2 |
| **Rhizopus arrhizus** Fischer | 46c | 2 | 2 |
| “ | 187a | 1 | 2 |
| “ | 808 | 2 | 1 |
| “ | 809 | 2 | 1 |
| “ | 839 | 2 | 1 |
| “ | 500 | 3 | 2 |
| **Rhizopus nigricans** Ehrenberg | 387 | 2 | 2 |
| “ | 810 | 2 | 1 |
| “ | 860 | 2 | 2 |
| **Rhizopus oryzae** Went and Geerlings | 811 | 3 | 1 |
| **Rhizopus** sp. | 231 | 1 | 1 |
| “ | 1032 | 3 | |
| **Scopulariopsis brevicaulis** (Saccardo) Bainier | 609 | 1 | 1 |
| “ | 773 | 1 | 1 |
| “ | 813 | 1 | 1 |
| “ | 814 | 1 | 1 |
| “ | 815 | 1 | 1 |
| “ | 816 | 1 | 1 |
| **Scopulariopsis repens** Bainier | 399 | 1 | 1 |
| **Sepedonium** sp. | 913 | 0 | 0 |
| **Septonema** sp. | 818 | 4 | 3 |
| **Spegazzinia tessarthra** (Berk. and Curt.) Saccardo | 373c | 2 | 1 |
| **Sphaeropsis** sp. | 47a | 2 | 1 |
| “ | 104g | 2 | 1 |
| **Spicaria violacea** Abbott | 1031 | 1 | 1 |
| **Spiroschisma** sp. ? | 708 | 2 | 1 |
| **Sporotrichum pruinosum** Gilman and Abbott | 168 | 1 | 1 |
| “ | 244 | 1 | 1 |
| “ | 303 | | 1 |
| “ | 591 | 1 | 1 |
| “ | 593 | 2 | 1 |
| “ | 825 | 1 | 1 |
| **Stachybotrys atra** Corda | 102a | 1 | 1 |
| **Stemphylium botryosum** Wallroth | 544 | 2 | 1 |
| **Stereum purpureum** Fr. | 1014 | 0 | 0 |
| **Syncephalastrum racemosum** (Cohn) Schroeter | 57a | 2 | 1 |

| Organism | QM Number | Relative Activity on Coconut Oil | Ricinoleate |
|---|---|---|---|
| **Torula** sp. | 986 | 2 | 1 |
| **Trichoderma viride** Harz | 6a | 2 | 1 |
| " | 13b | 2 | 1 |
| **Tritirachium roseum** van Beyma | 164 | 1 | 1 |
| **Ustilago zeae** (Beckm.) Unger | 990 | 1 | 2 |
| **Sporocytophaga myxococcoides** (Krzemieniewska) Stanier | B482 | 1 | 0 |
| **Streptomyces** sp. | B1549 | 1 | 0 |

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# NEW LICHENS FROM NORTHERN PATAGONIA, WITH NOTES ON SOME RELATED SPECIES

I. MACKENZIE LAMB

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The new entities described in the present paper are all from the westernmost parts of Argentine Patagonia situated between latitudes 39° and 43° S., chiefly from around the great Cordilleran lakes of Nahuel Huapí (Prov. Río Negro), Futalaufquen and Menéndez (Terr. Chubut) and Lacar and Quillén (Prov. Neuquén). They are based partly on material preserved in the Argentine Museum of Natural Sciences in Buenos Aires (collections made chiefly by Oscar Kühnemann) and partly on specimens collected by the present author on a field trip to those parts of northern Patagonia in 1950. Most of the localities visited lie within the Argentine National Parks of Nahuel Huapí, Lanín, and Los Alerces. At the western ends of the lakes mentioned, where most of the collections were made, the lichen vegetation is extremely rich and luxuriant; it accompanies the species-rich Valdivian rain forest, largely composed of evergreen Antarctic beech (*Nothofagus dombeyi*), bamboos (*Chusquea*) etc., eastwards through the mountain passes from the Chilean side, and the species composing it are for the most part characteristic of the very humid Valdivian floristic region, with some Magellanic elements at the higher altitudes. The finding of a number of undescribed species of lichens in this area is not altogether surprising, because very few data have been published concerning its cryptogamic vegetation. Apart from a few records mentioned by Malme (1899, 1925) and others, there exist only two papers dealing especially with the lichen flora of this part of northern Patagonia: * that of Räsänen (1939), based on a collection made in the Nahuel Huapí National Park by A. Donat, and that of Santesson (1942) on lichens from the same area collected by Ljungner in 1932–34. A semi-popular lichen flora of the Argentine National Parks, by the present author, is now in course of preparation, and the new entities here described were encountered in the elaboration of a large amount of undetermined lichen material being worked up in connection with its compilation. Some apparently new species of *Cladonia* found in the collections were submitted to Dr. Alexander W. Evans (Yale University), who is reporting separately on them in due course.

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* The paper "Lichenes argentinienses a cl. Dr. Lorentz in Argentina australi s. patagonica et prope Conceptionem lecti" by J. Müller-Argau (*Flora*, Vol. LXXII, 508; 1889) deals mainly with species from the more arid and floristically quite distinct region to the east of the National Parks.

### **Verrucaria lacustris** M. Lamb (n. sp.)

Thallus epilithicus, effusus, tenuis, obscure cyanescenti-griseus aut chalybaeus, madefactus vix gelatinosus et colore haud mutatus, continuus vel passim subreticulato-rimosus, haud areolatus, opacus, hypothallo obscuro haud cinctus; intus pseudoparenchymaticus, I– , strato basali tenui, olivaceo-fusco sed haud carbonaceo; gonidia 4–8 μ diam., irregulariter disposita. Perithecia sparsa, semi-immersa, tandem hemisphaerico- vel subconico-emergentia, in parte infima thallo tenuiter obducta, dimidio superiori (0.3–0.5 mm. lato) nuda et nigra; ostiolo saepe distincto, minuto, impresso. Excipulum globosum vel depresso-globosum, 170–255 μ latum, integre fuscum; involucrellum crassum, carbonaceum, excipulum superne et lateribus fere usque ad basin tegens, inferne crassescens et extrinsecus productum. Periphyses graciles, ramosae; paraphyses nullae (omnino diffluxae). Sporae 6–8nae, ellipsoideae, incoloratae, simplices, 13.5–15.3 (–17.0) μ longae, 6.5–7.5 (–8.5) μ latae, pariete tenui. — Gelatina hymenialis I + vinoso-fulvescens (nulla praecedente caerulescentia). — Inter species aquae dulcis stirpis *V. aethiobolae* locanda, *V. hydrelae* Ach. et *V. kernstockii* Zschacke proxime ut videtur accedens, a quibus differt excipulo bene et integre infuscato, thallo magis chalybaeo, etc. — In saxis granitoideo-quartziticis praeter litus lacus Verde in Argentina, Patagonia, Chubut, ubi temporibus asperitatis coeli adspersione procellarum facile humectatur: M. Lamb, 1950, no. 5884.

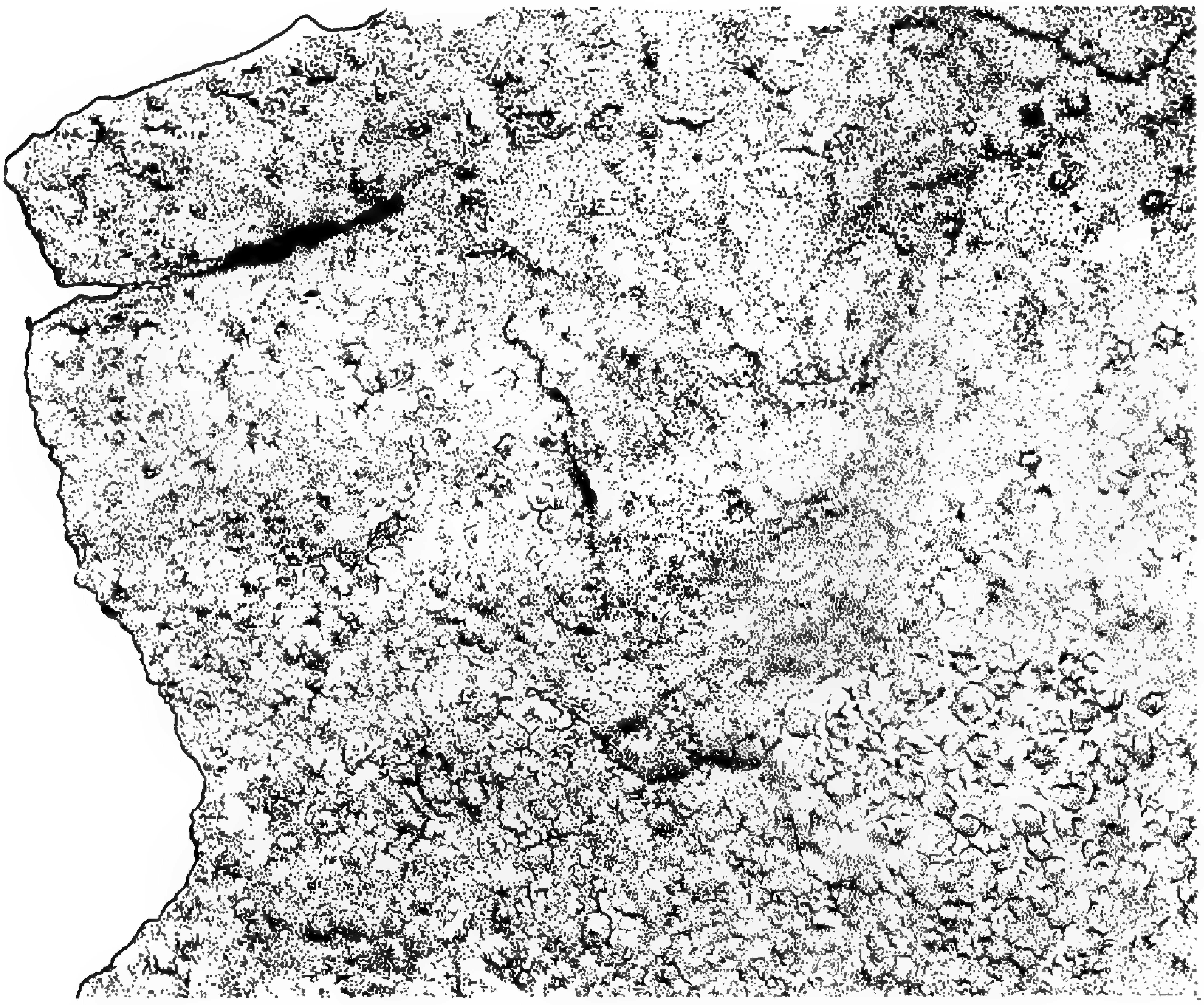


**Fig. 1.** *Verrucaria lacustris* M. Lamb. Part of the type-specimen (× 4).

Thallus epilithic, forming irregular confluent patches up to 5 cm. or more in diameter, thin, effuse, not bounded by any dark hypothallus, smooth, even, dark blue-green-gray or "chalybaeous" (comparable to Pl. LII, 35'''' i–k in Ridgway's

"Color Standards," 1912), without any brownish tinge, not changing color when moistened, matt, continuous or in places obsoletely reticulate-rimose, not areolate, not punctate. Perithecia fairly abundant, irregularly scattered, semi-immersed, finally forming hemispherical- or subconical-emergent black verrucae 0.3–0.5 mm. diam., only in the lower half thinly clothed by thallus; matt or rarely subnitid, with the apical ostiole usually ± distinct, minute, impressed.

Thallus 30–65 μ thick, with a somewhat vaguely limited, dark olive-brownish upper cortical layer 6–10 μ thick; basal 10–17 μ also gradually dark olive-brownish (not or hardly carbonaceous); the intervening medullary-algal layer greenish (from the algae), not pigmented, entirely ± filled with algae, which are disposed haphazardly, not in rows. Thallus entirely distinctly pseudoparenchymatic in structure (the cortex and basal layer distinctly so), the cells rounded or oblong, with walls about 0.7 μ thick; those of upper cortex and medulla about 2 μ diam., those of the basal layer slightly larger, 2–3 μ. Algae pale green, globose or oblong, thin-walled, small, 4–8 μ diam. All thalline tissues I–.

Perithecia in section show a globose or slightly flattened excipulum 170–255 μ diam., with entire, dark brown wall about 10 μ thick of tangentially compressed cells 6–10 × 1.5–3.0 μ. Involucrellum well developed, carbonaceous, 65–78 μ thick above, 100–155 μ thick below, lying over the excipulum and extending down its sides almost to its base, where it is wider and angulate-produced; its lowest part separated from the excipulum by a distinct crack. Involucrellum covered to about half-way from the base (or sometimes higher) by a thin thalline layer up to 24 μ thick containing algae. Structure of involucrellum pseudoparenchymatic, with ± isodiametric, rounded or angulose cells 3–4 μ diam., their brown-pigmented walls 0.7–1.0 μ thick. Periphyses present on upper inner wall of excipulum; branched, slender, up to 40 μ long, about 1 μ thick. No paraphyses (diffluxed). Asci soon diffluxed. Spores 6–8 in ascus, irregularly massed, ellipsoid, thin-walled, colorless, simple, 13.5–15.3 (–17.0) × 6.5–7.5 (–8.5) μ. "Nucleus" I + vinous-fulvescent (no preceding blue coloration). (No pycnidia found.)

**Fig. 2.** *Verrucaria lacustris* M. Lamb. The type-specimen. Structure of the perithecium.

This species is one of the freshwater *Verrucariae* of the *aethiobola*-group, related to *V. hydrela* Ach. and *V. kernstockii* Zschacke (Syn. *V. rheithrophila* Zschacke, *V. minutipuncta* Erichs.). From *V. aethiobola* it differs in the differently colored thallus without any brownish tinge, the larger perithecia, and the smaller spores; from *V. hydrela* in the quite smooth thallus, the dark brown entire excipulum, and the somewhat shorter spores; and from *V. kernstockii* in the more emergent perithecia, dark entire excipulum of larger diameter, and somewhat larger spores. *V. laevata* Ach. has a thinner, much lighter colored thallus, and smaller perithecia. Some species recently described by Servít more or less closely resemble *V. lacustris*: *V. schistosa* Serv. in *Stud. Bot. Čechoslovaca*, Vol. XI, 34: 1950 (differing in its smaller perithecia and smaller spores), *V. kalenskýi* Serv. in *Věstn. Král. České Spol. Nauk*, Vol. IV, 3: 1951 (differing in the punctate-maculate thallus and smaller dimensions of perithecia and excipulum), *V. subhydrela* Serv., *op. cit.*, p. 6 (differing in the smaller, completely colorless excipulum, the thinner, more adpressed involucrellum, and the longer and somewhat broader spores), and *V. diabasica* Serv. in *Preslia*, Vol. XXIV, 355: 1952 (differing in the partly minutely verruculose thallus and smaller perithecia and excipulum, the latter colorless or almost so at the base). Among Southern Hemisphere species, *V. lacustris* is most closely comparable with *V. riograndensis* Malme (from Brazil), *V. sublaevata* Müll. Arg. (from Brazil), and *V. submargacea* Kn. (from New Zealand); from *V. riograndensis* it differs in the larger perithecia and smaller spores, from *V. sublaevata* in the dark chalybaeous thallus and smaller spores, and from *V. submargacea* also in the distinctly smaller spores.

Collected on granitoid-quartzitic rocks at the edge of the lake, just above water level, certainly inundated during stormy weather. It was of more or less sporadic occurrence, and did not form a continuous supralitoral zone.

Type in Herb. Mus. Nat. Canada, Ottawa; isotype in Herb. Inst. Bot. Darwinion, San Isidro, Buenos Aires.

### **Sphaerophorus ramulifer** M. Lamb (n. sp.)

Thallus caespitosus, erectus, altitudine 2.5–4.0 cm.; rami primarii congesti, subsimplices aut parce irregulariter ramosi, teretes (nec complanati), validi, 0.8–2.0 (–2.5) mm. crassi, pallide cinereo-straminei, hinc inde spurie rubrotincti, opaci, laeves, cortice saepe transversim diffracto, ramulis phyllocladoideis numerosis minutis divaricatis muniti. Ramuli ramis concolores vel paullo pallidiores, ad basin usque 6 mm. longi, ad ramos breviores (0.5–1.5 mm.) et ibidem saepe fasciculato-aggregati. Cephalodia desunt. Apothecia terminalia, primo subglobosa, mox late calyciformia et apice irregulariter dehiscentia, demum 2.5–3.0 mm. lata, receptaculo thallino ramulis minutis vel papillis parce obsito; mazaedium prominens, nigrum, subtiliter fibrosum. Sporae globosae, decolores aut leviter cyanescenti-obscuratae (nunquam fuscae), membrana tenui, pigmento nigricante friabili obductae, simplices, 6.5–8.5 μ latae. — Medulla alba, solida, KHO– , $CaCl_2O_2$– , PD– , I– . — Ad speciem neozelandicam *Sph. nobilem* Zahlbr. proxime accedit, a qua statura humiliori, medulla iodo haud reagente, sporis minoribus et forsan aliter coloratis recedit. *Sph. stereocauloidi* Nyl. item neozelandico haud absimile, at defectu cephalodiorum et reactionis iodeticae mox distinctus. — Ad corticem *Fitzroyae* in Argentina, Patagonia, Rio Negro, lacus Frias: M. Lamb, 1950, no. 5977.

**Fig. 3.** *Sphaerophorus ramulifer* M. Lamb. The type-specimen (× 1.25).

Caespitose, forming close, irregular, intricated tufts; primary branches upright, crowded, 2.5–4.0 cm. high, subsimple or sparingly branched in irregular fashion, terete (not flattened), 0.8–2.0 (–2.5) mm. thick, entirely covered with a smooth, matt, non-pruinose cortex which is often transversely annulate-cracked (in the thicker branches with some cracks in other directions also); color pale grayish-stramineous, in a few places (artificially) stained crimson-reddish. Numerous small disharmonic phyllocladioid branchlets present, both on the primary branches and around their base; terete-coralloid, furcately branched, concolorous with the primary branches or paler (whitish), smoothly corticate, those at the base up to 6 mm. long, those on the primary branches themselves shorter (0.5–1.5 mm.) and often in fasciculate groups; about 0.15 mm. in thickness. No cephalodia present. Apothecia numerous, terminal on the primary branches, at first subglobose, soon dehiscing irregularly at the apex and becoming shallowly cup-shaped; when fully expanded 2.5–3.0 mm. diam. Receptacle corticate, concolorous with the rest of the thallus, smooth or slightly scrobiculate, studded with small reduced phyllocladioid branchlets or papillae; mazaedium prominent, black, finely fibrose.

Cortex of primary branches 100–120 $\mu$ thick, in outermost one-third gradually inspersed with sordid yellowish-gray granules, the inner part clear and hyaline; on the outside covered by a colorless, amorphous, necrotic stratum 6.0–8.5 $\mu$ thick. Cortex composed of completely gelatinized and fused, very thick-walled hyphae intricated in various directions, only the tubular lumina (1.0–1.7 $\mu$ wide) visible in the gelatinous matrix. Inner boundary against the algal-medullary layer ± even (not of "zigzag" formation). Algal-medullary layer 50–100 $\mu$ deep, densely dark grayish-inspersed and ± opaque in water. Central core compact, without interstices, grayish-cloudy but without visible granules, composed of colorless, fairly thick-walled, ± discrete hyphae 3.5–6.0 $\mu$ thick, closely intricated in various directions, but chiefly in a ± longitudinal sense. Algae protococcoid, globose, bright green, thin-walled, 5.5–8.5 $\mu$ diam. In KHO, nubilation of outer cortex is dissolved with effusion of yellow mist; that of the algal-medullary layer and the central core dissolved without any color. Spores simple, globose, colorless to faintly cyanescent-darkening, but never brown, surrounded by quantities of a friable blackish pigment; thin-walled, 6.5–8.5 $\mu$ diam.

Medulla KHO– , $CaCl_2O_2$– , KHO($CaCl_2O_2$)– , PD– (also in the finer branches and younger growing parts), I– .

There are four other known species of *Sphaerophorus* which are provided with the same type of characteristic minute divaricate phyllocladioid branchlets: *Sph. stereocauloides* Nyl., *Sph. jamaicensis* Räs., *Sph. tuckermanii* Räs., and *Sph. nobilis* Zahlbr. *Sph. jamaicensis* belongs obviously to the *melanocarpus*-group, and is distinguished from our species by its compressed thallus-branches and different chemical composition (medulla PD + red). *Sph. tuckermanii* Räs. is a much more slender species, and has the medulla I + blue. *Sph. stereocauloides* differs in the presence of the characteristic cephalodia and has the medulla I + blue. The greatest similarity seems to be with the New Zealand species *Sph. nobilis* Zahlbr., of which unfortunately no authentic material could be obtained for comparison; according to the description (in *Denkschr. Akad. Wiss. Wien, math.-naturw. Kl.*, Vol. CIV, 258: 1941) this agrees well in habitus with *Sph. ramulifer*, but is much larger, up to 16 cm. high, has a positive reaction of the medulla with iodine, a subcorymbose arrangement of the apothecia, and distinctly larger and brown-pigmented spores.

It was found growing in conspicuous tufts towards the base of trunks of *Fitzroya* in open forest near the shore of the lake.

Type in Herb. Mus. Nat. Canada, Ottawa; isotypes in Farlow Herb., Herb. Inst. Syst. Bot. Uppsala, and Herb. Inst. Bot. Darwinion, San Isidro, Buenos Aires.

### **Psoroma internectens** M. Lamb (n. sp.)

Thallus minute squamulosus, squamulis vix 0.5 mm. latis, primum dispersis, mox contiguis et imbricatis, cervinis aut alutaceo-fuscidulis, rotundatis, passim margine angustissime et indistincte pallidioribus, hypothallo inconspicuo nigricanti superpositis, marginibus liberis aut subliberis; apothecia inter squamulas dispersa, discoidea, sessilia, 0.9–1.8 mm. lata, persistenter plana, disco obscure rufescenti aut rufofusco, opaco, nudo, margine tenui, integro, haud vel vix prominulo, rufofusco (disco concolori vel paullulum pallidiori), demum fere excluso. Thallus latere superiore tantum corticatus, cortice 17–20 μ crasso, indistincte pseudoparenchymatico. Apothecia gonidia et in margine et (parcius) sub hypothecio foventia, strato corticali marginis inferne evoluto, superne deficienti. Hypothecium pallidum, hyphosum, grumosum, strato basali excipulare indistincte pseudoparenchymatico insidens. Hymenium circ. 120 μ altum, superne fulvescens; paraphyses separabiles, apicibus vix incrassatae; asci clavati, 95–100 μ longi. Sporae 6–8nae, uniseriatae aut partim biseriatae, simplices, hyalinae, ellipsoideae, longit. 20–24 μ, crassit. 9–12 μ, apicibus leviter acuminatis aut interdum obtuse apiculatis, episporio sat incrassato et exasperato. — Aspectu *Psoromariam* in memoriam revocat, ab illo genero autem structura lecanorina apotheciorum secernendum et *Psoromeis* veris adscribendum, reliquis speciebus hujus generis margine thallino obscurius colorato et deflexo diversum. — Supra terram arenosam inter muscos in Argentina, Patagonia, Chubut, lacus Menéndez: O. Kühnemann, 1940, no. 4747.

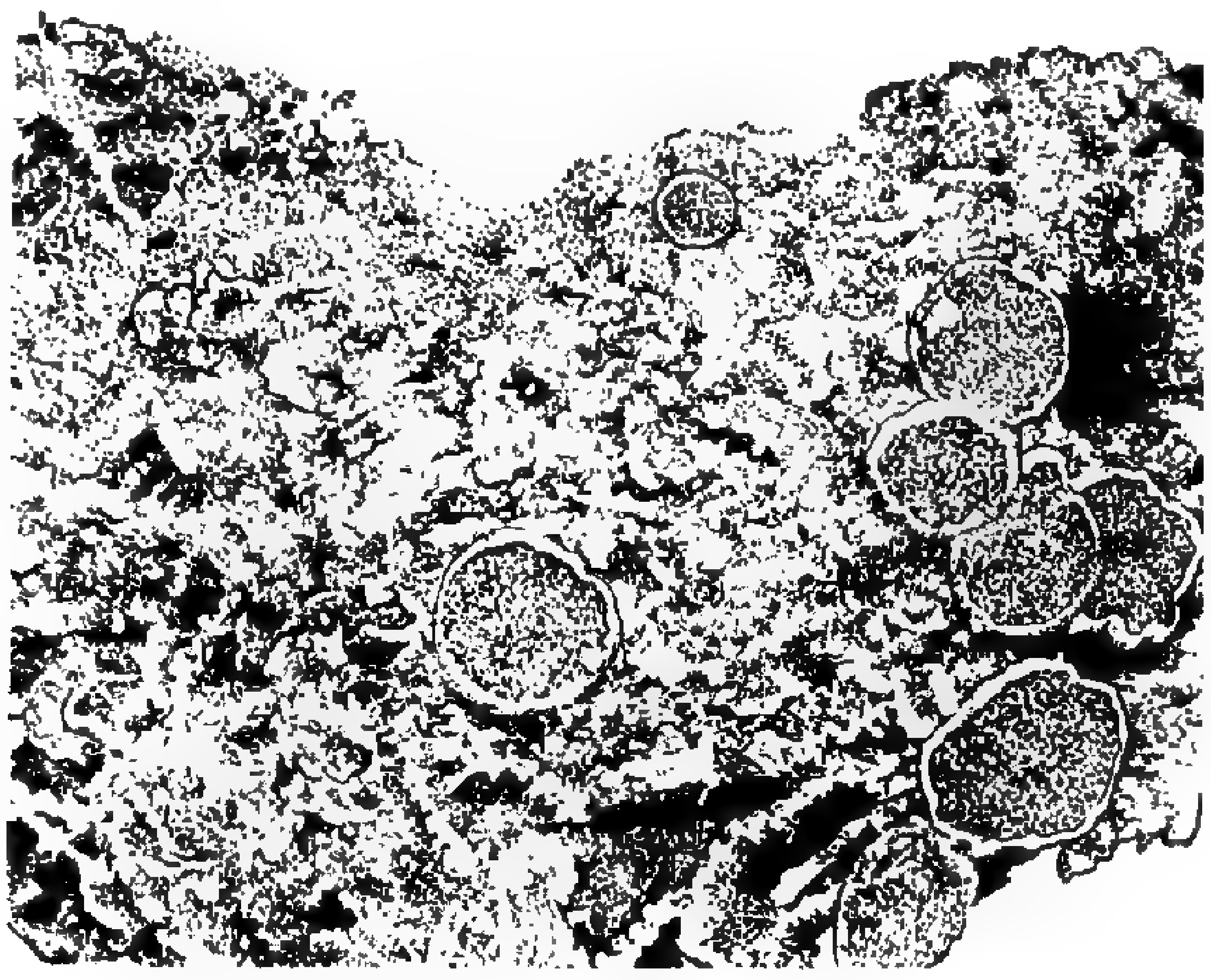


**Fig. 4.** *Psoroma internectens* M. Lamb. Part of the type-specimen (× 4).

Thallus effuse, in small scattered or confluent patches up to 1 or 2 cm. across, consisting of scattered, contiguous, or finally imbricated, minute, tawny or brownish-buff squamules not over 0.5 mm. diam., which are thin, sometimes very narrowly and indistinctly paler at the margins, on an indistinct, non-zonate, non-fibrous, blackish hypothallus. The scattered squamules are slightly free at the edges, the imbricate ones completely free at the edges. Lower side of squamules concolorous with upper side or slightly paler, or blackish from the adherent hypothallus, not rhizinose. Upper surface of thallus smooth, matt. Apothecia fairly numerous, irregularly scattered among the squamules, discoid, sessile, constricted at base, 0.9–1.8 mm. diam., persistently plane, with dark reddish or red-brown, smooth, matt, naked disc and thin, entire, not or hardly prominent, reddish-brown margin (concolorous with, or somewhat lighter than, the disc), which may finally be ± reflexed and almost excluded. In outward appearance, the apothecia look biatorine. The margin on its outer side is occasionally minutely and obsoletely verrucose-crenulate, but this not noticeable except by close examination.

Thalline squamules 100–140 μ thick; upper cortex 17–20 μ thick, colorless to faintly sordid yellowish, ± clear or slightly cloudy in section (but without granules), indistinctly pseudoparenchymatic with isodiametric, rounded cell-lumina 3.5–5.0 μ diam.; interior completely filled with symbiotic algae embedded in compact hyphal tissue; no distinct lower cortex developed. Hypothallus consisting of lax, brown or colorless hyphae about 3.5 μ thick entangled with the particles of the substratum. Algae pale green, globose, 8–14 μ diam., thin-walled.

Margin of apothecia distinctly corticate only in its lower part; the upper part has the algae reaching almost to the surface, covered only by a ± amorphous, colorless to pale brownish weft of indistinct gelatinous hyphae. Cortex of lower part 30–120 μ thick, becoming thicker downwards, colorless and hyaline, or reddish-brown in outermost 10–17 μ, pseudoparenchymatic, with oblong, radially parallel, thin-walled cells 7–12 × 4–7 μ. Algae abundant and crowded in the margin, also present in ± scattered groups below the lower excipular stratum. Some colorless or brownish rhizoid-hyphae are developed on the outside of the apothecia at the base. Hypothecium 35–70 μ deep, grayish-cloudy in section, compactly hyphose, grumose, resting on a colorless or faintly yellowish, indistinctly pseudoparenchymatic, lower excipular stratum 35–60 μ thick with ± isodiametric, indistinct cell-lumina 2.5–4.0 μ diam.; this layer running up at the sides of the hymenium to form a ± obsolete, non-prominent proper margin. Hymenium about 120 μ high, fulvescent in uppermost 9–13 μ, otherwise colorless and hyaline. Paraphyses separable in water, involved in mucilage and ± gelatinous, 1.5–2.5 μ thick, simple or branched, ± irregular but not articulated; not or hardly thickened at apices, where they are fused into a gelatinous, brownish-yellow epithecium. Asci clavate, 95–100 μ long, with wall about 1.5 μ thick at sides, at the apex gelatinously thickened to 15–20 μ. Spores 6–8 in ascus, uniseriate or partly biseriate, ellipsoid, slightly pointed or sometimes bluntly apiculate at ends, with uneven-scabrid, ± gelatinous wall up to 1.5 μ thick, and often vacuolate contents; 20–24 × 9–12 μ. Hymenium I + light blue then wine-red (only the asci stained).

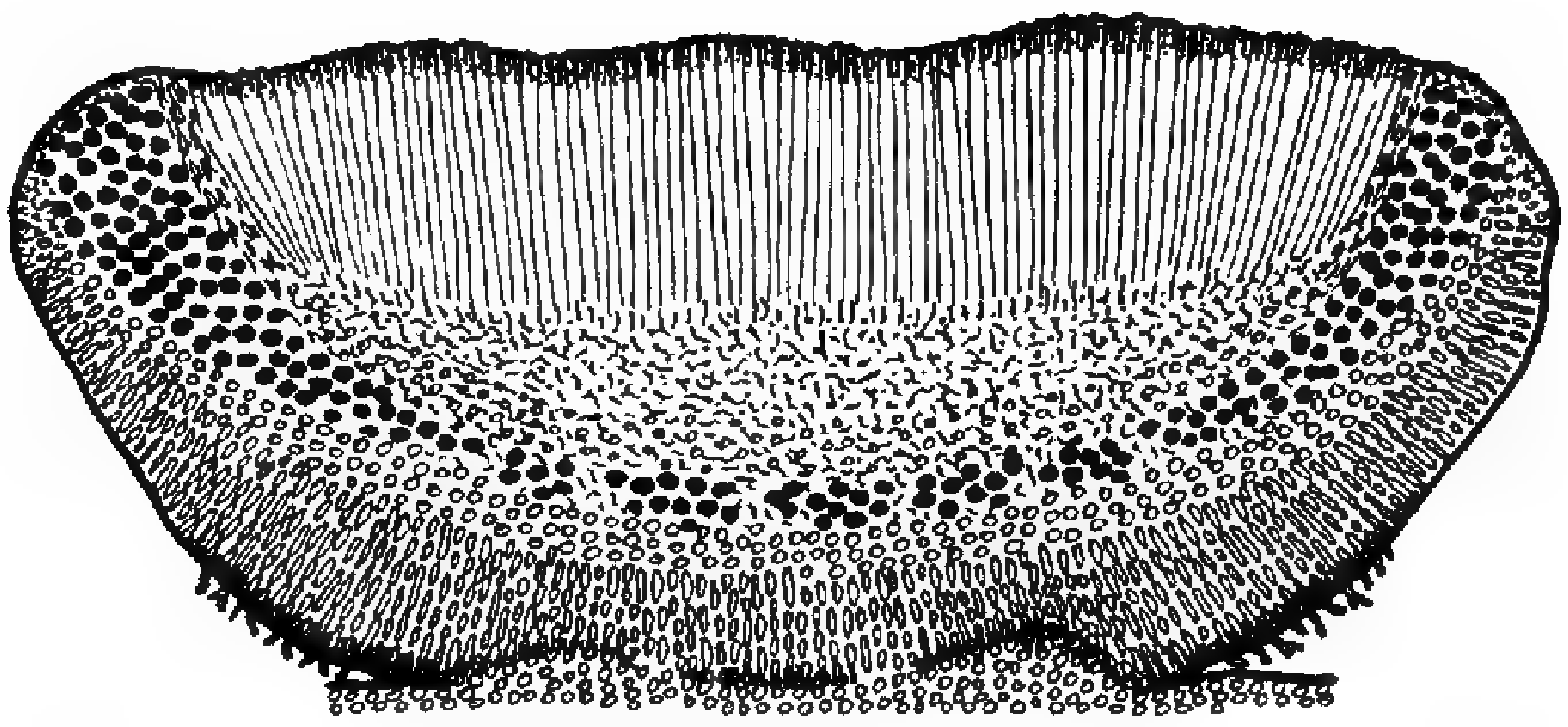


**Fig. 5.** *Psoroma internectens* M. Lamb. The type-specimen. Section of an apothecium.

The thallus, consisting of minute, ± imbricated squamules, strongly resembles that of the two species of *Psoromaria*, *Ps. descendens* and *Ps. subdescendens*, and the apothecia outwardly resemble those of the latter species, but differ anatomically in the presence of algae in the margin and below the lower excipular stratum; their structure is fundamentally the same as in other species of *Psoroma*, but the cortex of the thalline margin is pushed down and reflexed, giving a biatoroid appearance; in *Psoromaria* the apothecia are truly biatorine, not containing algae (see M. Lamb in *Lilloa*, Vol. XXVI, 408: 1953).

Collected by Oscar Kühnemann on sandy soil among mosses at Lago Menéndez in the western part of the Los Alerces National Park (Chubut).

Type in Herb. Mus. Argent. Cienc. Nat., Buenos Aires; isotype in Herb. Mus. Nat. Canada, Ottawa.

### **Parmeliella granulata** M. Lamb (n. sp.)

Thallus foliaceo-crustosus, plus minusve orbicularis, ad 10 cm. latus, margine laciniato-lobatus, in centro crustaceo-squamulosus, undique (saltem in herbario) alutaceus, opacus, peripheriam versus in superficie granulato-scabrosus (ut in *Peltigera scabrosa*); subtus et passim margine tomento rhizinoso caeruleoatro vel partim pallescente dense vestitus. Laciniae marginales longit. 4–8 mm., latit. 1.5–4.0 mm., crassit. circ. 0.2 mm., irregulariter divisae et lobatae, planiusculae, haud sulcatae;

thallus in parte centrali ad 2 (–3) mm. crassus, squamulis coacervatis, concrescentibus, rotundatis aut varie lobato-crenatis, laevigatis aut thalli marginem versus scabriusculis. Apothecia numerosa, sessilia, rotundata, basi modice vel bene constricta, 0.5–1.0 mm. lata, ab initio nigra aut fusconigra, nuda, primo plana et margine proprio mediocri integro concolori cincta, dein mox convexa et immarginata; excipulum integrum, inferne incoloratum et sat grosse pseudoparenchymaticum, lateribus extus anguste fuscescens et ex hyphis radiantibus contextum; hypothecium isabellinum, ad 270 μ crassum. Hymenium 80–100 μ altum, superne obscure olivaceo-fuscescens aut fuligineum, caeterum decolor et hyalinum, paraphysibus discretis, simplicibus. Sporae 8nae, simplices, incoloratae, ellipsoideae, vulgo apicibus acutiusculae, 12–15 × 5.5–7.0 μ, pariete tenui et laevigato. — Thallus extus intusque KHO– , $CaCl_2O_2$– , PD– , I– ; hymenium I + persistenter caerulescens, epithecium KHO– , $HNO_3$ + violaceo-rubescens. — Similitudinem quamdam, quod ad habitum attinet, cum *P. plumbea* (Lightf.) Müll. Arg. ostendit, at colore et scabrositate thalli diversa. — Ad cortices in Argentina, Patagonia, Neuquén, prope lacum Quillén: O. Kühnemann, 1943, nos. 789, 791 pr. p. (typus speciei), 795.

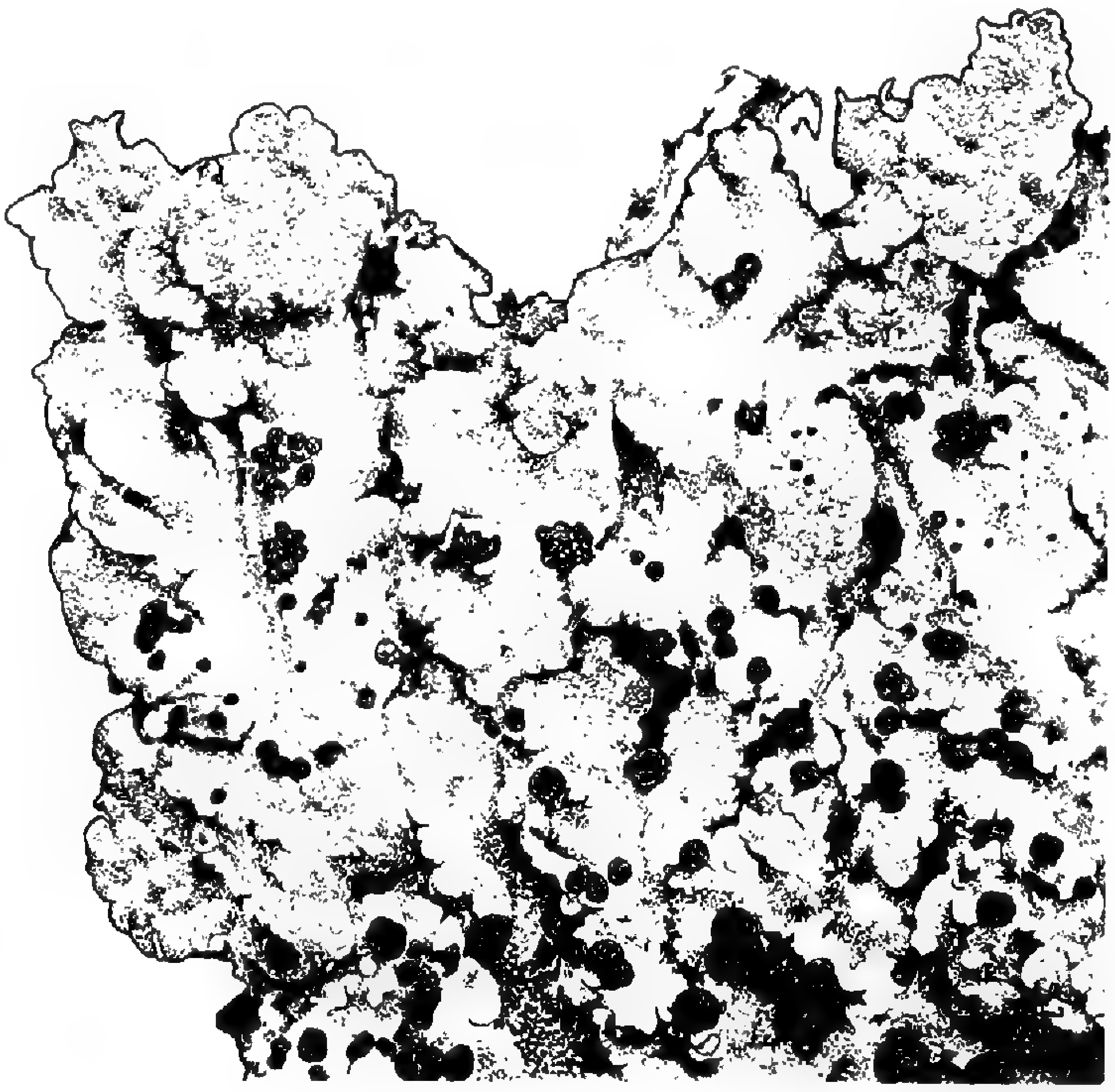


**Fig. 6.** *Parmeliella granulata* M. Lamb. Part of the type-specimen showing peripheral lobes (× 4).

*Description of the type-specimen* (*Kühnemann no. 791 pr. p.*): Thallus foliose-crustose, adpressed, ± orbicular, up to 5–10 cm. diam., laciniate-lobate at periphery, crustose-squamulose in central part, alutaceous in color ("Cinnamon-Buff," "Clay Color," or "Tawny Olive" in Pl. XXIX of Ridgway's "Color Standards"), quite matt, distinctly scabrid-granulate towards the periphery (as in *Peltigera scabrosa*). Peripheral laciniae 4–8 mm. long, 1.5–4.0 mm. broad, loosely adpressed to substratum, irregularly branched, rounded and lobate-crenate, about 0.2 mm. thick, ± plane, not striate or sulcate. Central part of thallus consisting of heaped-up and concrescent squamules forming a ± continuous, uneven crust up to 2 (–3) mm. thick; squamules rounded or irregularly lobate-crenate, 0.8–1.3 (–2.0) mm. diam., up to 0.3 mm. thick, with smooth surface in central parts, becoming gradually scabrose towards periphery of thallus. Underside of thallus with a dense, felted, green-blackish (rarely pallescent) mat of rhizinae, which is visible in places also at the periphery. Thallus externally and internally KHO– , $CaCl_2O_2$– , PD– ; medullary hyphae I– .

Apothecia numerous in central part of thallus, lecideine, scattered or crowded together and sometimes ± confluent, sessile, round, moderately to well constricted at base, 0.5–1.0 mm. diam., black or brown-blackish from the first, matt or slightly nitid, naked, at first plane with ± distinct, moderate, entire, concolorous proper margin, then soon becoming moderately to strongly convex and immarginate.

Thallus corticate on upper side only; cortex pale sordid yellowish or faintly brownish (almost colorless in very thin section), not nubilated, irregular on account of scabrosity, 45–95 μ thick, pseudoparenchymatic, of isodiametric cells with rounded or ± angulose lumina 4.5–9.0 μ diam. and walls 1.5–2.0 μ thick. Algal stratum irregular, somewhat dispersed, 30–90 μ deep; algae Nostocoid, sordid aeruginose or pale blue-green, round, 3–4 μ diam., enclosed in clumps in thin colorless slime-sheaths, no concatenate arrangement apparent. Medulla loose, almost arachnoid, up to 400 μ thick, colorless or in places slightly pale brownish-nubilated, of thin-walled, colorless hyphae 3.0–3.5 μ thick loosely intertexted in various directions. On underside of thallus the medulla goes over gradually into matted, dirty aeruginose, thin-walled, rhizoidal hyphae 3.0–4.5 μ diam.

The apothecia contain no algae. Excipulum entire, developed both at sides and below apothecium; at sides 95–125 μ thick, not nubilated, ± colorless internally, in outermost 20–30 μ gradually pale sordid brownish; composed of strictly radiate-parallel, confluent and conglutinated hyphae 3–4 μ thick with walls of moderate thickness. Lower part of exciple below hypothecium ± colorless, hyaline, 45–65 μ thick, ± grossly pseudoparenchymatic with oblong, ± vertically elongated cells 8–13 × 6–9 μ, their walls up to 3 μ thick, but showing transition to radiate hyphae at the sides of the exciple. Hypothecium up to 270 μ thick, sordid yellowish or isabelline and ± clear (± colorless in very thin section), in the upper and greater part composed of densely compacted or partly indistinctly pseudoparenchymatic, moderately thick-walled hyphae 3–4 μ diam., closely intertexted in various directions (in upper subhymenial 60–70 μ ± elongated and vertically parallel); lower 45–65 μ of hypothecium gradually more distinctly pseudoparenchymatic, with isodiametric, ± round cells 4.5–6.0 μ diam. (walls about 1.5 μ thick), showing transition into the more grossly pseudoparenchymatic basal excipular layer. Hymenium 80–100 μ high, ± abruptly dark olivaceous-brown or brown-blackish in uppermost 12–18 μ, otherwise colorless and hyaline. Paraphyses discrete in water, 1.5–2.0 μ thick, simple, not articulated, at tips clavate-capitate up to 4.5 μ and there brownish-fuliginous (KHO– , HNO$_3$ + dark purple-crimson). Asci clavate, 60–80 × 10–15 μ, with wall about 1 μ thick at sides, thickened up to 10 (–15) μ at apex. Spores 8, biseriate or ± uniseriate in ascus, simple, colorless, ellipsoid, usually obtusely or ± acutely pointed at ends, 12–15 × 5.5–7.0 μ, with thin smooth wall. Hymenium I + persistently dark blue (only the asci stained).

The other two specimens collected in the same locality by Kühnemann are identical with the holotype, and indeed seem to be parts of the same collection. *P. granulata* resembles *P. plumbea* (Lightf.) Müll. Arg. in the habitus and form of the thallus, but differs in the alutaceous color and noticeably chagrined-scabrose surface of the peripheral parts, reminding strongly of *Peltigera scabrosa*. It may be related to *P. diffracta* Müll. Arg. (from Australia), but that is a saxicolous species with a more distinctly diffract-areolate thallus and pale, pseudolecanorine apothecia. *P. vieillardi* Müll. Arg. from New Caledonia has a different type of scabrosity, due to brown verruculae on the otherwise smooth and ± shining surface, and differs also in the pale underside with marginal rhizinae, and the larger and thickly margined apothecia.

Type in Herb. Mus. Nat. Canada, Ottawa; isotype in Herb. Admin. General Parques Nacionales, Avda. Santa Fe 690, Buenos Aires.

### **Parmeliella concinna** M. Lamb (n. sp.)

Thallus plagulas sparsas orbiculares 5–12 mm. latas efficiens, effigurato-laciniatus, cinereo- aut glaucescenti-alutaceus, opacus, haud sorediosus; laciniae marginales radiantes, substrato laxe adpressae, 0.5–1.3 mm. longae, 0.3–0.7 mm. latae, planae aut leviter concavae, laeves et glabrae, irregulariter divisae et rotundato-crenatae, subtus ambitu anguste liberae, pallidae, glabrae, laevigatae; laciniae centrum thalli versus magis confluentes et ad margines minutissime squamuliferae (sed haud isidiatae). Hypothallus obsoletus aut nullus. Apothecia numerosa, partem centralem thalli sparsim tegentia, rotundata, basi leviter vel modice constricta, 0.5–0.9 mm. lata, carneo-alutacea aut pallide testaceo-fuscescentia, opaca et nuda, primitus plana et margine proprio pallidiore cincta, denique immarginata et modice convexa. Excipulum integrum, pseudoparenchymaticum, hyalinum aut tantum extrinsecus angustissime fuscescens. Hypothecium incoloratum aut isabellinum, compacte hyphosum, inferne sensim magis pseudoparenchymaticum. Hymenium 90–100 μ altum, totum hyalinum, epithecio nullo; paraphyses discretae, simplices, crassitudine mediocri. Sporae 8nae, ellipsoideae, apicibus rotundatae vel vix acuminatae, simplices et hyalinae, 13.5–16.0 × 6–8 μ, pariete tenui et laevigato. — Thallus extus intusque KHO– , $CaCl_2O_2$– , PD– . — *P. thysanotae* (Stirt.) Zahlbr. (e Nova Zelandia) arcte affinis, thallo orbiculari-effigurato et apotheciis minoribus diversa. Forsan prope *P. amphibolam* (Kn.) Müll. Arg., etiam in Nova Zelandia inventam, locanda, at sporis haud distincte apiculatis et thallo esorediato distinguitur. — Ad truncos combustos in Argentina, Patagonia, Chubut, prope litora lacus Verde: M. Lamb, 1950, no. 5879.

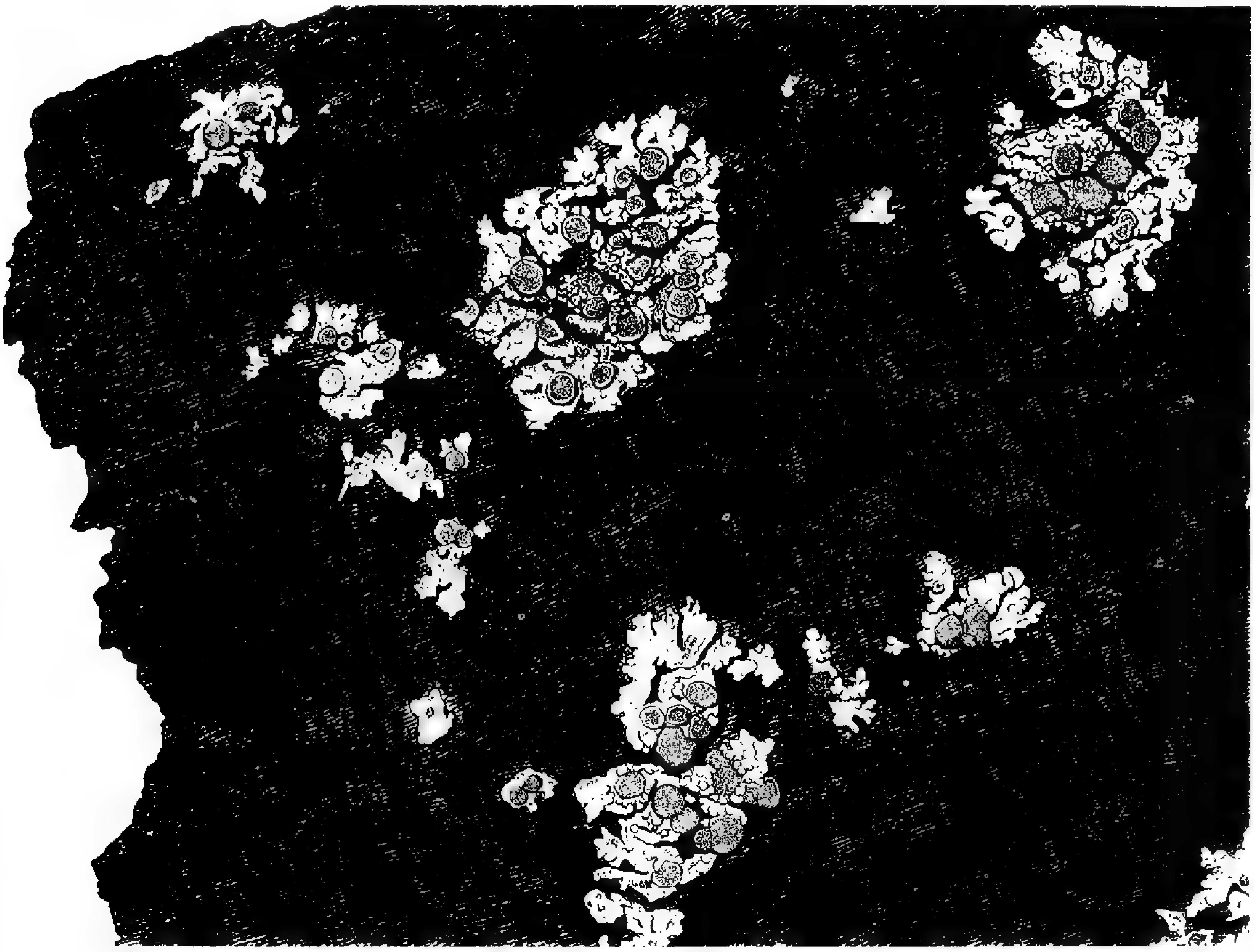


**Fig. 7.** *Parmeliella concinna* M. Lamb. Part of the type-specimen on carbonized wood (× 4).

Thallus forming small scattered orbicular effigurate patches 5–12 mm. diam. on the bare carbonized lignum; composed of radiating, loosely adpressed laciniae, grayish-alutaceous or sordid yellowish-glaucescent (between "Citrine-Drab" and "Buffy

Brown" in Ridgway's "Color Standards," Pl. XL), matt, not isidiate or sorediate. No dark hypothallus developed. Laciniae small, 0.5–1.3 mm. long, 0.3–0.7 mm. broad, plane or slightly concave, irregularly divided, rounded and crenate at the ends, not paler at the margin; towards center of thallus confluent and with the edges dissected into minute rounded squamules up to 0.15 mm. diam., but not truly isidiate. Surface of laciniae smooth, glabrous. Underside of peripheral laciniae free from the substratum, glabrous, smoth, pale (isabelline or faintly brownish); no rhizoids or hypothallus present. Thallus externally and internally KHO– , $CaCl_2O_2$– , PD– . Apothecia numerous in central part of thallus, sessile on the laciniae, round, 0.5–0.9 mm. diam., buff-flesh-colored or pallid testaceous-brownish (approx. "Sayal Brown" in Ridgway, Pl. XXIX), matt, naked, slightly to moderately constricted at base, at first plane with thin, entire, hardly prominent, paler (carneous-yellowish) proper margin, then finally becoming moderately convex and immarginate.

Thallus corticate on upper side only. Cortex 45–55 μ thick, colorless, clear, grossly pseudoparenchymatic, with isodiametric, rounded or obtusely angulose cells 7–14 μ diam., with walls 1.5–2.5 μ thick. Medulla colorless, clear, thin, about 30 μ deep, of ± closely compacted, variously intricated or mainly ± longitudinally running, thin-walled hyphae about 3 μ thick. Algal stratum about 45 μ deep, ± continuous. Algae blue-green, ± globose, 5–9 μ diam., in irregular clumps (not in chains).

The apothecia contain no algae. Excipulum entire below apothecium, colorless and hyaline (or faintly brownish in outermost 6–10 μ), grossly pseudoparenchymatic, of isodiametric or radially oblong cells 7–15 μ diam., their walls 1.5–3.0 μ thick. Hypothecium colorless (or isabelline in thicker sections), not nubilated, 90–120 μ deep, of compacted and intricated hyphae 1.5–3.0 μ diam., in lower part becoming gradually minutely pseudoparenchymatic and with transition into the excipulum. Hymenium 90–100 μ high, entirely colorless and hyaline (no colored epithecium). Paraphyses discrete, simple, 1.5–3.0 μ thick, at tips clavate-capitate up to 4.5 μ and there occasionally slightly moniliform-constricted. Asci clavate, 70–80 × 8–10 μ, persistently blue with Iodine, with gelatinous wall 1.0–1.5 μ thick at sides, slightly thickened at apex (about 4 μ). Spores 8, uniseriate or subbiseriate in ascus, simple, colorless, ellipsoid, not or hardly pointed at ends, 13.5–16.0 × 6–8 μ, with smooth wall about 0.7 μ thick.

*Parmeliella thysanota* (Stirt.) Zahlbr., described from Chatham Island, New Zealand, obviously comes very close to the present species, to judge from the description. Its apothecia are however larger, up to 1.5 mm., and the thallus is of crowded, ascendant laciniae, not orbicular-effigurate. *P. microphylloides* (Nyl.) Zahlbr. (from Chile) has a more granulate thallus and distinctly smaller spores, 8–9 × 4–6 μ. *P. nigrocincta* (Mont.) Müll. Arg. and the closely related *P. miradorensis* Vain. are quite distinct from the present species in having a conspicuous black limiting hypothallus; a cotype of *P. miradorensis* was examined in the Farlow Herbarium. *P. amphibola* (Kn.) Müll. Arg., from New Zealand, could not be obtained for comparison, but if Knight's description is correct it should have the thallus gray-sorediate at the margins and distinctly apiculate spores.

Numerous well-fruited thalli were found over the carbonized surface of a fallen burnt tree trunk in open forest near the shore of the Lago Verde, at the west end of the Lago Futalaufquen.

Type in Herb. Mus. Nat. Canada, Ottawa; isotypes in Farlow Herb., Herb. Inst. Syst. Bot. Uppsala, and Herb. Inst. Bot. Darwinion, San Isidro, Buenos Aires.

### **Pseudocyphellaria exanthematica** M. Lamb (n. sp.)

Thallus foliaceus, sat late expansus (7–15 cm. latus), lobato-laciniatus, laciniis brevibus aut sat elongatis, (0.3–) 0.5–1.0 cm. latis, ramosis, axillis rotundatis, apicibus rotundatis aut truncatis, lateribus laciniolis seu foliolis permultis simplicibus aut ramosis, 0.4–1.8 mm. latis munitis; superne fusco-glaucescens aut pallide rufofuscescens, haud scrobiculatus, opacus vel nonnihil nitidus, pustulis minutisismis numerosissimis pallide rufofuscescentibus (ad instar variolarum vel morbillorum) crebre obsitus; inferne centrum versus fuscescens et obscure tomentosus, peripheriam versus pallide alutaceus et glabrescens, pseudocyphellis parvis, albis, planis aut leviter prominentibus munitus. Medulla alba. Soredia et isidia desunt. Gonidia palmellacea, laete viridia. (Apothecia tantum juvenilia visa, ad 0.7 mm. lata, margine subintegro thallo subconcolori et gonidiis destituto, disco concavo rufofuscescenti, hypothecio leviter rufofuscescenti, hymenio solummodo paraphysibus constituto.) — Thallus extus reagentibus immutatus; medulla KHO + lente fuscoflavescens, PD + rubescens (praesertim in strato gonidiali), $CaCl_2O_2$– . — Laciniis lateribus microphyllino-dissectis et superficie thalli peculiariter morbillose exasperata jam statu sterili mox distinguenda. — In cortice muscoso *Nothofagi* in Argentina, Patagonia, Río Negro, lacus Frias: M. Lamb, 1950, no. 5986.

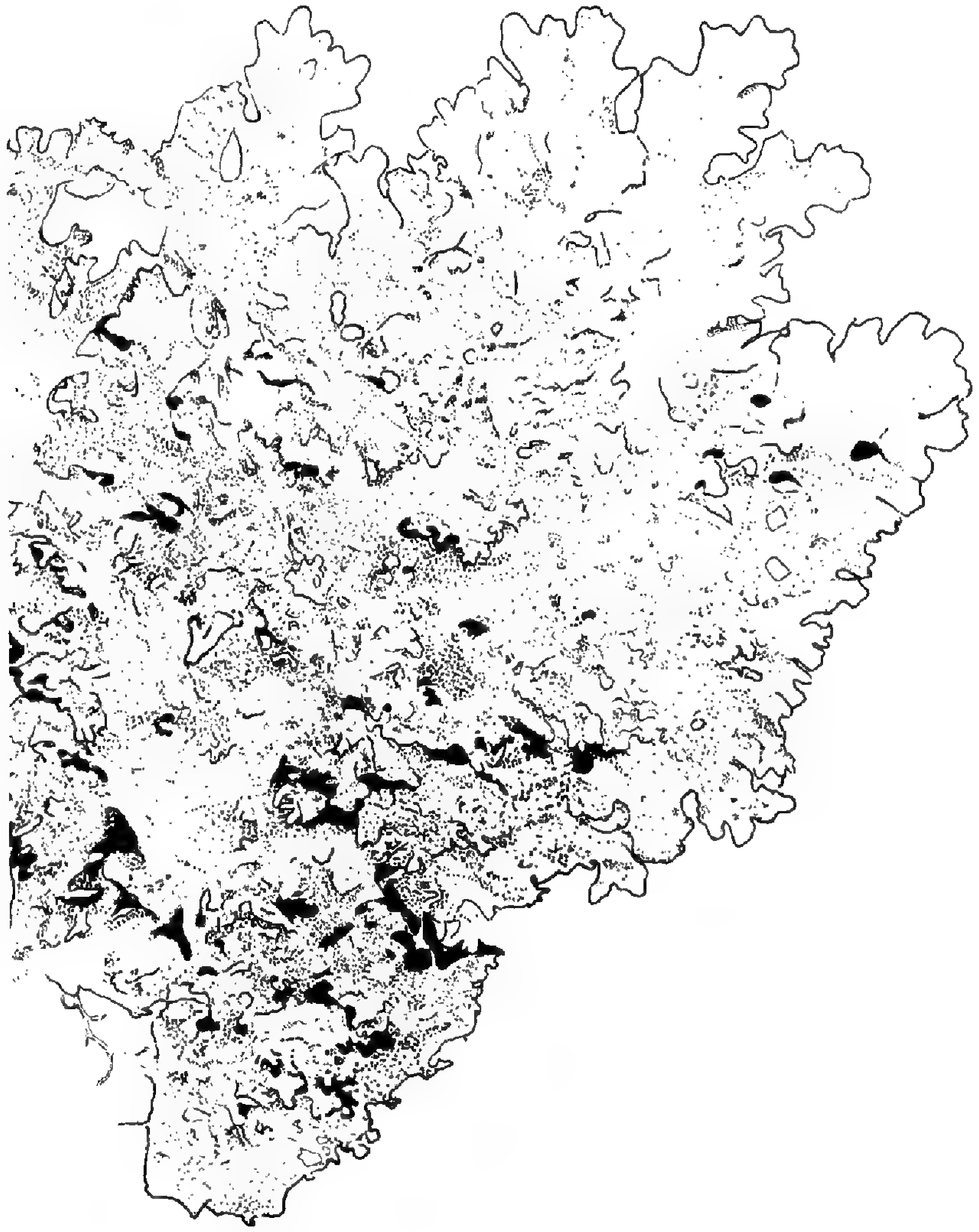


**Fig. 8.** *Pseudocyphellaria exanthematica* M. Lamb. Part of the type-specimen (× 1).

Thallus 7–15 cm. diam., ± rigid and subcoriaceous in the dry state, lobate-laciniate with short to ± elongated, sublinear laciniae (0.3– ) 0.5–1.0 cm. wide; laciniae branched with rounded axils, rounded or truncate at the apices, producing at their edges large numbers of simple or branched, microphylline laciniolae 0.4–1.8 mm. wide; upper surface even (no scrobiculation), brownish-glaucescent to pale reddish-brown, matt or subnitid, without pseudocyphellae, but thickly strewn with minute, pale reddish-brown, pustular excrescences up to 0.05 mm. diam., resembling the markings of smallpox or measles. Under surface brown towards the center, with a short, coarse, spongy-fibrous, dark tomentum, towards the periphery pale alutaceous and glabrous, matt or subnitid, smooth or in places faintly wrinkled-scrobiculate, not bullate or costate. Pseudocyphellae moderately abundant, pure white, small, up to 0.5 mm. diam., round or sometimes oval, plane to slightly convex-erumpent, powdery. Medulla white. Some immature apothecia present, up to 0.7 mm. diam., mostly superficial but a few also marginal or submarginal; the thickish, prominent, entire or ± irregular margin concolorous with the thallus or gradually reddish-brown on the inner side, the concave disc reddish-brown, matt, naked.

Thallus in section 150–260 μ thick. Upper cortex pseudoparenchymatic, 30–50 μ thick, clear, yellow or yellow-brownish in its outer half, with rounded, isodiametric cells 3.5–7.0 μ diam., their walls about 1.5 μ thick. Algal stratum ± continuous, 35–60 μ deep; algae bright green, separate, round, thin-walled, 7–15 μ diam. Medulla inspersed and ± opaque in section from a yellowish-gray nubilating substance; its hyphae colorless, thin-walled, 3.0–4.5 μ thick, closely or ± loosely interwoven. Lower cortex 35–60 μ thick, clear, faintly yellowish to almost colorless, pseudoparenchymatic with rounded, isodiametric cells 3.5–6.5 μ diam. (walls 1.5–3.0 μ thick). The pustular excrescences in section are merely thickenings of the normal cortex, without peculiar structure, but often with a more intense reddish-brown pigmentation. Surface of thallus KHO– , $CaCl_2O_2$– , PD– ; medulla KHO + (slowly) brownish-yellow (chiefly in the algal layer), $CaCl_2O_2$– , PD + (slowly) red (chiefly in the algal layer), $FeCl_3$ + faintly purple-violascent.

A section through one of the immature apothecia shows that the margin contains few or no algae; the algal stratum of the thallus runs up into the pedicel of the apothecium, but does not extend above the base. Apothecial margin ± brownish and cloudy in inner part, colorless and hyaline in outer part; composed of radiately parallel, gelatinously conglutinated hyphae with short thick-walled cells 6.5–10.0 μ diam., the rounded lumina giving a ± pseudoparenchymatic appearance. Hypothecium faintly reddish-brown. Hymenium immature, without asci, consisting of closely packed paraphyses only, about 100 μ high, faintly brownish-yellow in its uppermost part.

In the shape of the thallus lobes and in the microphylline lobules at their margins, this species resembles the *Pseudocyphellariae: homalosticta* Vain., *multipartita* Vain., *phaeorhiza* Vain., *polyschista* (Mey. & Flot.), *subvariabilis* (Nyl.) Vain., *prolificans* (Nyl.) Vain., and *psilophylla* (Müll. Arg.), but all of these have a perfectly smooth and even upper surface. A Chilean species, described by Nylander as *Sticta valdiviana* (apud Stizenberger in *Flora*, Vol. LXXXI, 115: 1895) with a very short and incomplete diagnosis ("Similis vel subsimilis *S. prolificanti* sed reactione thalli ut in *S. Billardierii* (K +). Variat etiam thallo subfaveolato.") seemed to come very close to the present species, but Dr. Ö. Szatala, who kindly compared our material with Nylander's type-specimen, stated *in litt.* that the latter differs in its quite smooth and non-pustulate upper surface and thinner, more fragile thallus of a darker (brown) color. He supplied the following emended diagnosis of "*Sticta valdiviana*" Nyl., based on the type-specimen (Herb. Nyl. no. 33470): "Thallus laciniato-divisus, laciniis elongatis, 0.3–0.6 mm. latis, subcanaliculatis, superne leviter et obsolete scrobiculato-inaequalis, laevibus et nitidis, obscure fuscis, margine numerose v. rarius superne hinc inde sparse microphyllino-isidiosis, K + lutescens, Cl– , KCl– , subtus pallide ochraceus versus apicem omnino nudus, nitidiusculus, centro densissime tomentoso-rhizinosus, rhizinis usque ad 0.1–0.3 mm. longis, fasciculato-ramosis, pallide v. obscure fuscidulis; pseudocyphellis albis, 0.1–0.2 mm. latis, pulverulentis, haud prominentibus; medulla alba. Cortex superior 30–40 μ latus, intis albidus, extus pallide fusco-flavescens, distincte pseudoparenchymaticus, cellulis sphaericis, oblongis v. varie angulatis, ca. 3–6 μ latis et extus strato tenui, hyalino, amorpho, ca. 2–5 μ lato tectis, constitutus. Cortex inferior 20–30 μ latus, omnino pallide fuscescens, distincte pseudoparenchymaticus, cellulis 2–3 μ latis, constitutus. Gonidia globosa, protococcoidea, 10–15 μ lata, membrana incrassata. Sterilis." The type was collected in Chile, near Valdivia, by H. Hahn. The present author does not intend to make here formal new combinations of the species *polyschista*, *psilophylla* and *valdiviana* under *Pseudocyphellaria*, as he has not made a sufficient study of them, and they may be synonyms of earlier described species.

Only one specimen was seen, but plentifully and well developed, on the mossy trunk of a "Coihue" (*Nothofagus dombeyi*) in open woods near the shore of Lago Frias near the western end of Lago Nahuel Huapí.

Type in Herb. Mus. Nat. Canada, Ottawa; isotypes in Farlow Herb., Herb. Inst. Syst. Bot. Uppsala, and Herb. Inst. Bot. Darwinion, San Isidro, Buenos Aires.

### **Pseudocyphellaria hirsuta** (Mont.) Malme, f. **leucosticta** M. Lamb (n. f.)

A forma typica speciei pseudocyphellis omnino albis vel albidis, nec luteis, differt.— Argentina, Patagonia, Chubut, lacus Futalaufquen: O. Kühnemann, 1941, no. 5449 (holotypus); lacus Menéndez: O. Kühnemann, 1940, no. 4752; lacus No. Uno: O. Kühnemann, 1941, no. 5465; Río Negro, lacus Nahuel Huapí, insula Victoria, Puerto Radal: R. Pérez-Moreau, 1940, no. 4541.

The specimens are in every way typical of *Ps. hirsuta* except in having white pseudocyphellae. In the normal species some of the older pseudocyphellae may lose their yellow color by being worn down to the white medulla, but in this form all the pseudocyphellae, even the youngest, are without yellow color.

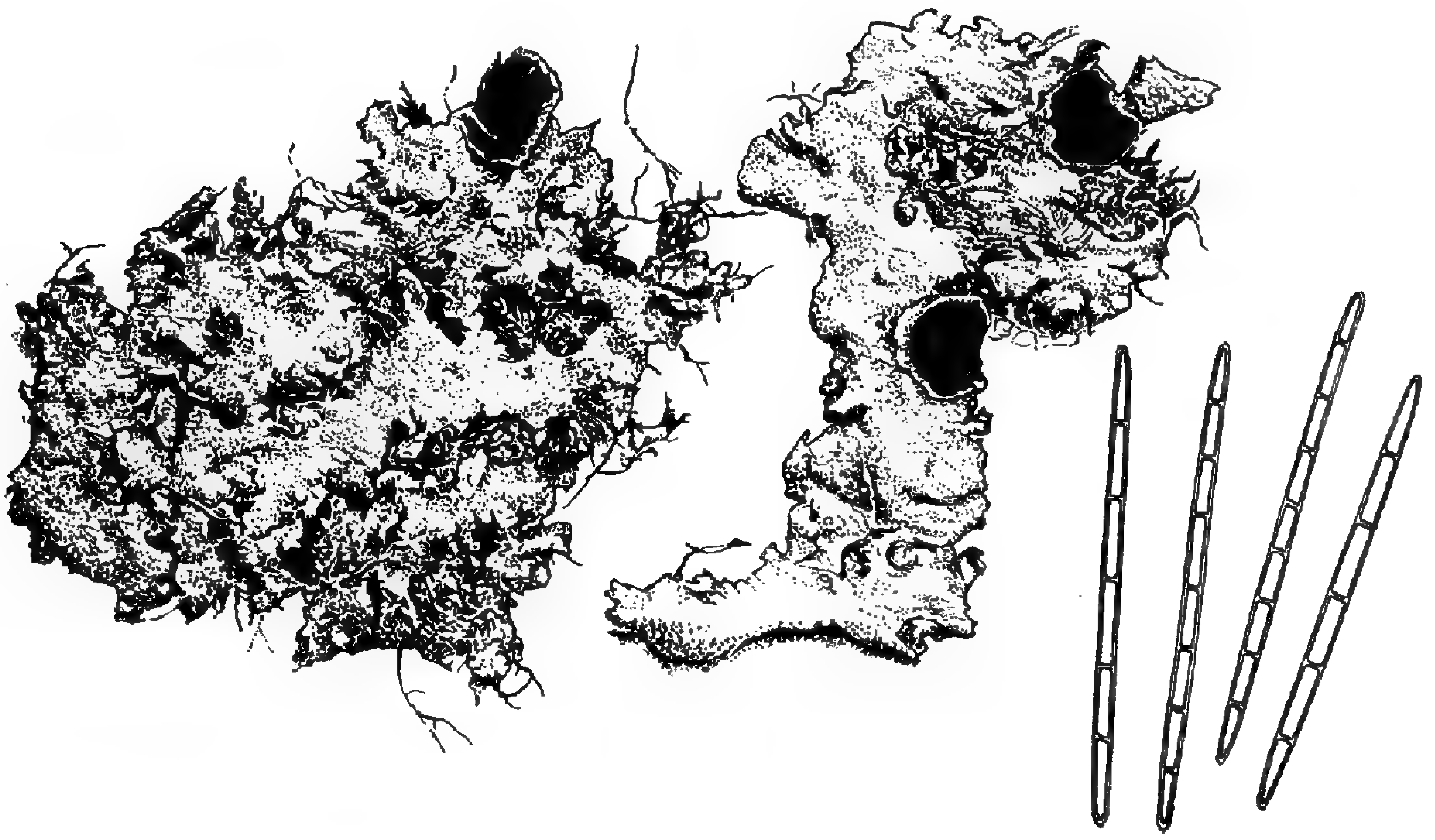
Type and other specimens cited in Herb. Mus. Argent. Cienc. Nat., Buenos Aires; isotype in Herb. Mus. Nat. Canada, Ottawa.

### **Nephroma** (Eunephroma) **kuehnemannii** M. Lamb (n. sp.)

Thallus late expansus, laxe adpressus, haud adscendens, irregulariter laciniato-lobatus, lobis 3–5 cm. longis, 0.7–1.3 cm. latis, marginibus varie incisis, superne stramineo-fuscescens, glaber, nitidus, inferne totus pallidus et ubique rhizinis pallidis aut fuscescentibus villoso-vestitus. Isidia et soredia desunt, cephalodia tamen in pagina infera thalli sparsa, concoloria aut pallide fuscescentia, subglobosa, ad 0.8 mm. lata, laevia, algas Nostochineas foventia. Medulla albida (nec flavescens); gonidia protococcoidea, pallide viridia. Apothecia terminalia, mox sese sursum revolventia, rotundata aut oblonga, 4–9 mm. lata, disco plano aut concaviusculo, obscure rufofusco et nudo, margine thallino sat prominulo, irregulari, saepe discisso, receptaculo glabro, minute verruculoso- aut areolato-aspero. Hypothecium subdecolor, hymenium 95–115 μ altum, superne fulvo-fuscescens; sporae 5–6 ( –8 ?)nae, incolores, aciculari-cylindricae, rectae, utrinque obtuse acuminatae, 5–8-septatae, longit. 68–95 μ, crassit. 3.0–3.5 μ. — Medulla KHO tantum indistincte fuscescens, $CaCl_2O_2$– vel partim flavescens, PD + bene flavescens, I– . — Species peculiaris, praesertim sporis perlongis et multiseptatis et cephalodiis veris in pagina infera thalli dignota, obiter visa *N. patagonico* Kphbr. haud absimile, nullae attamen alii speciei arcte relata. — Corticola inter muscos in Argentina, Patagonia, Chubut, lacus Menéndez, loco dicto "Alerzal del Norte": O. Kühnemann, 1941, no. 5485.

On bark, among mosses. Thallus forming extensive, ± continuous patches up to 15 cm. or more across, composed of irregular branching laciniae or elongated lobes 3–5 cm. long, 0.7–1.3 cm. broad, loosely adpressed, not ascendant, irregularly incised at the edges. Upper side stramineous-fuscescent (between "Honey Yellow" and "Isabella Color" on Pl. XXX of Ridgway's "Color Standards"), smooth, nitid, without isidia or soredia; underside concolorous or paler (ochraceous-whitish), not blackening, matt, in all places, except at the extreme tips of the laciniae, villose with shaggy, whitish to brownish, matted rhizinae up to 1.5 mm. long. Scattered cephalodia present on underside; concolorous with underside or pale brownish, subglobose, up to 0.8 mm. diam., smooth, often cracked, containing *Nostoc*. Medulla white or whitish, without any yellow tinge. Apothecia fairly numerous, terminal on laciniae, formed on the underside and then reflexed to face upwards; round or oblong, 4–9 mm. diam., plane or slightly concave, with dark red-brown, matt or subnitid, naked disc and prominent, irregular thalline margin 0.3–1.0 mm. wide, which is often torn open to expose the medulla. Underside (i.e. original upper side) of apothecium corticate, minutely verruculose or areolate-verruculose.

Thallus corticate on both surfaces; upper cortex 30–37 μ thick, pseudoparenchymatic, stained dark yellowish (without granules) in outermost 11–17 μ, the inner part colorless and hyaline; cells ± isodiametric, obtusely angulose, 6–9 μ diam., with walls about 1.2 μ thick. Algal stratum 20–35 μ deep, pale green; algae protococcoid, pale green, globose, thin-walled, 13–22 μ diam., without visible pyrenoid. Medulla entirely sordid yellow-brownish-nubilated with minute granules and semi-opaque in section, composed of colorless, thin-walled hyphae 2–4 μ thick fairly compactly intricated in various directions or predominantly horizontally parallel. Lower cortex 11–35 μ thick, faintly dull yellowish in section, not nubilated, pseudoparenchymatic, of isodiametric, rounded cells 3.5–4.5 μ diam. with rather thick walls (1.5–2.5 μ). Rhizinae dull yellowish in section, not nubilated, composed of elongated, parallel cells 13–20 μ long, 3–4 μ wide, with walls up to 1.7 μ thick.



**Figs. 9 & 10.** *Nephroma kuehnemannii* M. Lamb. The type-specimen (× 1); spores (× 450).

Apothecia corticate on lower side (i.e. original upper side) with an uneven-verrucose, pseudoparenchymatic cortex up to 70 μ thick, sordid yellowish-nubilated in its outer half, colorless and hyaline in its inner half, with isodiametric or vertically oblong cells 5–9 μ diam., the colorless walls 1.5–2.0 μ thick. Algal stratum continuous, 50–85 μ deep. Medulla sordid yellow-brownish-nubilated, as in the thallus, running up into the apothecial margin. Apothecial margin usually without algae, composed of medullary hyphae and an outermost, clear, yellowish, gelified, indistinctly pseudoparenchymatic cortical layer about 35 μ thick; or sometimes ecorticate with the medulla exposed on the surface. Hypothecium 70–80 μ deep, clear, colorless in lower half, faintly sordid yellowish in upper half, composed of compactly intricated hyphae 2–3 μ thick. Hymenium 95–115 μ high, yellow-brownish in uppermost 10–14 μ, otherwise colorless and hyaline. Paraphyses separable in water, 3.0–3.5 μ thick, simple or branched, thin-walled, not articulated, but at the apices often submoniliform and there thickened (up to 5 or 6 μ) and faintly yellowish. Asci clavate, 90–100 μ long, 12–15 μ broad, with wall 1.0–1.5 μ thick at sides, not or only slightly thicker at the apex. Spores seen 5 or 6 in ascus, packed ± straight and parallel, acicular-cylindrical, 5–8-septate, colorless, straight, bluntly pointed at the ends, often more tapered towards one end, 68–95 × 3.0–3.5 μ. Hymenium light blue, then yellow, with Iodine.

Medulla of thallus $FeCl_3$ + reddish-purple, KHO + faintly brownish, $CaCl_2O_2$– or in places + yellow, PD + good persistent yellow, I– .

A very distinct and rather peculiar species on account of the cephalodia on the underside and especially the long and multiseptate spores; the spores are seldom over 3-septate in other species of *Nephroma*. Seen from the upper side, it looks not unlike *N. patagonicum* Kphbr. (Syn. *N. analogicum* Nyl.), but that species is quite different in its yellow medulla and black, glabrous underside (see below).

Fairly plentiful material collected by O. Kühnemann in the *Fitzroya*-forest ("Alerzal") at Lago Menéndez in Chubut.

Type in Herb. Mus. Argent. Cienc. Nat., Buenos Aires; isotypes in Herb. Mus. Nat. Canada, Ottawa, and Herb. A. H. Magnusson, Göteborg.

*Nephroma analogicum* Nyl. and *N. patagonicum* Kphbr. are placed apart as separate species in Zahlbruckner's *Cat. Lich. Univ.*, Vol. III, 422, 425: 1925, but Zahlbruckner himself, in *Kgl. Svensk. Vet.-Akad. Handl.*, Vol. LVII, no. 6, 20: 1917, pointed out that they are synonymous, an opinion which could be completely confirmed by the present author's examination of the type specimens at Helsingfors and at München. Köfaragó-Gyelnik gave a long description of the type-specimen of *N. patagonicum* in *Ann. Cryptog. Exot.*, Vol. IV, 122: 1931; his statement that rhizinae are present here and there on the underside is erroneous, for in Krempelhuber's specimen the black underside is completely glabrous, as it is also in the Nylander type of *N. analogicum*, as far as can be seen from the scanty, glued-down material. Gyelnik has also redescribed the type of *N. analogicum* (in *Ann. Mus. Nat. Hungar., Pars Bot.*, Vol. XXIX, 9: 1935), and here again his description is partly erroneous. His mention of pubescence on the underside of the thallus is misleading, for he used this term in his *Nephroma*-studies in cases where short projecting hyphae are visible only under the microscope, without any macroscopically visible pubescence. He is also wrong in attributing Nostocoid algal symbionts to *N. analogicum*; in the type-specimen they are clearly protococcoid, pale green, globose, 7–12 μ diam., thin-walled, separable, not in slime-sheaths.

### **Nephroma** (Nephromium) **chubutense** M. Lamb (n. sp.)

Thallus suborbicularis, 5–7 cm. latus, substrato arcte adnatus, sat rigidus et coriaceus, stramineo-flavens, opacus vel subnitidus, in centro isidiis fuscis aut stramineo-fuscis, complanato-squamulosis, numerosissimis, quasi crustam hic illic diffractam formantibus, late et confluenter obsitus. Laciniae ambitu confertae, longit. 0.5–1.0, latit. 0.2–0.4 cm., superficie reticulato-rugosae et marginibus elevatis, crispatis, isidiis fuscis squamulosisque parce aut sat abundanter munitis. Thallus subtus substrato late adhaerens, tantum zona peripherica 3–9 mm. lata visibilis, glaber, griseo-nigrescens, ambitu pallidior (pallide fuscus aut alutaceo-fuscescens), opacus, undulatus, haud distincte bullatus, laevigatus. Medulla partim alba, partim pallide flavescens aut aurantiaco-flavescens. Gonidia Nostochinea, coeruleo-pallescentia aut virescentia, interdum flavidula aut rubescentia, vagina gelatinosa sat crassa induta. (Apothecia ignota.) — Thallus extus KHO– , $CaCl_2O_2$– , PD– , intus KHO– , $CaCl_2O_2$– , PD + leviter testaceo-rubescens. — In sect. *Nephromio* colore stramineo et isidiis fuscescentibus, squamulaeformibus, in parte centrali thalli late confluentibus et quasi crustam formantibus, locum bene distinctum tenet. — Corticola in Argentina, Patagonia, Chubut, ad lacum Menéndez: M. Lamb, 1950, no. 5916.

Thallus ± orbicular, 5–7 cm. diam., closely attached to the substratum (bark), ± rigid and coriaceous, shortly and crowdedly lobate at periphery, in central parts ± covered and concealed by a crust of brown or yellowish-brown, squamulose isidia. Peripheral zone 0.7–1.5 cm. wide, only sparingly isidiate, stramineous-yellow (yellow-brownish or brown at the extreme ends of the lobes), matt or subnitid, the lobes crowded, 0.5–1.0 cm. long, 0.2–0.4 cm. wide, with reticulate-rugose surface and ±

raised, crisped edges garnished more or less abundantly with brown, flattened-squamuliform isidia 0.2–0.4 mm. diam. Central part of thallus ± completely covered with a continuous or irregularly diffract, brown, matt crust of very crowded, squamuliform isidia. Underside free from the substratum only at the periphery, in a zone 3–9 mm. wide; glabrous, pale brown to buff-brown at the edges, gray-blackish further in, matt, irregularly undulate-folded but not distinctly bullate, not wrinkled, matt. Medulla in places white, in other places pale yellow to orange-yellow. Thallus externally KHO– , $CaCl_2O_2$– , PD– ; medulla KHO– , $CaCl_2O_2$– , PD + brick-red (not very intensely). (Sterile.)

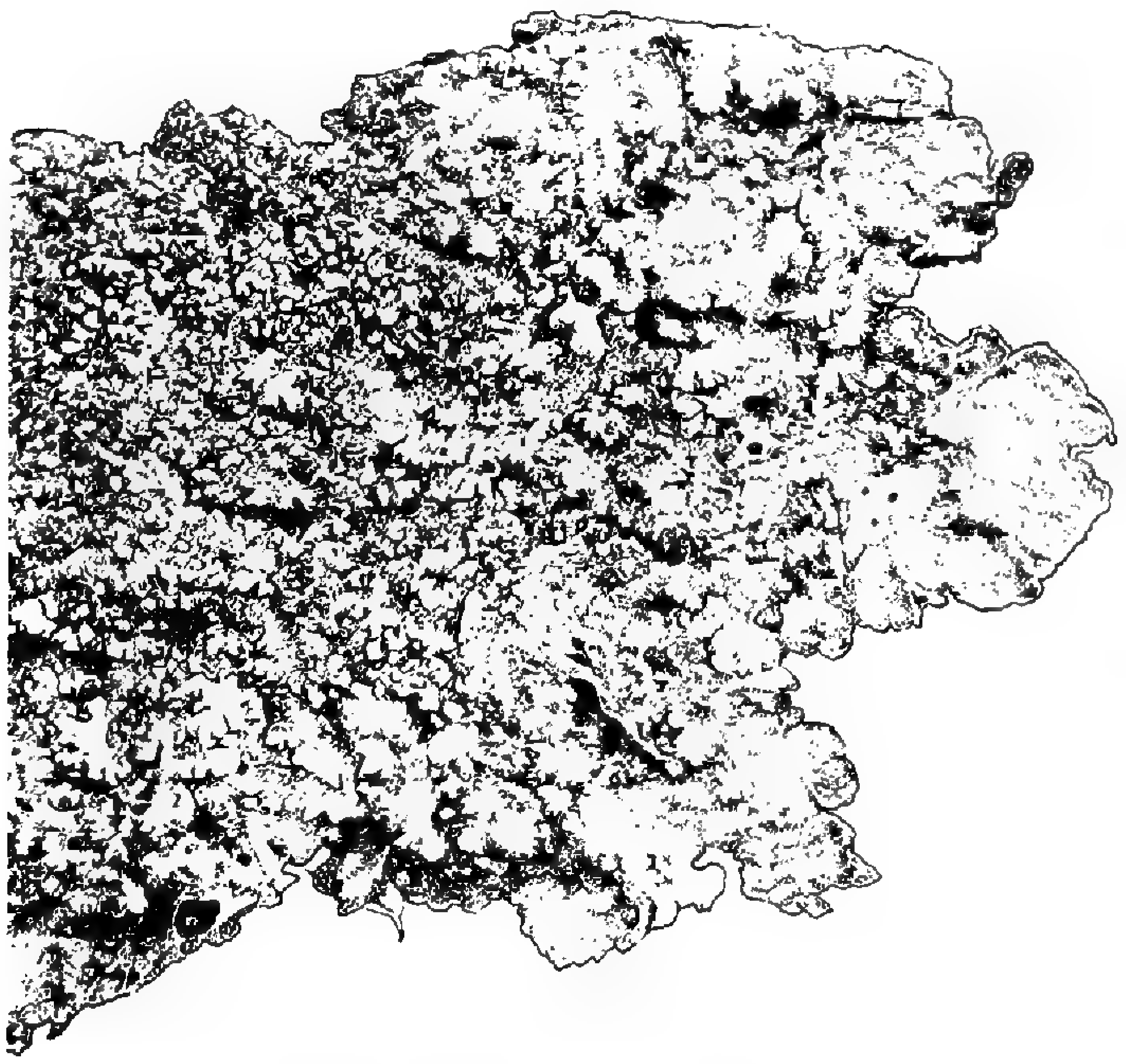


**Fig. 11.** *Nephroma chubutense* M. Lamb. Part of the type-specimen (× 3).

Thallus 200–275 μ thick where not isidiate, corticate on both surfaces; upper cortex 35–40 μ thick, dull yellowish-inspersed or in places brown, ± opaque except in very thin sections, pseudoparenchymatic, of isodiametric, obtusely angulose cells 3.5–5.0 μ diam. with walls about 1 μ thick; in places covered by a colorless, hyaline, amorphous, gelatinized, necrotic stratum up to 7 μ thick. Algal layer 50–70 μ deep, in ± interrupted nests; algae Nostocoid, pale blue-greenish to yellowish or reddish, in clusters surrounded by distinct hyaline mucilage-sheaths, not distinctly concatenate, round or slightly oblong, 3.5–7.0 μ diam. Medulla grayish-nubilated, of colorless, thin-walled, ± closely entangled hyphae 3 μ thick running in various directions or predominantly horizontally. Lower cortex 14–24 μ thick, pale sordid brownish to dark brown, not or hardly cloudy, but ± obscured by pigment, somewhat indistinctly pseudoparenchymatic, of isodiametric, rounded or obtusely angulose cells 2.5–3.5 μ diam., their walls about 1 μ thick. No rhizinae or tomentum-hyphae present.

As far as the present writer's knowledge goes, there is no other species in the sect. *Nephromium* with distinctly stramineous-yellow color of thallus.

Collected at the west end of the Lago Menéndez on the trunk of a small tree in open scrub formation in the lower reaches of the Torrecillas glacier stream.

Type in Herb. Mus. Nat. Canada, Ottawa.

### **Nephroma** (Nephromium) **lepidophyllum** (Räs.) Gyeln., f. **hypomelaena** Räs. (n.f.)

"Thallus subtus laevigatus, fusconiger vel ad marginem fuscescens" (Räs. *in litt.*). Thallus 3–8 cm. latus, pallide aut obscure fuscus, opacus vel partim subnitidus, irregulariter lobatus, crebre et subtiliter reticulato-costatus et lacunosus, costis isidiis parvis squamulosis munitis et simul saepe excoriatis. Apothecia orbicularia aut reniformia, ad 7 mm. lata, rufofusca, margine thallino pertenui. (Sporae haud evolutae.) — Ad corticem *Nothofagi pumilionis* in Argentina, Patagonia, Río Negro, lacus Frias: M. Lamb, 1950, no. 6010.

Thallus 3–8 cm. diam., pale to dark brown, matt or subnitid, irregularly lobate, closely and finely reticulate-costate and lacunose, the ridges beset with small squamulose isidia and often splitting open to expose the white medulla. Underside brownish-black, brown towards the periphery, glabrous, smooth. Apothecia roundish to kidney-shaped, up to 7 mm. diam., reddish-brown, with very thin thalline margin. (Spores not developed.) Medulla KHO– , $CaCl_2O_2$– , PD– .

The authentic material of *Nephroma lepidophyllum* (Räs.) Gyeln., described from southern Chile (Magallanes and Ñuble) has not been seen by the present author, but Dr. V. Räsänen, to whom a portion of no. 6010 was sent, kindly compared it with the type of the species in his herbarium and stated it to be conspecific but differing in the darker and smooth underside; in the typical species the underside is ochraceous-whitish and ± bullate. There is some resemblance to *N. cellulosum* (Sm.) Ach., but isidia are present and the reticulations of the thallus are finer and closer. *N. venosum* Degel., from the Azores (Degelius in *Göteborgs Kgl. Vetensk.- och Vitterh.-Samh. Handl.*, ser. 6 B, Vol. I, no. 7, 23, Pl. II: 1941) is in many respects similar, but differs in the thin papery thallus, usually more scanty isidia, smaller apothecia, different chemical reactions, etc.

A single small population found in the trunk of a "Lenga" (*Nothofagus pumilio*) alongside the bed of a stream near the Lago Frias by the western end of Lago Nahuel Huapí.

Type in Herb. V. Räsänen (Helsingfors Botanical Institute); isotypes in Herb. Mus. Nat. Canada, Ottawa, and Farlow Herb.

### **Lecidea** (Eulecidea) **patagonica** M. Lamb (n. sp.)

Thallus albus, tenuis, effusus, indistincte et minute areolatus aut partim continuus vel fere membranaceus, passim parcius evolutus et (propter hypothallum cyaneo-nigrescentem) caesioalbescens; ambitu vulgo linea hypothallina tenui nigricanti limitatus. Apothecia numerosa, sparsa, sessilia, rotundata, basi constricta, (0.5–) 0.8–2.0 mm. lata, nigra, nuda, diu sat plana et margine proprio integro vix prominenti cincta, demum depresso-convexa et immarginata. Excipulum extus anguste aeruginoso-obscuratum, intus late hyalinum et cum hypothecio confluens. Hypothecium incoloratum, hyalinum, saltem inferne granulis sordide flavidis parce inspersum. Hymenium 70–95 μ altum, hyalinum, paraphysibus concretis, epithecio obscure aeruginoso aut cyanescenti-fuligineo. Sporae 8nae, ellipsoideae aut elongato-ellipsoideae, simplices, incoloratae, 15–18 × 6–7 ( –8) μ, apicibus rotundatae aut obtuse acuminatae, interdum halone mucilaginosa tenui indutae. — Thallus KHO– , $CaCl_2O_2$– , PD– , hyphae medullares I– . Epithecium KHO– , $HNO_3$ + purpureo-violascens. Hymenium et hypothecium subhymeniale I + coerulescens. — In stirpem *L. lithophilae* prope *L. subdeclinantem* Müll. Arg. locanda, a qua colore excipuli, hymenio altiori et sporis majoribus distinguitur. — Saxicola et lapidicola in Argentina, Patagonia, Río Negro, insula Victoria in lacu Nahuel Huapí: M. Lamb, 1950, no. 5818, et prope lacum Frias: M. Lamb, 1950, no. 6029 (typus speciei).

*Description of the type-specimen* (*M. Lamb no. 6029*): Thallus forming ill-defined and ± confluent patches 2–5 cm. diam., bounded in most parts of periphery by a thin blackish hypothalline line; thin (not over 0.15 mm. thick), white (or in places sordid ochraceous-conspurcated), partly very thin, continuous and ± membranaceous, interrupted, with the filmy bluish-gray hypothallus visible in between; or partly thicker, contiguous and indistinctly areolate; areolae usually not well defined, minute, 0.2–0.4 ( –0.6) mm. diam., plane or only slightly convex, separated by very narrow and often indistinct cracks. Seen with the naked eye, the thallus appears as a thin whitish film, partly bluish- or greenish-gray (from the hypothallus). Thallus KHO– , $CaCl_2O_2$– , PD– ; medullary hyphae I– . Algae protococcoid, bright green, globose, thin-walled, 7–15 μ diam. Apothecia numerous, irregularly scattered, sessile, slightly to moderately constricted at base, round, (0.5–) 0.8–1.5 ( –1.8) mm. diam., entirely black and matt (shining only where rubbed), for a long time plane with moderate but not prominent, entire proper margin, finally becoming moderately convex with the margin excluded. Disc smooth, not papillate or fissured, not pruinose.

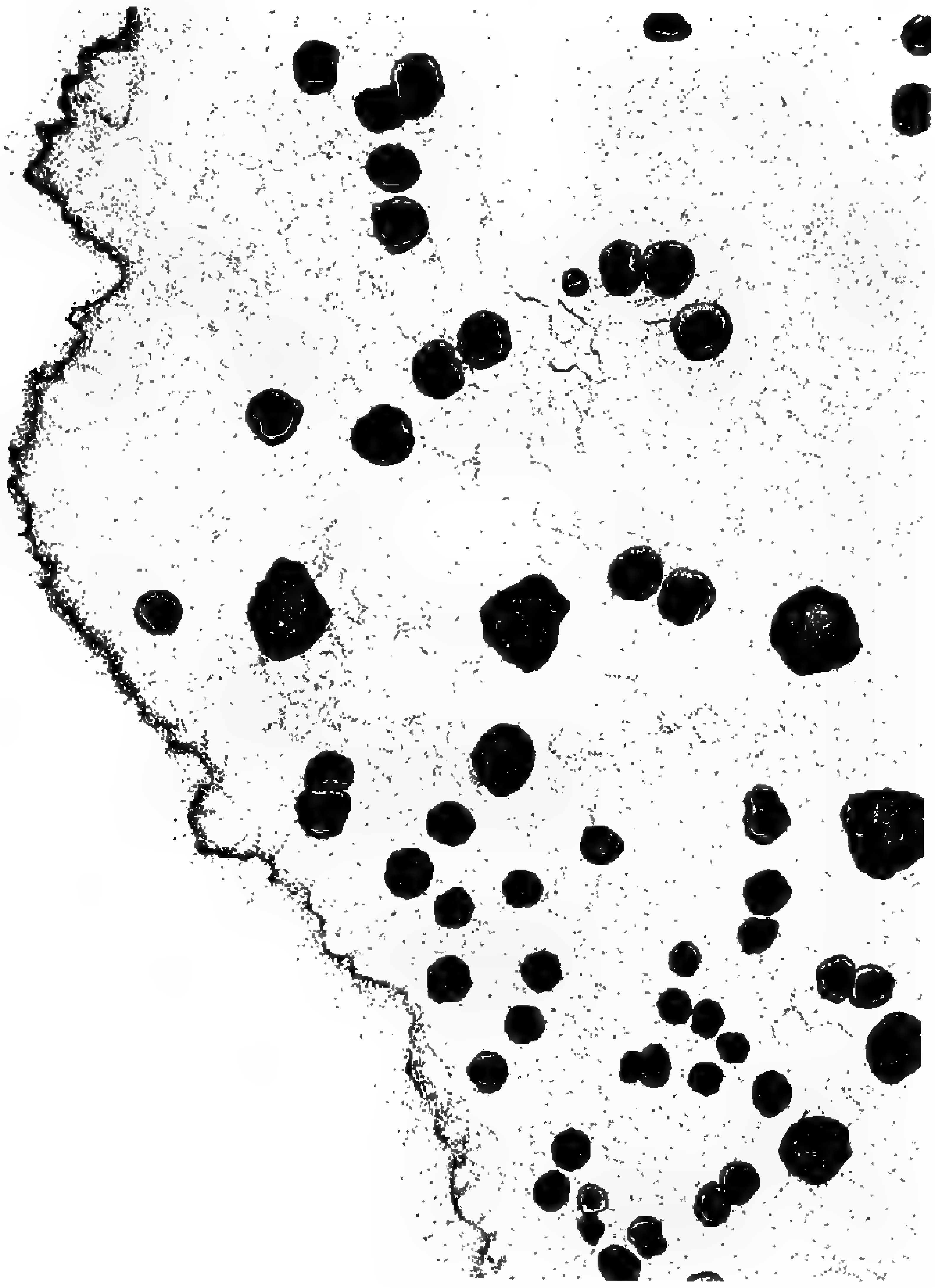


**Fig. 12.** *Lecidea patagonica* M. Lamb. The type-specimen (× 4).

Excipulum continued a long way round below apothecium, but not quite reaching to center; 60–100 μ thick, abruptly dark aeruginose or aeruginose-blackish in outermost 7–15 μ, internally colorless and hyaline, with a few scattered sordid yellowish-gray granules; of radiating palisade-structure, with parallel, conglutinated and gelatinized, indistinct, pachydermatic hyphae 4–5 μ thick. Hypothecium merging gradually into excipulum at sides, colorless, up to 260 μ deep, composed of indistinct, gelatinized, densely compacted and intertexted hyphae 1.5–2.0 μ thick, hyaline but with scattered irregular inclusions of ± granular, sordid yellowish-gray substance (especially in lower part). Hymenium 85–95 μ high, in uppermost 10–17 μ ± gradually dark aeruginose or aeruginose-blackish, otherwise colorless and hyaline. Paraphyses concrete in mucilage, 1.0–1.5 μ thick, simple or sparingly branched, not articulated, ± clavate-capitate to 2.5–3.5 μ at the blue-green tips. Asci clavate, 60–85 × 12–16 μ, with ± gelatinous wall up to 1.5 μ thick, in immature asci thickened up to 13 μ at the apex. Spores 8, biseriate in ascus, ellipsoid to elongate-ellipsoid, rounded or obtusely pointed at ends, with thin smooth wall, 17–18 × 6.0–6.5 μ, sometimes invested in a thin clear refractive mucilaginous coat. Hymenium and upper part of hypothecium I + blue (contents of asci finally vinous-fulvescent); inner colorless part of excipulum I + faint blue. Epithecium and outer part of excipulum KHO– or more olivaceous greenish, $HNO_3$ + violet-purple.

The other specimen, no. 5818 from the Isla Victoria, agrees well with the holotype, differing only in the following unimportant respects: apothecia up to 2 mm. diam., well constricted at base; excipulum up to 150 μ thick; hypothecium up to 340 μ deep; hymenium 70–90 μ high; paraphyses up to 2 μ thick; spores 15–17 × 6–7 ( –8) μ, without mucilaginous coat.

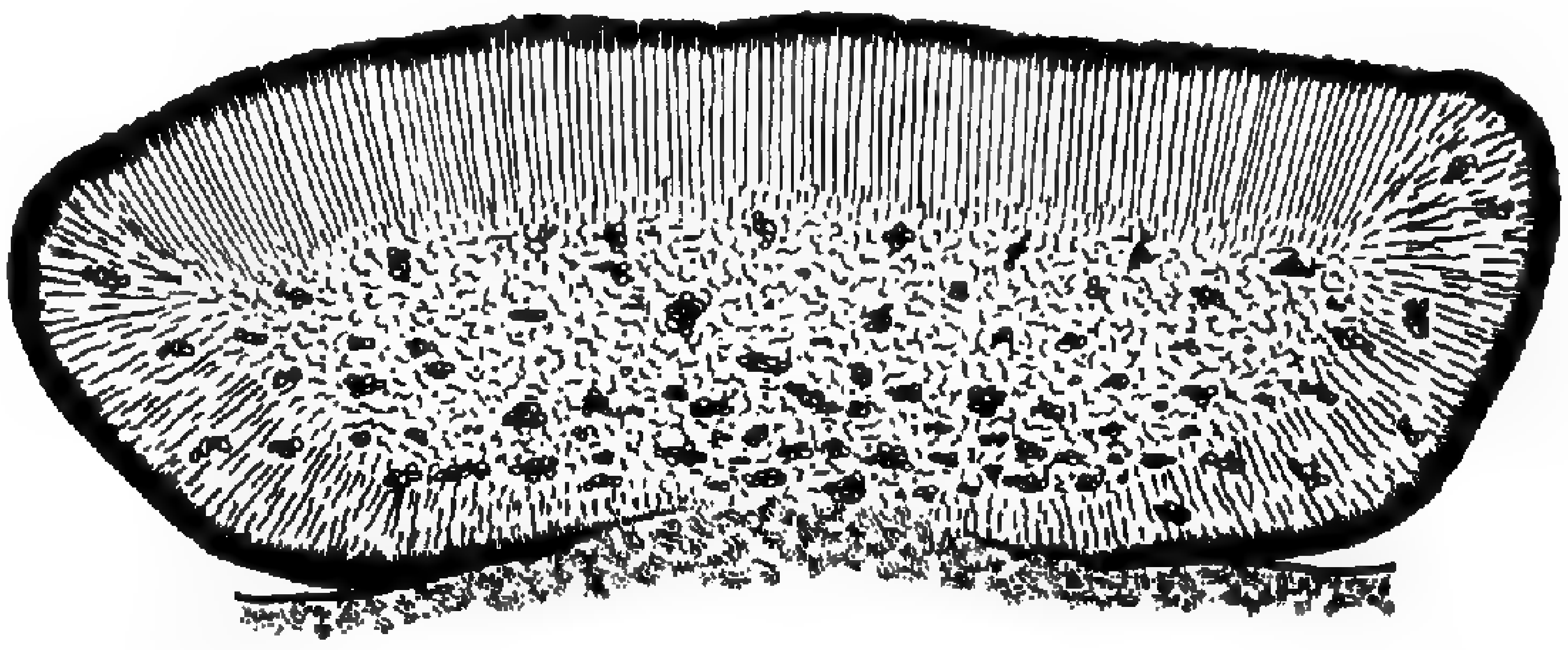


**Fig. 13.** *Lecidea patagonica* M. Lamb. The type-specimen. Section of an apothecium.

*L. patagonica* obviously belongs to the *Lecidea lithophila*-group, and is distinguished by the high hymenium and relatively large spores. Other Patagonian species to which it appears to be closely related are *L. subdeclinans* Müll. Arg., *L. lechleri* Zahlbr., *L. xantholeuca* Müll. Arg., and *L. corralensis* Räs. *L. subdeclinans* (see following revision) differs in the entirely darkly pigmented excipulum without colorless internal part, lower hymenium, and somewhat smaller spores. *L. lechleri* (Syn. *L. leucoplaca* Müll. Arg., non Steud.) differs in the quite continuous thallus without bounding hypothallus, the greenish hymenium, and the shorter spores. *L. xantholeuca*, otherwise similar, is distinguished by its yellowish thallus. *L. corralensis* has much smaller apothecia. *L. subauriculata* B. de Lesd., a N. American species, somewhat resembles our plant, but differs in the less developed, differently colored thallus and more broadly ellipsoid spores. *L. hornii* Lynge, from N. E. Greenland, has many characters in common with *L. patagonica*, but its apothecia are smaller and its spores distinctly larger. Among the European species, *L. patagonica* approaches only *L. italica* B. Lesd., which has larger, concave and persistently marginate apothecia.

The type-specimen was found on non-calcareous metamorphic stones beside the pathway through the forest between Lago Frias and the Frias Glacier; the other specimen from the Isla Victoria was growing on dry non-calcareous rocks near the shore of the lake, associated with *Verrucaria aethiobola* Wbg.

Type in Herb. Mus. Nat. Canada, Ottawa.

### **Lecidea** (Eulecidea) **subdeclinans** Müll. Arg.

in *Nuov. Giorn. Bot. Ital.*, Vol. XXI, 45: 1889.

*Revision of the type-specimen from Fuegia, Staten Island, Port Cook, coll. Spegazzini, 1888 (no. 68), in Herb. Müll. Arg., Herb. Boissier, Geneva*: On apparently metamorphic, ± schistose rock. Thallus well developed, effuse, thickish and tartareous, 0.3–0.6 mm. thick, not areolate but with anastomosing and ± reticulating, ± sharp-edged cracks less than 0.1 mm. wide; ash-gray (in places with a faint ochraceous tinge), smooth or only slightly uneven, or in places indistinctly verruculose, matt. No hypothallus seen (acc. to Müller Arg. the thallus is bounded by a black hypothalline line). Thallus KHO + distinct yellow, $CaCl_2O_2$– , medulla I– under

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microscope. The thallus is ecorticate, of compact undifferentiated structure with ± gelatinously fused, indistinct hyphae, grayish-nubilated and oily-grumose in the lower part; uppermost 15–35 μ yellowish as if from the sheaths of blue-green algae: the symbiotic algae are however protococcoid. Apothecia numerous, irregularly dispersed, sometimes several confluent, many of them undeveloped, small and semi-immersed; mature apothecia sessile, slightly to moderately constricted at base, 0.8–1.0 mm. diam., round or ± angulose, black, matt (nitid only where rubbed), persistently plane or finally very slightly convex, naked, with ± persistent, thin and somewhat indistinct, hardly prominent, entire or slightly flexuose, concolorous proper margin.

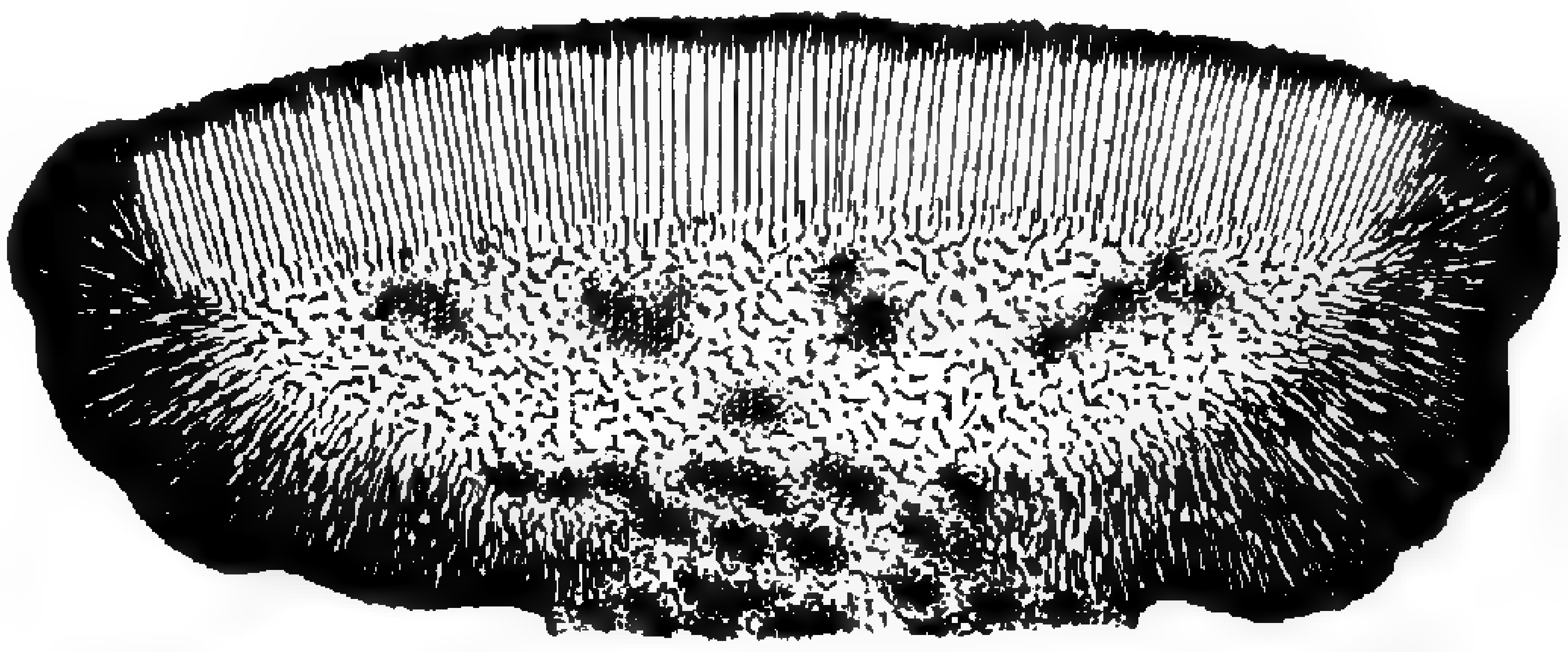


**Fig. 14.** *Lecidea subdeclinans* Müll. Arg. The type-specimen. Section of an apothecium.

Excipulum developed at sides, where 65–90 μ thick, becoming indistinct at the base below the apothecium; entirely brown or reddish-brown in section from dense pigment between the hyphae, which are parallel, conglutinated, about 3.5 μ thick, with indistinct walls. There is no pale inner excipular stratum as in *L. lapicida* Ach. Hypothecium colorless or in places with irregular patches of brownish pigment, 100–115 μ deep, its base resting on a vague, patchily brownish-pigmented tissue (apparently basal continuation of the excipulum) which runs down slightly into the underlying thallus. In thicker sections the hypothecium appears ± uniformly pale brownish. Hymenium 55–65 μ high, gradually dark brown (no aeruginose tinge) in uppermost 6–10 μ, otherwise colorless or towards the base slightly brownish-cloudy. Paraphyses concrete in mucilage, 1.0–1.5 μ thick, at the tips capitate up to 3.5 ( –5.0) μ and there ± brown-pigmented. Asci 45–55 × 12–15 μ. Spores ellipsoid to elongate-ellipsoid, with thin smooth wall, not halonate, 13.5–16.0 × 5–6 μ. With KHO, a yellow mist flows from sections of thallus and apothecia; the excipulum becomes lighter reddish-brown, the hypothecium ± entirely colorless, the epithecium lighter and more olivaceous brownish. With Iodine, hymenium blue then dark greenish-blue; hypothecium and excipulum I– .

Müller Arg., *loc. cit.*, also published a β *steriza* Müll. Arg. of the species from the same locality, distinguished by the obsolete thallus. In his herbarium there are two specimens bearing this name, both from Staten Island, Port Cook, collected by Spegazzini in 1888, nos. 62 and 63 respectively. Number 63 is obviously referable to *Lecidea lapicida* Ach. (var. *ecrustacea* (Bausch.) Anzi), having the thickly margined apothecia and internal structure characteristic of that species; the other specimen, no. 62, is different and is apparently conspecific with *L. subdeclinans* Müll. Arg., differing chiefly in the obsolete thallus, which is represented only by a few indistinct, sordid whitish traces around and below the apothecia. This specimen, no. 62 of Spegazzini's collection, is therefore proposed as the lectotype of the var. *steriza* Müll. Arg. In addition to the obsolete thallus, it differs slightly from the holotype of the typical *L. subdeclinans* in the dark aeruginose or aeruginose-blackish (not brown) color of the outer excipulum and the epithecium, and in slightly smaller spores (12–14 × 5 μ), both of these probably normal variations.

Certainly belonging to the *Lecidea lithophila*-group, and coming nearest to *L. subplanata* Vain., from which it differs chiefly in the longer spores.

### **Lecidea** (Psora) **hypotheja** M. Lamb (n. sp.)

Thallus congesto-squamulosus, caespites latos, crassos, deplanato-pulvinatos efficiens, squamulis confertis, imbricatis, erectis aut varie intricatis, 1.0–2.5 ( –4.0) mm. longis et latis, ambitu rotundatis aut sinuato-lobatis, planis aut concavis, superne fusco-alutaceis, laevigatis, opacis, nudis, ad peripheriam anguste sulphureo-flavescentibus, ibique sat tumidis et nonnihil pulverulentis; inferne laete sulphureis, subtilissime radiatim adpresso-fibrosis (haud rhizinosis), opacis. Apothecia satis numerosa, squamulis superficialiter et marginaliter insidentia, ab initio subglobosa et omnino immarginata, fuscorufescentia, aetate fusconigrescentia, basi constricta, laevigata, nitidiuscula, ad 1.3 mm. lata, dein saepe proliferantia et acervulos ad 2.5 (–3.0) mm. latos formantia. Excipulum (amphithallinum) superne rufofuscescens, basin versus sensim hyalinum. Hymenium cum hypothecio rufo- aut purpureo-fuscescens, in summa parte intensius ita tinctum, 60–80 μ altum; hypothecium 50–70 μ crassum, strato myelohyphico (cono centrali) crystalligeno et partim flavovirescenti superpositum. Paraphyses concretae, indistinctae. Asci clavati (sporis haud evolutis). — Thallus extus intusque KHO– , $CaCl_2O_2$– , PD– ; hyphae medullares I– . Hymenium I + partim sordide aeruginascens, in KHO (cum hypothecio) solutionem violaceo-rubricosam effundens. — Pulchra et insignis species, affinis ut videtur *L. ictericae* (Mont.) Tayl., squamulis adscendentibus, intricato-congestis, caespites pulvinatos formantibus dignota. — In fissuris rupium praeter litora lacustria in Argentina, Patagonia, Chubut, prope Futalaufquen: M. Lamb, 1950, nos. 5870 (typus speciei), 5932.

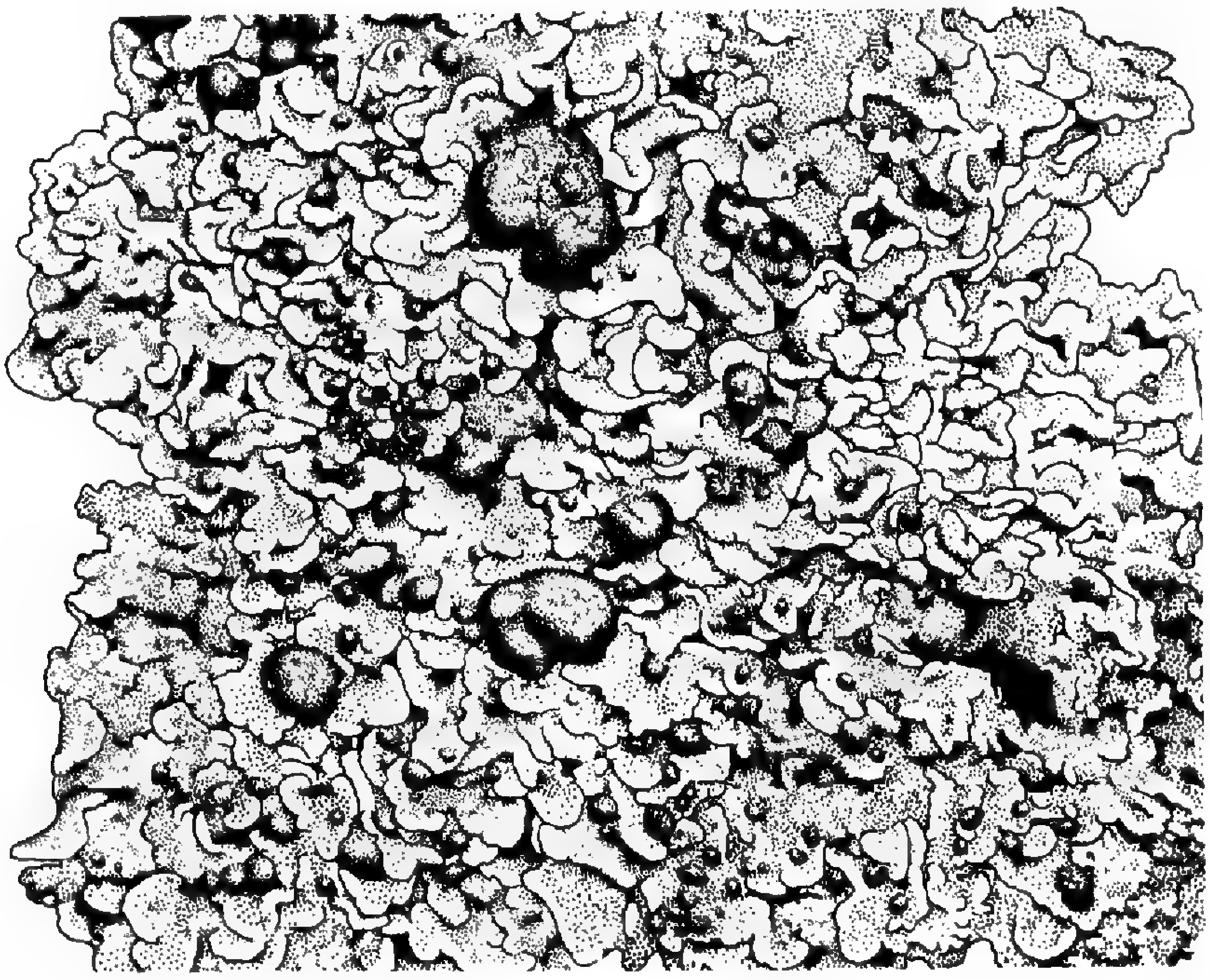


**Fig. 15.** *Lecidea hypotheja* M. Lamb. Part of the type-specimen (× 3).

*Description of the type-specimen* (*M. Lamb no. 5870*): thallus congested-squamulose, forming compact, flattened-pulvinate patches 5–10 cm. diam. and 1.0–1.5 cm. thick; squamules crowded, imbricated, upright to ± horizontal, 1.0–2.5 ( –4.0) mm. long and broad, about 0.15 mm. thick, rounded or ± sinuate-lobed, plane or concave, alutaceous or pale brown on upper side, with finally ± tumid, yellow, often slightly pulverulent (but not sorediate) margins. Upper side smooth, matt, not pruinose. Lower side of squamules sulphur-yellow, subtly radiately adpressed-fibrose but not rhizinose, matt. No isidia or soredia. Squamules externally and internally KHO– ,

$CaCl_2O_2$– , PD– ; medulla I– . Apothecia fairly numerous, on upper side of squamules, both marginal and superficial, subglobose and completely immarginate from the first, reddish-brown, finally becoming brown-blackish, well constricted at base, simple or the larger ones becoming sulcate and ± completely divided into aggregations of pulvinate secondary discs; smooth, moderately nitidous; simple apothecia up to 1.3 mm. diam., compound apothecia up to 2.5 ( –3.0) mm. diam. and often sharply fissured.

Upper side of squamules corticate with a colorless, hyaline cortex 70–120 μ thick composed of gelatinized, thick-walled hyphae intricated in various directions, only the lumina, 2–3 μ wide, visible in the clear gelatinous matrix. Upper side of cortex somewhat irregular; lower side sharply delimited from the algal stratum. Algal stratum continuous, 60–90 ( –100) μ deep, somewhat diffuse on lower side. Medulla 120–200 μ thick, hyphose, sordid yellowish- or greenish-yellowish-cloudy in section (but without visible granules), composed of thin-walled hyphae 3–4 μ thick completely intricated in various directions or partly predominantly ± horizontal, without noticeable air-spaces. No lower cortex developed; underside of squamules formed by the medullary tissue, with the hyphae somewhat larger (up to 4.5 μ diam.) and thicker-walled (walls up to 1.5 μ thick), more loosely intertexted; no visible granules. The medulla becomes ± clear and hyaline with KHO, without mist; sections $CaCl_2O_2$– , I– . Symbiotic algae protococcoid, bright green, globose, 6–10 μ diam., thin-walled. The yellow color of the underside and edges of the squamules is due to the sordid yellowish nubilation of the medullary layer.

Excipulum of amphithecial origin, merging gradually into the thallus cortex below and into the hymenium above; in upper part yellow-brownish or red-brownish, in lower part becoming colorless and hyaline; composed of conglutinated and gelatinized, thick-walled, parallel-radiate hyphae, the lumina distinct, 1.5–2.0 μ wide. Central cone compact, filled with irregular colorless crystals up to 10 μ diam. and a ± amorphous, yellow-greenish substance; the intertexted hyphae colorless, indistinct. Hypothecium 50–70 μ deep, reddish-brown (concolorous with the hymenium), composed of compactly intricated hyphae 2–3 μ thick with thin, ± pigmented walls. Hymenium 70–80 μ high, entirely reddish-brown, darker reddish-brown in uppermost 9–14 μ. Paraphyses concrete, indistinct in water, in KHO ± discrete, about 2 μ thick, embedded in turgescent mucilage, simple or occasionally branched, not articulated, not noticeably thickened at tips. Asci clavate, immature, 45–50 × 10 μ. (No spores developed.) Both hymenium and hypothecium give off a crimson-purple solution with KHO.

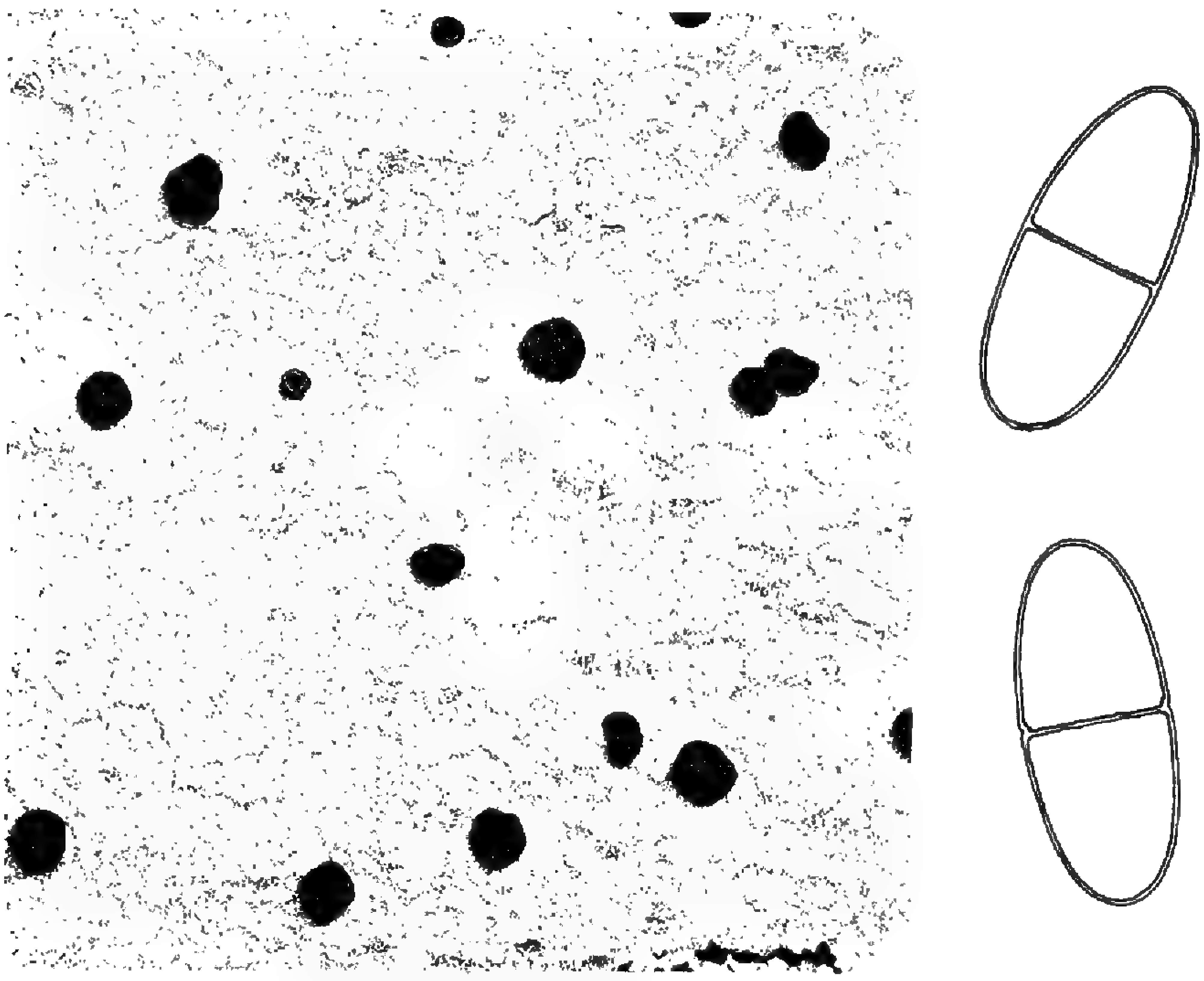
In both the specimens the hymenium is completely destitute of spores, although the apothecia are otherwise well developed. The only other species of sect. *Psora* which at all resembles it is *L. icterica* (Mont.) Tayl., which has similarly yellow-edged squamules of about the same color, but these in *icterica* are all closely applanate to the substratum, not ascendant.

*L. hypotheja* was locally abundant in both the localities, Lago Verde and Lago Cisnes, some miles apart, forming clumps and patches on detritus in crevices of steep rocks by the shores of the lakes, 1 to 1.5 m. above the water level.

Type in Herb. Mus. Nat. Canada, Ottawa; isotypes in Farlow Herb., Herb. Inst. Syst. Bot. Uppsala, and Herb. Inst. Bot. Darwinion, San Isidro, Buenos Aires.

### **Catillaria melanopotamica** M. Lamb (n. sp.)

Thallus sat late effusus, saepe ambitu hypothallo tenui, viridinigrescenti aut obscure cinereo limitatus, albidus, opacus, tenuis, continuus aut partim minute reticulato-rimosus (haud rite areolatus), sat laevigatus aut minute granuloso-inaequalis. Apothecia copiosa, sparsa, sessilia, ad basin modice constricta, rotundata, 0.6–1.0 mm. lata, ab initio nigra, plana aut demum convexa, primitus margine proprio concolori, opaco vel nonnihil nitido, mediocri, integro, satis prominenti cincta, deinque immarginata. Excipulum integrum, ad marginem irregulariter purpureo-tinctum, caeterum incoloratum; e hyphis radiantibus, pachydermaticis, conglutinatis constans. Hypothecium totum hyalinum (incolor aut leviter sordide lutescens) aut superne leviter purpureo-fuscescens. Hymenium 100–125 μ altum, pallide purpureo-violascens, epithecio purpureo-fuligineo; paraphysibus discretis, apicibus capitatis. Sporae 6–8nae, subbiseriatae, ellipsoideae, 1-septatae, incolores, 18–23 × 8.5–10.0 μ. — Thallus KHO + lutescens, $CaCl_2O_2$– , PD– aut indistincte flavescens; hymenium I + coerulescens deinque sordide aeruginascens, KHO (cum parte marginali excipuli) + purpureo-rubescens. — *C. superfluae* (Müll. Arg.) Zahlbr. e Australia arcte relata, excipulo marginali purpurascenti, hymenio altiori et purpureo-violascenti, epithecio purpureo-fuligineo, sporis angustioribus, aliisque notis diversa. — Ad corticem *Nothofagi* in Argentina, Patagonia, Río Negro, insula Victoria in lacu Nahuel Huapí: M. Lamb, 1950, nos. 5815 (typus speciei), 5836.



**Figs. 16 & 17.** *Catillaria melanopotamica* M. Lamb. Part of the type-specimen (× 4); spores (× 1250).

*Description of the type-specimen (M. Lamb no. 5815)*: thallus effuse, forming patches 5–10 cm. diam. on the smooth bark, bounded at most places of periphery by a thin, non-fimbriate, greenish-black or dark gray hypothallus, which is also visible here and there in the thinner parts of the central thallus. Thallus whitish or cream-colored, matt, thin (up to 0.2 mm. thick), continuous or in most places minutely reticulate-rimose (not areolate), ± smooth or usually minutely granulose-uneven, KHO + yellow, $CaCl_2O_2$– , PD + (slowly) faint yellowish. Apothecia numerous, evenly scattered, sessile, moderately constricted at base, discoid, 0.6–1.0 mm. diam., entirely black at all stages of development, plane to slightly convex, not pruinose, with matt, smooth or minutely scabrid disc; proper margin black, matt or subnitid, moderate, entire, at first somewhat prominent, finally becoming reflexed and disappearing. Symbiotic algae of thallus protococcoid, pale green, globose, 6–9 μ diam., thin-walled.

Excipulum entire below apothecium, 65–78 μ thick, at the margin up to 100 μ thick; composed of conglutinated, radially parallel, thick-walled, gelatinous hyphae, with only the fistulose lumina (about 1 μ wide) distinctly visible; in the basal part colorless and hyaline, in the margin unevenly purplish from amorphous pigment between the hyphae. Hypothecium 100–135 μ deep, either entirely colorless and hyaline, or in the upper subhymenial 20–30 μ very faintly and unevenly purple-brownish; composed of densely compacted, thin-walled hyphae 2–3 μ diam. intricated in various directions. Hymenium 100–125 μ high, pale purplish-violascent from vertical purplish streaks between the paraphyses; the epithecium up to 17 μ thick, irregular, purple-blackish. Paraphyses discrete in water, 1.5–2.0 μ thick, at the tips capitate to 5 μ and there coated with amorphous, purple-blackish pigment; simple or sparingly branched, not anastomosing. Asci clavate, 75–85 μ long, 15–18 μ wide, with wall about 1.5 μ thick at sides, at the apex spuriously gelatinously thickened up to 25 μ. Spores 7–8 in ascus, irregularly biseriate; ellipsoid, 1-septate, occasionally very slightly constricted at the septum, with wall and septum of equal thickness (about 1 μ); plasm clear and hyaline; 18–23 × 8.5–10.0 μ. With KHO added to sections of apothecium, the hymenium and colored lateral parts of excipulum turn purple-red; the hypothecium and colorless lower excipulum + slight yellow. Hymenium I + blue then sordid dark aeruginose, other parts I– .

The other specimen, no. 5836, collected some distance away in the Isla Victoria, agrees well with the holotype; the only differences of note are the following: hypothallus often indistinct. Thallus PD– . Apothecia finally well convex and immarginate. Hypothecium colorless or entirely faintly lutescent in section, the upper subhymenial part more grumose-inspersed but not purple-brownish. Asci up to 100 μ long (but height of hymenium the same). Spores 6–8 in ascus; wall and septum up to 1.5 μ thick.

The species comes closest to the Australian *C. superflua* (Müll. Arg.) Zahlbr., and could not be distinguished with certainty from the latter on the basis of the diagnosis alone. Müller Arg.'s type specimen was therefore examined (see revision below), and the following differences, which seem to be specific, were found:

| *C. melanopotamica* | *C. superflua* |
|---|---|
| Marginal part of excipulum purplish or purple-reddish. | Marginal part of excipulum dark olivaceous, greenish-brown, sordid aeruginose or fuliginous. |
| Hypothecium entirely colorless or faintly lutescent, occasionally very faintly purple-brownish in upper part. | Hypothecium colorless and hyaline in lower part, in upper part pale sordid olivaceous or olivaceous-isabelline. |
| Hymenium 100–125 μ high, entirely pale purplish-violascent from streaks of pigment between the paraphyses. | Hymenium 85–100 μ high, entirely colorless and hyaline except for the epithecium. |
| Epithecium purple-blackish (KHO + purple-reddish). | Epithecium aeruginose-blackish (KHO + dark sordid brown). |
| Spores 8.5–10.0 μ broad. | Spores 10–12 μ broad. |

*C. melanopotamica* is probably also related to the Australian *C. frenchiana* (Müll. Arg.) Zahlbr., but differs from the latter in different color of thallus, smaller spores, etc.

Both specimens seen were on trunks of "Coihue" (*Nothofagus dombeyi*).

Type in Herb. Mus. Nat. Canada, Ottawa; isotypes in Farlow Herb. and Herb. Inst. Bot. Darwinion, San Isidro, Buenos Aires.

### **Catillaria phaeolomiza** M. Lamb (n. sp.)

Thallus effusus, tenuis, albicans, inaequalis aut verruculoso-inaequalis (praesertim e asperitate substrati), opacus, continuus aut indistincte et minute reticulato-rimosus (haud rite areolatus), hypothallo haud bene visibili. Apothecia numerosa, sparsa, sessilia, rotundata, 0.5–0.8 mm. lata, basi leviter aut modice constricta, nigra aut saepe partim pallidiora (fusconigrescentia), plana et margine mediocri, parum prominenti, integro, concolori circumdata, dein leviter convexa et immarginata. Excipulum integrum, ad basin incoloratum, in margine striatim purpureo-rubescens aut fere hyalinum, e hyphis radiantibus et conglutinatis formatum. Hypothecium inferne hyalinum, superne irregulariter obscure fuscescens aut purpureo-fuscescens. Hymenium 95–120 μ altum, hyalinum, epithecio olivaceo-fuligineo, paraphysibus discretis, apicibus capitatis et subaeruginosis aut fuligineis. Sporae 8nae, biseriatae, ellipsoideae, incolores, 1-septatae, 18–25 × 8.5–10.0 μ. — Thallus KHO + lutescens, $CaCl_2O_2$– , PD– ; hymenium I + coerulescens deinque aeruginascens; hypothecium superius (cum excipulo marginali) KHO + purpurascens; epithecium KHO + olivaceo-fuscescens. — Affinis praecedenti (*C. melanopotamicae*), at hypothecio superne fusco, hymenio hyalino, epithecio aliter colorato et KHO haud purpurascenti, et apotheciis saepe pallidioribus distincta videtur. Ad *C. phaeolomam* (Kn.) Zahlbr. e Australia, hucusque tantum e descript. cognitam, arcte accedere possit. — Corticola in Argentina, Patagonia, Nahuel Huapí, loco accuratius non indicato: L. E. Cannelle, 1943, no. 120.

Thallus effuse, thin, 0.1–0.2 mm. thick, cream-colored or whitish, uneven or verruculose-uneven (largely from the inequalities of the substratum), matt, continuous or indistinctly and minutely reticulate-rimose, not areolate. No dark hypothallus seen. Thallus KHO + yellow, $CaCl_2O_2$– , PD– . Apothecia numerous, ± evenly scattered, 0.5–0.8 mm. diam., discoid, sessile, slightly to moderately constricted at base, black or occasionally partly paler (brown-blackish), at first plane with moderate but hardly prominent, entire, black or brownish margin, then becoming slightly convex and immarginate. Disc matt, black or rarely partly brownish, smooth or minutely scabrid, not pruinose. Symbiotic algae of thallus protococcoid, globose, separable, 7–14 μ diam., pale green, thin-walled.

Excipulum entire below, up to 85 μ thick below and at sides, at the base colorless, at the sides colorless or streaked with purple-reddish pigment between the hyphae, becoming ± purpurascent on the inner side against the hypothecium; of palisade-structure, with conglutinated, gelatinized, parallel, thick-walled hyphae, the fistulose lumina about 1 μ wide. In a few places on the outer side of the excipulum there may be a faint aeruginose pigmentation in patches. Hypothecium consisting of two parts: (*a*) a lower 35–68 μ, clear and colorless (or in places faintly purplish in its lower half) of indistinctly pseudoparenchymatic structure, without inclusions; and (*b*) an upper 40–57 μ, somewhat patchily dark brown or dark purplish-brown. Total depth of hypothecium is 100–130 μ. Hymenium 95–120 μ high, hyaline, without any purple color, the epithecium irregular, sordid olivaceous-blackish, without any purplish tinge. Paraphyses discrete in water, about 1.5 μ thick, clavate-capitate up to 4 μ at tips and there sordid aeruginose to olivaceous-blackish. Asci 78–95 μ long. Spores 8, biseriate in ascus, ellipsoid, 1-septate, with equally thickened wall and septum (about 1 μ), 18–25 × 8.5–10.0 μ. With KHO added to sections of apothecium, lower colorless hypothecium and colorless parts of excipulum turn yellow; upper dark hypothecium and colored parts of excipulum turn purpurascent; epithecium KHO + dark olive-brown (not purpurascent). Hymenium I + blue then blue-green; other tissues of apothecium I– .

Comes very close to the foregoing (*C. melanopotamica*), but differs in the distinct dark brown or purplish-brown pigmentation of the upper hypothecium, lack of streaky purpurascent color in the hymenium, olivaceous-blackish epithecium not purpurascent with KHO, and the somewhat paler, not pure black apothecia. There seems to be a considerable resemblance to the Australian species *C. phaeoloma* (Kn.) Zahlbr. and *C. melaloma* (Kn.) Zahlbr., both described in *Trans. Linn. Soc. Lond.*, *ser. 2*, *Bot.*, Vol. II, 45: 1882, sub *Lecidea*, as far as can be judged from Knight's inadequate descriptions. Unfortunately all attempts to obtain reliably authenticated original material of these two species for comparison were unsuccessful. No specimens could be found in Herb. Kew; in Herb. Nylander, Helsinki, there is a specimen (no. 20934 in Herb. Nyl.) sent by Knight under the name "*Biatora melaloma*," but on examination it proved to be a *Buellia*.

Type in Herb. Crypt. Inst. Miguel Lillo, Tucumán, Argentina, under no. 8618.

### **Catillaria lacarensis** M. Lamb (n. sp.)

Thallus sat late effusus, tenuis, crassit. vix 0.2 mm., partim membranaceus, partim plus minusve desquamescens; albidus, opacus, continuous aut obsolete et subtiliter rimulosus (haud areolatus), laevigatus aut sat inaequalis, haud distincte granulosus, hypothallo haud viso. Apothecia copiosa, sparsa, sessilia, rotundata, basi modice vel bene constricta, 0.6–1.8 ( –2.0) mm. lata, nigra, diu plana et margine tenui aut mediocri, integro, satis prominenti praedita, dein paullo convexa, margine evanescenti. Excipulum integrum, lateribus extus aeruginoso-fuligineum, intus rubro- vel purpureo-fuscescens, in parte basali striatim aeruginoso-fuligineum; e hyphis radiantibus et conglutinatis contextum. Hypothecium inferne levissime purpureo-fuscescens aut fere incoloratum (partim sordide flavescenti-granulosum), superne obscure rufofuscescens aut purpureo-fuligineum. Hymenium 100–135 μ altum, sat hyalinum, epithecio fuligineo, paraphysibus discretis, apicibus capitatis. Sporae 6–8nae, subbiseriatae, incoloratae, ellipsoideae, 1-septatae, 24–32 × 10–13 μ. — Thallus KHO + indistincte (fusco-) flavescens, $CaCl_2O_2$– , PD– ; hymenium I + coerulescens deinque aeruginascens: hypothecium KHO + rubro-purpurascens; epithecium KHO + purpureo-fuligineum. — A *C. phaeolomiza*, quacum habitu externo et hypothecio superne fusco congruit, distat excipulo partim aeruginoso-fuligineo (nec purpureo-fuscescenti), hypothecio inferne granuloso-insperso, et sporis distincte majoribus. — Corticola in Argentina, Patagonia, Neuquén, ad lacum Lacar prope flumen Hua-Hum: O. Kühnemann, 1943, no. 780.

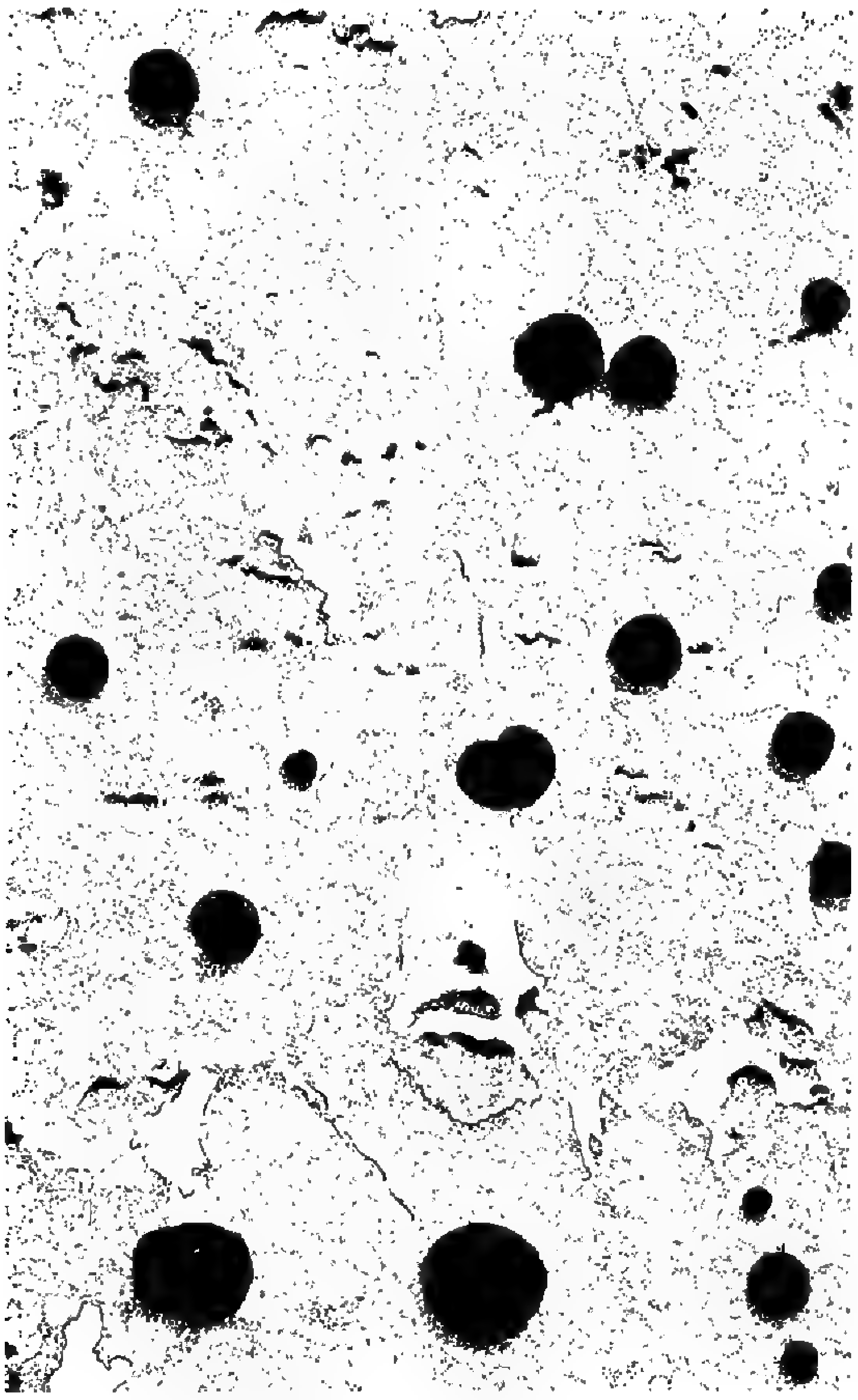


**Fig. 18.** *Catillaria lacarensis* M. Lamb. Part of the type-specimen (× 4).

Thallus effuse, forming patches 5 cm. or more in diameter on smooth bark; thin, up to 0.2 mm. in thickness, in places membranaceous, in other places thicker and ±

desquamescent; cream-colored or whitish, matt, continuous or obsoletely finely rimulose (not areolate), smooth or ± uneven but not distinctly verruculose; KHO + brownish or ferruginous-yellowish, $CaCl_2O_2$– , PD– . No dark hypothallus seen. Symbiotic algae pale green, consisting of thin-walled, globose cells 5–10 μ diam. cohering in clumps and seemingly concatenate, probably *Trentepohlia*. Apothecia numerous, ± evenly scattered, sessile, moderately to well constricted at base, discoid, unequal in size, 0.6–1.8 ( –2.0) mm. diam., entirely black, for a long time plane with thin to moderate, entire, moderately prominent, matt or subnitid proper margin, then becoming slightly convex with the margin indistinct or evanescent. Disc matt, smooth or minutely scabrid, not pruinose.

Excipulum entire below apothecium, 50–75 μ thick at sides, up to 100 ( –135) μ thick at base, at the sides aeruginose-blackish from amorphous pigment between the hyphae, grading into reddish- or purplish-brown on the inside; at the base ± colorless and hyaline, with scattered streaks of aeruginose-blackish pigment, or sometimes ± evenly aeruginose-blackish. It is composed of parallel, conglutinated, gelatinized, thick-walled hyphae about 5 μ thick, the fistulose lumina about 1 μ wide. Hypothecium 135–200 μ deep, in two distinct parts: (*a*) a lower, faintly purple-reddish or purple-brownish (or almost colorless) 75–120 μ; in its lower part this layer is ± densely packed with yellowish-gray granules; and (*b*) an upper, dark reddish-brown or purple-blackish layer 65–85 μ thick. Hymenium 100–135 μ high, colorless or in places faintly reddish- or purplish-brown, clear; epithecium irregular, fuliginous (not distinctly aeruginose or purplish). Paraphyses discrete in water, filiform, ± sinuous, sometimes branched but not anastomosing, 1–2 μ thick, at the tips slightly clubbed, up to 3.5 μ, and there overlaid with dense amorphous pigment. Spores 6–8 in ascus, subbiseriate; colorless, ellipsoid, 1-septate, with distinct wall and septum of equal thickness, about 1.3 μ; 24–32 × 10–13 μ. The lower unpigmented part of the hypothecium consists of densely packed, thick-walled hyphae 3–5 μ thick intricated in various directions; the upper pigmented part of somewhat thinner intricated hyphae, about 3 μ thick, much obscured by the dark purplish pigment. With KHO added to sections of apothecium, the colored parts of the excipulum become more olive-greenish; hymenium and upper and lower hypothecium become reddish-purpurascent; the epithecium turns purplish-fuliginous. With Iodine, hymenium blue then sordid dark olivaceous-aeruginose; other tissues I– .

It is difficult to identify with certainty the nature of the symbiotic algae, but probably they are *Trentepohlia*-filaments in a broken-up condition, as they often occur when enclosed in a lichen thallus. Accordingly this species would by some lichenologists be placed in the genus *Catinaria*, which has been placed by Zahlbruckner in the family Lecanactidaceae. Such a generic distinction, based on the nature of the algal symbionts, is purely artificial and quite untenable.

Type in Herb. Admin. Parques Nacionales, Avda. Santa Fe 690, Buenos Aires; isotype in Farlow Herb.

### **Catillaria superflua** (Müll. Arg.) Zahlbr.

*Cat. Lich. Univ.*, Vol. IV, 75: 1926. Syn. *Patellaria* (*Catillaria*) *superflua* Müll. Arg. in *Flora,* Vol. LXX, 336: 1887.

*Revision of the type-specimen from Australia, New England (New South Wales), Walcha, coll. Crawford (no. 14), in Herb. Müll. Arg., Herb. Boissier, Geneva*: On smooth cracky bark. Thallus effuse, not limited by any hypothallus, apparently extensive and widespread, now sordid subochraceous-whitish (white in fresh condition, acc. to Müll. Arg.), very thin, about 0.05 mm. thick, membranaceous, continuous or with only accidental cracks, smooth or rugulose (following the inequalities of the substratum), matt, not pruinose or scurfy, KHO + yellow or sordid yellow, $CaCl_2O_2$– , PD– . Apothecia numerous, scattered, sessile, round, moderately to well constricted at base, entirely black, 0.5–0.9 mm. diam., at first plane with a moderate, prominent, entire, black, matt or subnitid margin, then becoming slightly to moderately convex with the margin reflexed and invisible. Disc smooth, matt, naked.

Excipulum well developed at sides and continued for some distance round on underside of apothecium, where it becomes gradually indistinct, absent in the center; 60–85 μ thick, of distinctly radiating structure, in the upper marginal part streakily and irregularly pigmented with a dark olivaceous, greenish-brown, sordid aeruginose or fuliginous pigment between the hyphae, which are parallel, partly colorless, gelatinized and conglutinated, thick-walled, 3–5 μ thick (lumina about 1 μ wide). Pigment in KHO becoming fulvous-brown or purplish-brown, in $HNO_3$ distinctly purple. In the lower part of the excipulum the pigmentation is ± absent. Hypothecium clearly divided into two parts: (*a*) an upper, pale sordid olivaceous or olivaceous-isabelline 60–75 μ of distinct, rather thick-walled, variously intricated or partly vertical hyphae 3.0–4.5 μ thick, and (*b*) a lower, colorless and hyaline layer 65–125 μ deep of more subtle structure, consisting of fine, thin-walled, gelatinously conglutinated hyphae 1.5–2.5 μ thick compactly intricated in various directions; the boundary between the two layers ± sharp and distinct. Hymenium 85–100 μ high, densely and ± abruptly aeruginose-blackish or fuliginous in uppermost 9–14 μ, otherwise colorless and hyaline. Epithecium in KHO loses its aeruginose tinge and becomes dark sordid brown; $HNO_3$ + dark purple. Paraphyses involved in hyaline mucilage but ± discrete under pressure in water, 1.2–2.0 μ thick, at the tips clavate-capitate up to 3.5–4.5 μ and there overlaid and obscured with dense aeruginose-blackish pigment; simple or sparingly branched, not articulated. Asci clavate, finally (when filled with mature spores) broadly clavate, 75–88 μ long, 14–30 μ broad, with wall 1.2–1.5 μ thick at sides, at the apex gelatinously thickened to 9–12 μ. Spores 8, 2–3-seriate in ascus, colorless, ellipsoid, 1-septate, not constricted at septum, with septum and spore-wall of equal thickness, 1.0–1.3 μ; 20–24 × 10–12 μ (acc. to Müller Arg., 13–32 × 8–10 μ). Hymenium I + persistent dark blue. The upper, pale sordid olivaceous-isabelline part of the hypothecium becomes ± fulvescent with KHO.

Thallus up to 80 μ thick, ecorticate. Symbiotic algae protococcoid, yellow-green, ± globose, 4–9 μ diam.

The three *Catillariae* here described as *C. melanopotamica*, *C. phaeolomiza* and *C. lacarensis* form a closely related complex, possibly a single variable species, but until further collections allow the variability to be studied, it seems best to describe the three rather widely divergent anatomical types as separate species. They may be provisionally distinguished by the following key:

1. Spores 24–32 × 10–13 μ; excipulum aeruginose-blackish at sides and partly below; yellowish-gray granular inclusions present in lower part of hypothecium .......................................................... *C. lacarensis*

1a. Spores smaller, 18–25 × 8.5–10.0 μ; excipulum purplish or purple-reddish at sides, colorless below; no granular inclusions in hypothecium ................ 2.

2. Hymenium pale purplish-violascent (streaks of pigment between the paraphyses); upper part of hypothecium colorless or only faintly purple-brownish ............................................... *C. melanopotamica*

2a. Hymenium colorless and hyaline; upper part of hypothecium dark brown or purplish-brown............................ *C. phaeolomiza*

### **Bacidia** (Scoliciosporum) **spirospora** Knight

in *Trans. & Proc. New Zealand Inst.*, Vol. XII, 371: 1880.

As lectotype has been selected a specimen in Herb. Nylander (no. 17565) from New Zealand, exact locality and date not stated, coll. C. Knight, sent by Knight to Nylander as "*Lecidea* (*Bacidia*) *spirospora*, Kn." The following is a description of this specimen:

On smooth bark. Thallus in interrupted patches, bounded by blackish hypothallus only at point of contact with other crustaceous lichens, effuse, becoming thin and membranaceous at the margin, thin, up to 0.2 mm. thick, now whitish with a faint ochraceous tinge (cinerascent in fresh condition, acc. to Knight's description), matt, smooth, irregularly finely rimose, not areolate, KHO– or slightly brownish, $CaCl_2O_2$– , PD– . Apothecia numerous, scattered, adpressed-sessile, round, 0.4–0.7 mm. diam., moderately to well constricted at base, at first plane with a thin, entire, not or only slightly prominent, pale reddish-brown to black margin, then becoming finally slightly convex and immarginate. Disc brown-blackish to black (or occasionally fuscous in younger apothecia), matt, smooth, not pruinose.

Excipulum ± entire below apothecium, or becoming indistinct in the central part below; 55–85 μ thick, either entirely faintly sordid yellowish or isabelline, or gradually pale brown in the outer half, clear, without granules, composed of gelatinously conglutinated, thick-walled hyphae in flabellate-radiate formation, only the lumina visible, these 1–2 μ wide, simple or branched. Hypothecium consisting of two parts: (*a*) a lower, colorless and hyaline half composed of fine conglutinated hyphae about 1.5 μ thick compactly intricated in various directions or at the sides mainly horizontally parallel; and (*b*) an upper, faintly sordid isabelline half, not transparent, but without visible granules, composed of thick-walled, gelatinously concrete hyphae 3–5 μ thick closely intricated in various directions, in the upper subhymenial part going over into finer, ± vertically parallel hyphae about 1.5 μ thick. Hymenium 60–70 μ high, gradually or ± abruptly subaeruginose-fuliginous or indeterminately blackish (not pure aeruginose) in uppermost 8–10 μ, otherwise colorless and hyaline, not inspersed. Paraphyses discrete, 1.0–1.5 μ thick, simple or branched, not anastomosing, not articulated, at tips gradually thickened to 2–3 μ and there ± pigmented, dark sordid subaeruginose. Asci clavate, 50–62 × 12–15 μ, with wall about 1 μ thick at sides, at apex thickened in immature asci to 6–10 μ. Spores 6–8 in ascus, packed parallel in a bundle, not noticeably spirally twisted; outside asci ± straight or slightly flexuose or often sigmoid-flexuose, obtusely pointed at one end, gradually tapering and acuminate at the other, 8–15-septate with rectangular or ± cubical loculi, 45–65 × 3–4 μ. Hymenium I + persistent blue. Sections of apothecium KHO– in all parts; epithecium $HNO_3$ + bluish-violet.

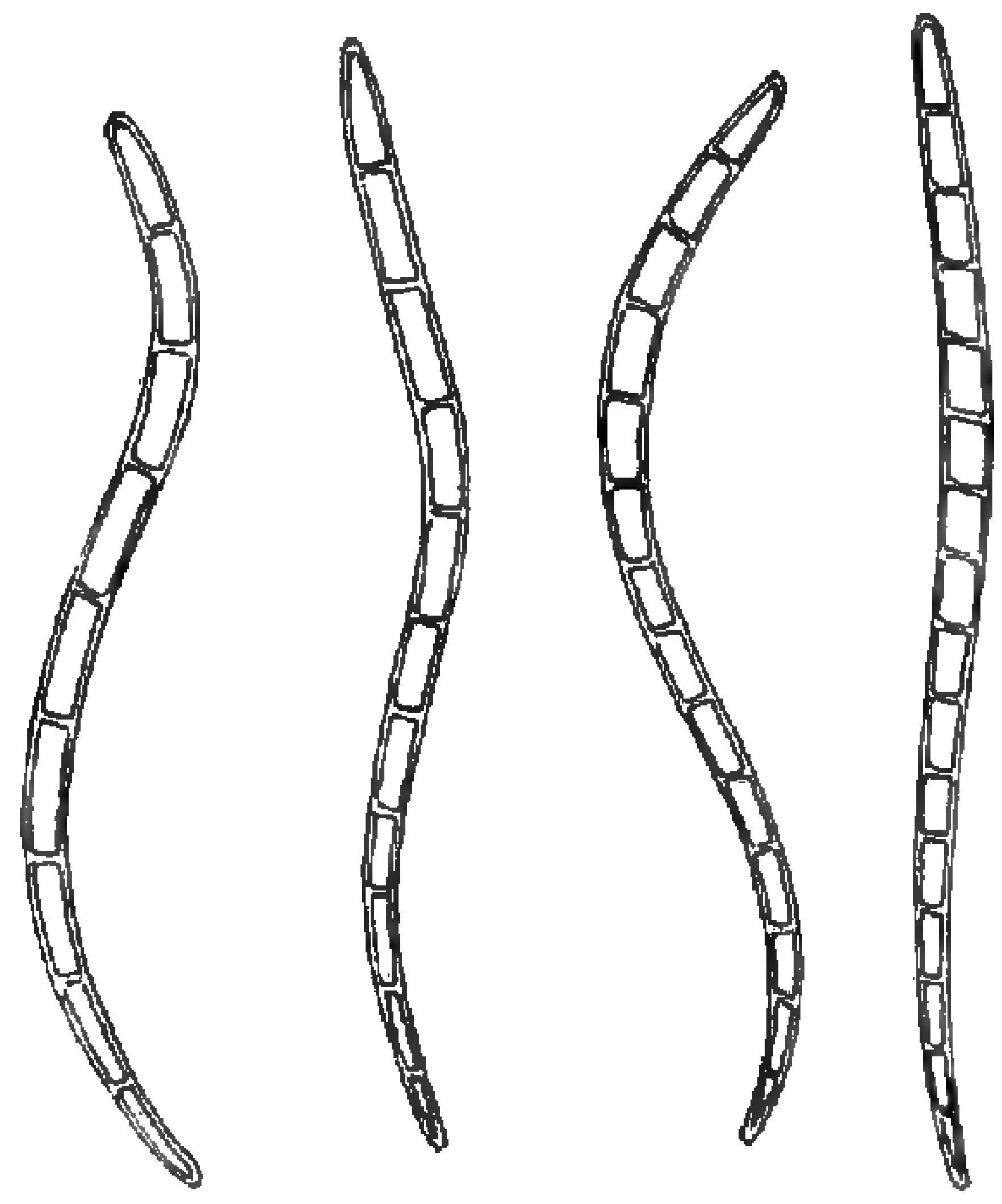


**Fig. 19.** *Bacidia spirospora* Knight. The lectotype-specimen. Spores (× 800).

Another specimen, no. 17568 in Herb. Nylander, from New Zealand, coll. Knight, 1867, no. 103, written up by Nylander as "*Lecidea deflexa* Nyl.," is on lignum, and has no distinct thallus, only a patchy whitish discoloration of the lignum. Apothecia entirely black, mostly slightly convex and immarginate, 0.4–0.7 ( –1.0) mm. diam.; the hymenium slightly higher than in the lectotype of *B. spirospora*, 65–80 μ, subaeruginose-fuliginous or indeterminately blackish in its upper part. Spores about 68 × 3 μ, usually sigmoid-flexuose, about 15-septate. It is obviously referable to *B. spirospora*, being a lignicolous, ± athalline condition. But another specimen, on bark, Herb. Nyl. no. 17566, coll. Knight, 1867, no. 302, called "*Lecidea deflexa* (corticola)" by Nylander, is a different species, very similar in the structure of the apothecia, but with different spores, cylindric-fusiform, straight or slightly curved, not flexuose or sigmoid, ± equally rounded at both ends, shorter, 30–43 × 3–4 μ, 7–13-septate: It belongs to the sect. *Eubacidia.*

"*Lecidea deflexa*" Nyl. in *Lich. Nov. Zeland.*, 100: 1888, is obviously an illegitimate synonym for *Bacidia spirospora* Knight, based on the material sent by Knight under the latter name. The species is somewhat similar to the Portuguese *B. acerinoides* Stnr. (in *Oesterr. Bot. Zeitschr.*, Vol. LXVII, 278: 1918), but differs in the color of the epithecium, which in *acerinoides* is colorless to yellow-brown, olivaceous, dark brown or purplish-brown, not aeruginose-fuliginous; also in Steiner's species the hypothecium and excipulum stain more or less violet-purple with KHO. *B. spirospora* also approaches the N. American species *Bacidia idahoënsis* H. Magn. (in *Medd. Göteborgs Bot. Trädg.*, Vol. XIX, 45: 1952, described as belonging to sect. *Eubacidia*, but from the description apparently referable to sect. *Scoliciosporum*), but differs in the thicker hypothecium, ± distinctly divided into two parts and KHO– , the negative reaction of the epithecium with KHO, and the smoother thallus of different color.

### Var. **patagonica** M. Lamb (n. var.)

Similis speciei typicae, solummodo apotheciis nonnihil majoribus (usque 1 mm. latis), hymenio altiori (75–100 μ) et epithecio magis aeruginoso differens. — Corticola in Argentina, Patagonia, Chubut, prope lacum Menéndez: M. Lamb, 1950, no. 5933.

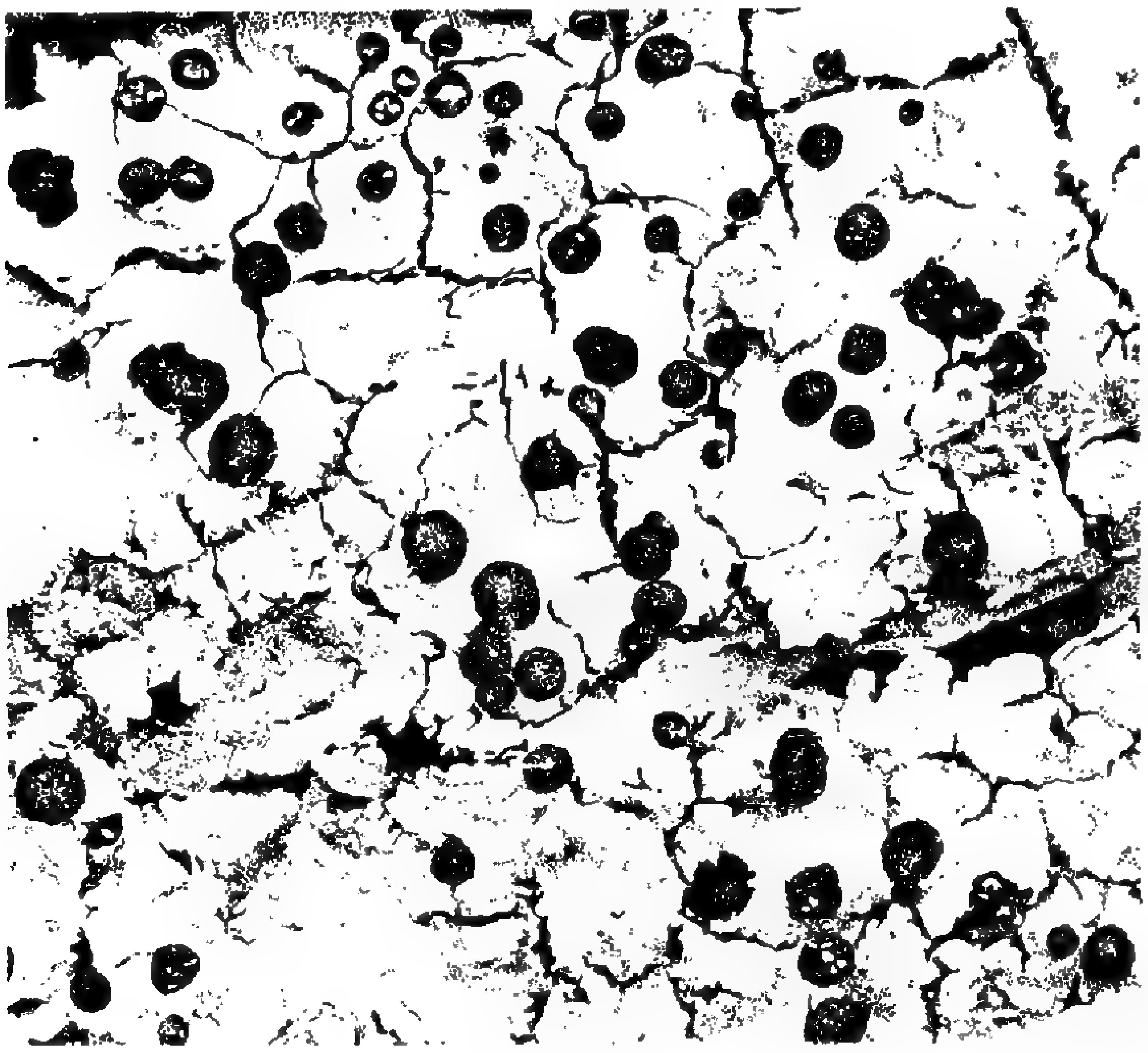


**Fig. 20.** *Bacidia spirospora* var. *patagonica* M. Lamb. Part of the type-specimen (× 4).

Thallus white or whitish, effuse, matt, very thin, not over 0.1 mm. in thickness, partly hypophloeodal, irregularly and grossly rimose from the cracking of the bark substratum, but really continuous, not areolate, smooth or indistinctly verruculose-rugulose, here and there with scanty, small, scattered soredial granules, but without distinct soralia. Faint traces of a blackish hypothallus visible here and there in the cracks. Thallus KHO– or indistinctly yellowish, $CaCl_2O_2$– , PD– . Medullary hyphae 2–3 μ thick, I– , with walls of moderate thickness. Symbiotic algae protococcoid, pale green, globose, 3–7 μ diam., thin-walled, cohering in clumps. Apothecia numerous, scattered, sessile, moderately to well constricted at base, round, 0.6–1.0 mm. diam., at first plane and thinly marginate, then slightly convex and immarginate. Proper margin sometimes lighter (brownish), moderate, entire, matt or subnitid. Disc matt, naked, smooth or minutely scabrid.

Excipulum entire below apothecium, 50–70 μ thick, in lower part colorless and hyaline, at sides faintly yellowish (or sometimes dark reddish in uppermost part adjoining the hymenium), clear and translucent, composed of parallel, thick-walled, gelatinized-concrescent hyphae, the lumina either fistulose, about 1 μ wide, or oblong, up to 3 μ wide. Hypothecium of two distinct equal parts: (*a*) a lower, colorless, hyaline half and (*b*) an upper, sordid yellow-brownish, faintly pigmented half; both parts composed of fine, ± thin-walled hyphae 2–3 μ thick compactly intertexted in various directions, or almost pseudoparenchymatic. Total depth of hypothecium 135–170 μ. Occasionally parts of the upper hypothecium are stained dark reddish in irregular patches. Hymenium 75–100 μ high, densely dark aeruginose or aeruginose-blackish above, otherwise ± colorless and hyaline. Paraphyses discrete, about 1.5 μ thick, somewhat sinuose, at the tips clavate-capitate up to 5 μ and there aeruginose-pigmented and ± conglutinated. Asci 50–85 μ long, clavate, thickened at apices. Spores ± straight or usually sigmoid or spirally curved, anguilliform, usually tapered at one end, (8– ) 12–15-septate, (47– ) 60–68 × 3.5 μ, packed 6–8 in ascus, at first straight and parallel, finally distinctly though loosely spirally wound.

Found growing on the trunk of *Colletia* at the edge of the *Nothofagus* forest by Lago Cisnes near Lago Menéndez.

Type in Herb. Mus. Nat. Canada, Ottawa.

### **Stereocaulon** (Enteropodium) **patagonicum** M. Lamb (n. sp.)

Pseudopodetia conferta, erecta, caespitosa, robusta, substrato arcte affixa, haud dorsiventralia, 2.5–7.0 cm. alta, 1–2 ( –3) mm. crassa, modice et irregulariter ramosa, teretia, decorticata, glabra aut tomento mediocri laevi vestita; phyllocladia lateralia, copiosa, albida aut glauco-cinerascentia, primum verrucosa, ad 0.3 ( –0.5) mm. lata, dein (praesertim in partibus inferioribus) squamulosa et crenata, usque 0.8 mm. lata, saepe imbricata. Cephalodia lateralia, verrucoso-globosa, 0.5–1.5 mm. lata, phyllo-

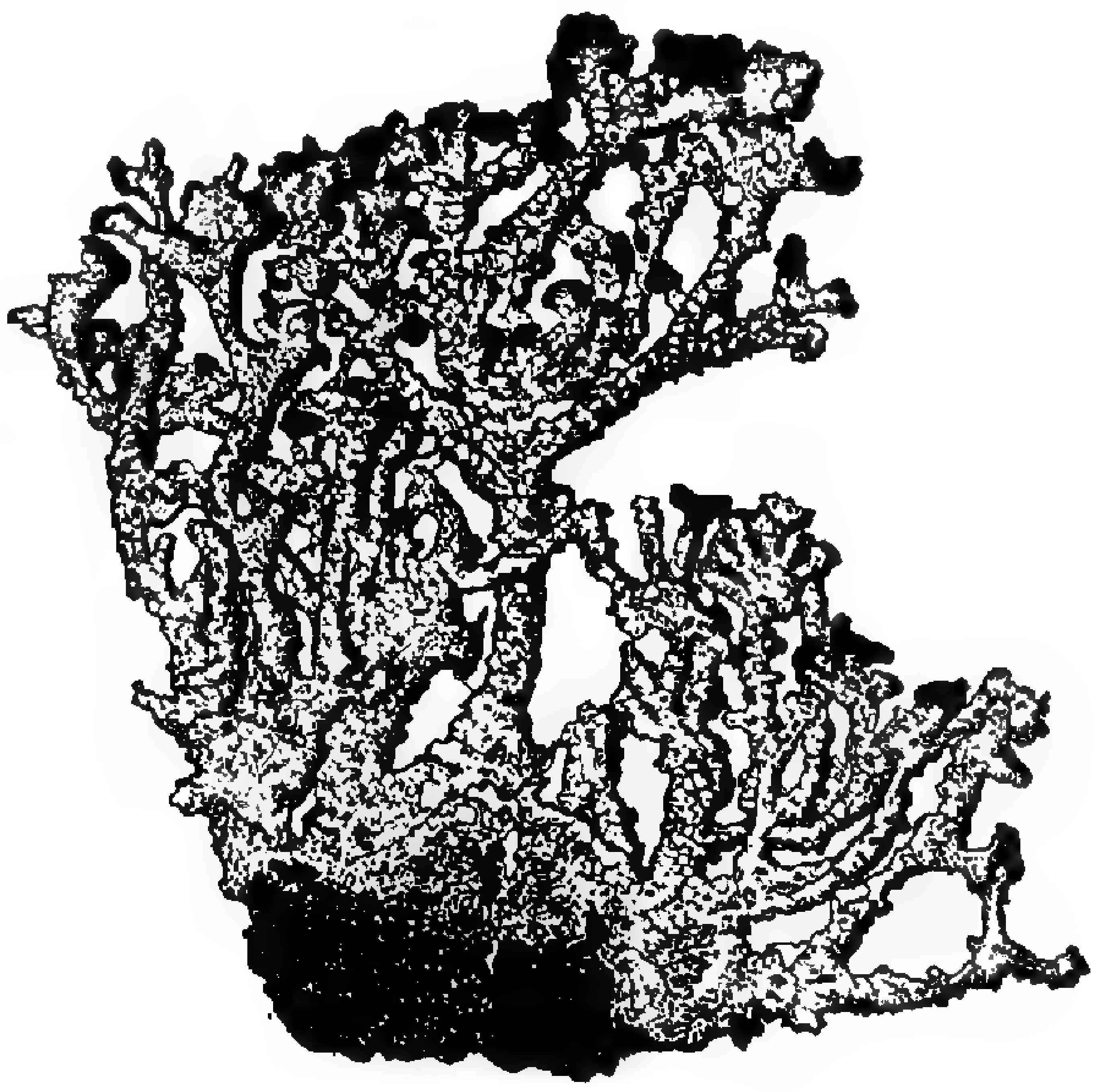


**Fig. 21.** *Stereocaulon patagonicum* M. Lamb. The type-specimen (× 1).

cladiis concoloria aut parum obscuriora (violascenti-cinerea), algam Nostochineam continentia. Apothecia copiosa, terminalia, 1.0–3.0 ( –3.5) mm. lata, obscure fusca aut fusconigricantia, e plano et tenuiter marginato mox convexo-immarginata, laevia, nuda. Stratum medullare apothecii (conus centralis) hyalinum, compactum, hyphis conglutinatis, saepe granulis opacis inspersum; hypothecium tenue, plus minusve sordide flavidulo-nubilatum vel fere hyalinum; hymenium 60–80 μ altum, purum, superne fuscescens. Sporae 8nae, cylindrico-fusiformes, rectae, 3 ( –4)-septatae, longit. 30–44 μ, crassit. 3.0–3.5 μ. — Phyllocladia plerumque PD + rubescentia (planta acidum sticticum gerente). — Affinis *Stereocaulo tomentoso* Fr., sed erectius, robustius, minus aut haud tomentosum, et apotheciis magnis et terminalibus. Quod phyllocladia attinet, nexum quodammodo inter typos *St. tomentosi* et *St. paschali* var. *alpini* ostendit, nam haec in partibus inferioribus pseudopodetiorum plane ut in *St. tomentoso*, in partibus superioribus autem magis ea *St. paschali* var. *alpini* in memoriam revocantia. — Ad terram sabulosam in Argentina, Patagonia, Chubut, lacus Menéndez: M. Lamb, 1950, no. 5790 (typus speciei), et multis aliis locis in Patagonia argentinensi et chilensi.

*Description of the type-specimen* (*M. Lamb no. 5790*): Pseudopodetia crowded, stipate-caespitose, rooted firmly at the base into the earthy substratum, 2.5–4.5 cm. high, (0.8– ) 1–2 mm. thick, slightly and irregularly branched, upright, rigid, not fragile, entirely decorticate, in places with a moderate smooth tomentum like that of *St. paschale*. Phyllocladia abundant and crowded in upper parts of pseudopodetia, often more abundant on one side, in lower parts often more scattered and showing the pseudopodetial surface in between; upper ones of the typical *alpinum*-type (at first simply verrucose, up to 0.2 mm. diam., then becoming lobate at the edges and convex-subsquamuliform, up to 0.3 or 0.5 mm. diam.), lower ones more divided, digitate-crenate or digitate-squamulose, rather similar to those of *St. tomentosum*. Cephalodia common, lateral on pseudopodetia, among the phyllocladia, forming globose-verrucose or verruculose masses 0.5–1.5 mm. diam., constricted at base, light-colored (± concolorous with the phyllocladia or slightly darker, purplish-cinerascent), often with minute darker spots on the surface; containing *Stigonema*. Phyllocladia KHO + yellow, PD + (slowly) sulphur-yellow deepening to orange-red. Apothecia abundant, terminal on ends of pseudopodetia, 2–4 mm. diam., dark brown or brown-blackish, at first plane with distinct, raised, concolorous proper margin, then soon slightly to strongly convex, with the margin excluded. Disc smooth, matt, not pruinose.

Excipulum poorly developed, almost obsolete, of radiating structure, colorless and ± hyaline, in places covered by a thin layer of pseudopodetial cortical tissue. Central cone cleft and ruptured, colorless, hyaline, compact, without inclusions, of gelatinized structure, appearing to be made up of leptodermatic hyphae about 3 μ thick loosely interwoven and embedded in transparent mucilage. Hypothecium 60–80 μ deep, not sharply differentiated from the central cone, slightly yellowish-gray-cloudy in section, not pigmented. Hymenium 60–70 μ high, brown above. Spores 3-septate, cylindrical-fusiform, straight, 35–48 × 3 μ.

Belongs to sect. *Eustereocaulon*, and is most closely related to *St. tomentosum* Fr., from which it differs in the robust, erect habitus and large terminal apothecia. The lower phyllocladia are unmistakably like those of *St. tomentosum*, but the upper ones are more convex-verrucose, like those of *St. paschale* var. *alpinum* (Laur.) Mudd. It was recognized as a distinct species from material seen in various herbaria, and this impression was confirmed by subsequent study of the populations in their natural habitat. Specimens have been seen to date from about 26 different localities in Argentine and Chilean Patagonia (Río Negro, Neuquén, Chubut, Santa Cruz, Chiloé, Aysén and Magallanes), and it would appear to be common between latitudes 40° and 55° S. It was recorded from the National Park of Nahuel Huapí in Río Negro by Räsänen in *An. Soc. Cient. Argent.*, Vol. CXXVIII, 136: 1939, under the erroneous identification of "*Stereocaulon myriocarpoides* Nyl." (specimen seen in Herb. Räsänen).

The type population especially studied in Chubut, W. end of Lago Menéndez, was on the sandy gravelly shore of the lake behind the beach, near the edge of the *Nothofagus* forest, where it occurred intermixed with a sward of *Stereocaulon paschale*.

Among the latter it grew in sporadic isolated tufts, which were very distinct by their larger stature and abundant apothecia. The pseudopodetia are always firmly rooted into the earthy substratum or onto small stones.

Type in Herb. Mus. Nat. Canada, Ottawa; isotype in Farlow Herb.

### F. **subirregulare** M. Lamb (n. f.)

Caespites deplanatos, compactos et crustosos formans, phyllocladiis valde congestis, verrucosis aut crenato-squamulosis. Pseudopodetia demum elongata, irregularia, parcius phyllocladiis tecta, partim denudata; apothecia terminalia, mox corymbose divisa.— Ad rupes et inter lapides in cacumine montis Rigi prope lacum Frias, altit. circ. 1750 m.: M. Lamb, 1950, nos. 5788, 5789 (typus).

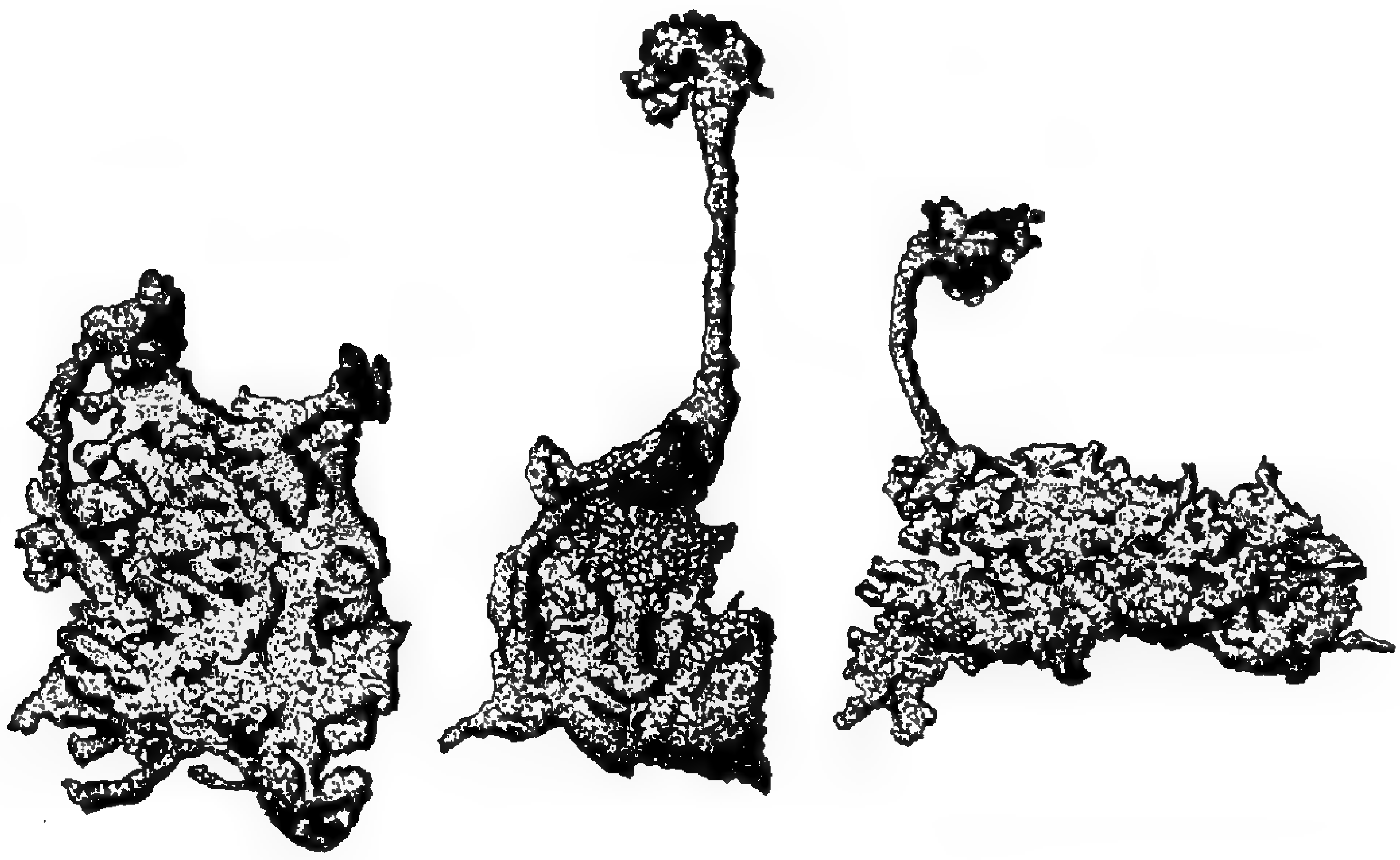


**Fig. 22.** *Stereocaulon patagonicum* f. *subirregulare* M. Lamb. The type-specimen (× 1).

*Description of the type-specimen* (*M. Lamb no. 5789*): Forming compact, flattened-pulvinate tufts, firmly attached to the rock or in clefts between stones, cinerascent whitish, with the phyllocladia very crowded and forming a crust. Tufts widely attached on underside, ± dorsiventral; phyllocladia mostly verrucose, about 0.25 mm. diam., in places larger, up to 0.8 ( –1.0) mm. diam. and flattened-crenate, like those of *St. paschale* var. *alpinum* (Laur.) Mudd; pseudopodetia finally irregularly elongated, 3.0–4.5 cm. long, partly denudated, partly covered with scattered or aggregated phyllocladia. Apothecia terminal on the pseudopodetia, 1–2 mm. diam., convex and immarginate from the first, soon dividing to form heads of numerous small secondary discs on corymbose stalks. Cephalodia fairly numerous on upper side of tufts among the phyllocladia, pulvinate, up to 3 mm. diam., dark cinereous, verruculose-tuberculate or ± botryose, containing *Stigonema*. Phyllocladia PD + (slowly) orange-red.

Central cone ruptured, compact, gelatinized, clear and hyaline but with some scattered inclusions of sordid yellowish depsidone-substance. Hypothecium 100–120 μ deep, isabelline-cloudy in upper half. Hymenium 65–78 μ high. Spores straight, 3–5-septate (the septa often indistinct), 34–50 × 3.5 μ.

Differing from the typical species in the more compacted and irregular habitus, which resembles that of *St. botryosum* f. *irregulare* H. Magn. From the latter it can be distinguished by the larger, ashy-whitish, finally crenate-squamulose phyllocladia.

The two specimens were found at the summit of the Cerro Rigi, above the tree limit, in a very exposed and windswept position probably with little or no protecting snow cover in winter.

Type in Herb. Mus. Nat. Canada, Ottawa; isotype in Farlow Herb.

### **Stereocaulon paschale** (L.) Hoffm., var. **alpinum** (Laur.) Mudd, f. **flabellans** M. Lamb (n. f.)

Pseudopodetia valde dorsiventralia, substrato arcte applanata, insigniter flabellatim expansa, phyllocladiis majusculis, deplanato-squamulosis, crenatis, congestis obtecta. —Terricola inter rupes et lapides in Argentina, Patagonia, Río Negro, in cacumine montis Rigi prope lacum Frias: M. Lamb, 1950, nos. 5786, 5787 (typus).

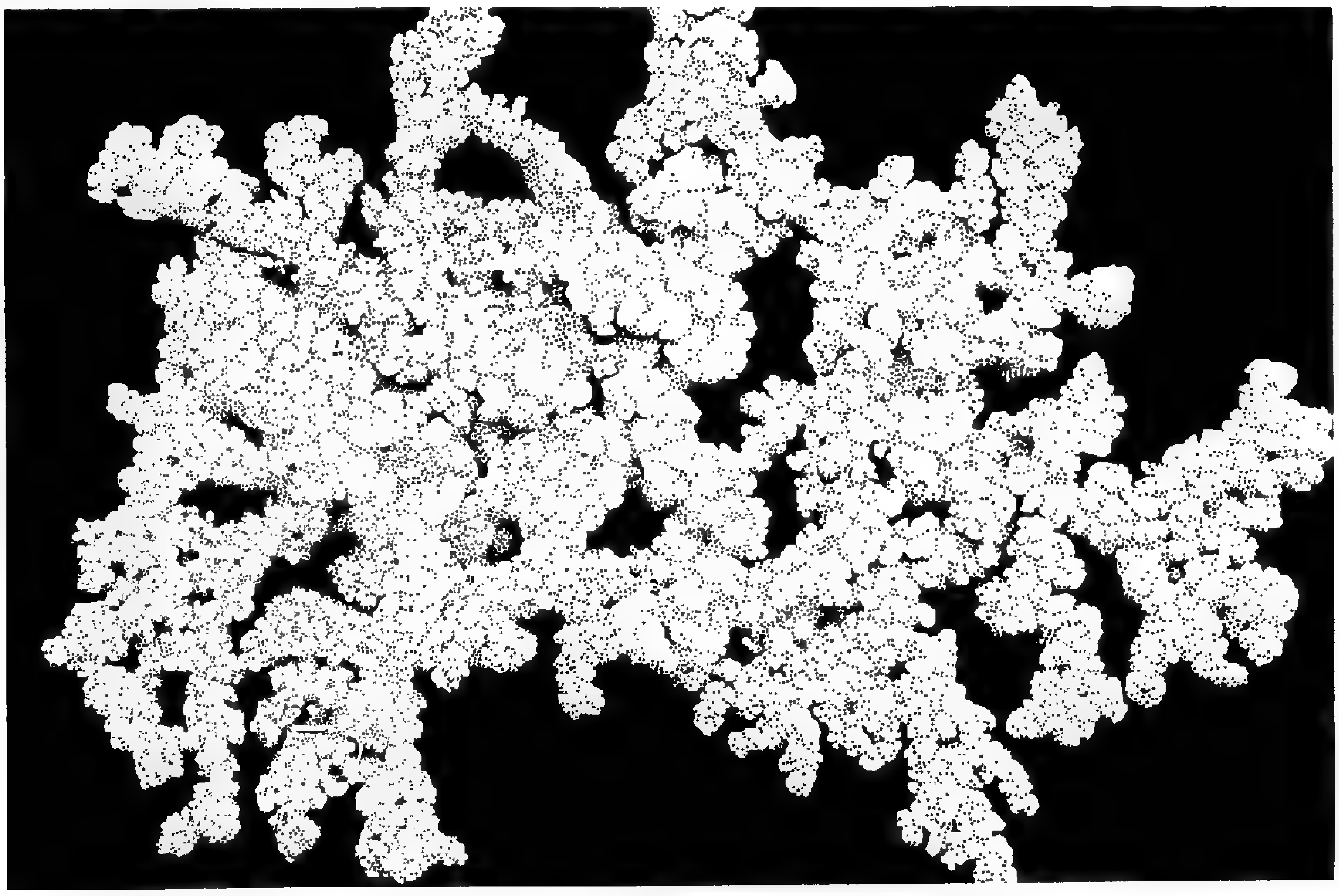


**Fig. 23.** *Stereocaulon paschale* var. *alpinum* f. *flabellans* M. Lamb. Part of the type-specimen (× 3).

*Description of the type-specimen* (*M. Lamb no. 5787*): forming small spreading tufts flattened and appressed to the ground, 2.5–4.0 cm. across, becoming ± confluent to cover large areas of ground; pseudopodetia copiously branched in a spreading fan-like fashion, the upper side entirely concealed by the phyllocladia; seen from the under side they are ± terete, 0.4–1.0 mm. thick, roseate-whitish to pallid ochraceous, glabrous or with a thin, subtle, concolorous tomentum. Phyllocladia very numerous on upper side, crowded, flattened-squamulose, 0.7–1.0 mm. diam., incised-crenate at the edges, white or whitish, often tending to fuse together. Cephalodia not abundant, on the under side, smooth, ± globose, sometimes aggregate-verrucose, 0.3–0.7 ( –0.9) mm. diam., light-colored (whitish or faintly dull roseate), containing *Nostoc*. Phyllocladia KHO + yellow, PD + (slowly) orange-red. (Sterile.)

On the summit plateau of the Cerro Rigi, at an altitude of about 1750 m., this form presented a very striking appearance on account of its decumbent, closely adpressed, flabellate-radiating habitus. The fan-like groups of pseudopodetia were congregated over fairly wide areas of ground, and were only loosely attached to the substratum. The patches were on open flat ground, in a position where probably considerable flooding of the ground takes place by snowmelt water in spring. Both collections gave the same orange-red reaction of the phyllocladia with Paraphenylenediamine, and are hence referable to the Stictic acid strain of the species.

Type in Herb. Mus. Nat. Canada, Ottawa; isotype in Farlow Herb.

**Stereocaulon** (Enteropodium) **speciosum** M. Lamb (n. sp.)

Pseudopodetia caespites usque 30 cm. latos formantia, erecta vel varie intricata, maxima, robusta, (5– ) 8–10 ( –13) cm. longa, 2.5–5.0 mm. crassa, simplicia vel parum ramosa, cylindrica, apicibus cornuto-acuminata; decorticata, superficie inter phyllocladia laevi aut nonnihil spongioso-fibrosa, phyllocladiis albidis circumcirca dense obtecta, partibus infimis emorientibus et fuscis, illic phyllocladiis destituta. Phyllocladia conferta, verrucosa, 0.2–0.5 ( –0.8) mm. lata, vulgo stipitata, saepius centro obscurius (olivacee- aut fusco-ochracee-) maculata. Cephalodia inter phyllocladia sessilia, irregulariter pulvinata, rufofusca aut fusconigricantia, 0.6–1.0 mm. lata, minute verruculosa, *Stigonemam* continentia. (Apothecia ignota.) — Phyllocladia (saltem apices pseudopodetiorum versus) PD + rubescens (planta acidum sticticum gerente). — Ad stirpem *Stereocauli vesuviani* pertinet, *St. cornuto* Müll. Arg. habitu cornuto-acuminato haud dissimile, sed multoties robustius, cephalodiis aliis, apotheciis destitutum (haec in *St. cornuto* vulgatissima). Aspectu portentoso, inter species spectabilissimas generis adnumerandum. — Ad terram sabulosam in Argentina, Patagonia, Chubut, lacus Menéndez: M. Lamb, 1950, nos. 6069 (typus speciei), 6071, et ibidem jam anno 1940 a cel. O. Kühnemann lectum; quoque in aliis locis Patagoniae argentinensis et chilensis obvium.

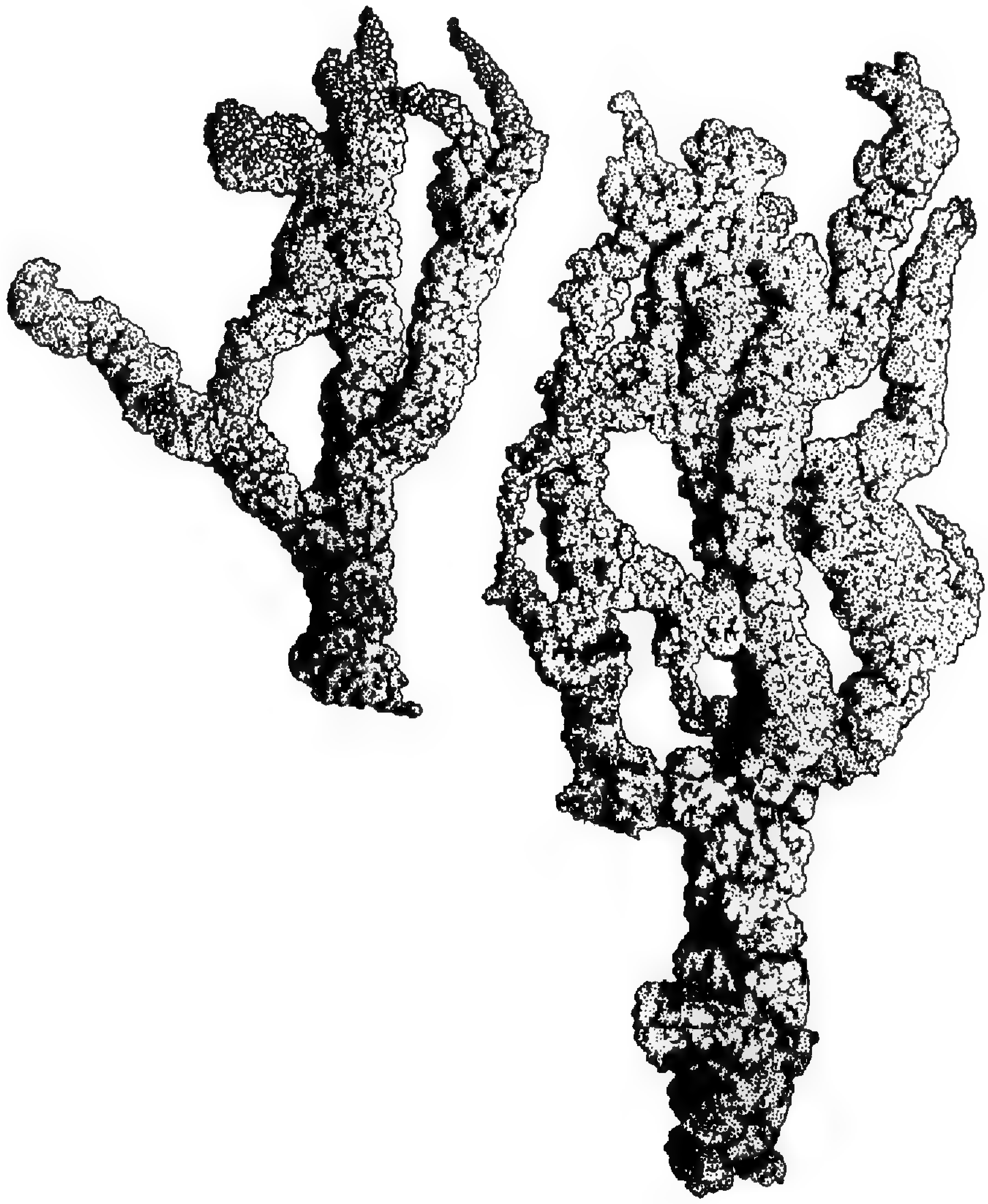


**Fig. 24.** *Stereocaulon speciosum* M. Lamb. Part of the type-specimen (× 1).

*Description of the type-specimen* (*M. Lamb no. 6069*): Forming caespitose clumps up to 30 cm. across of variously intricated or upright pseudopodetia which are gradually brown and emorient in lower parts: the living parts with a cover of whitish phyllocladia are 3–7 ( –9) cm. long, 2.5–5.0 mm. thick, simple or only sparingly branched, branching off from a common stem in the lower part, terete, cylindrical, cornute-acuminate towards the tips, ± thickly covered on all sides with crowded phyllocladia. Surface of pseudopodetia between phyllocladia decorticate, terete, pale ochraceous, with ± smooth to slightly spongy-fibrose surface, in places almost felted-tomentose. Phyllocladia crowded and contiguous, ± concealing the podetia, mostly distinctly stalked and usually in groups of 3–10 or more on simple or branched pedicels 0.5–2.0 mm. long; small, 0.2–0.3 (exceptionally up to 0.8) mm. diam., predominantly verrucose, always with distinct, olivaceous- or ochraceous-brown centers, which are minute and spot-like in the smaller phyllocladia, ± expanded in the few larger, ± flattened phyllocladia. Phyllocladia white to cream-colored, without any violascent tinge, smoothly corticate, matt or subnitid. Cephalodia common, ± conspicuous, sessile among the phyllocladia, dark red-brown to brown-blackish, matt or ± pellucid, verruculose or botryose, irregularly pulvinate, 0.6–1.0 mm. diam., containing *Stigonema*. Phyllocladia KHO + yellow, PD + (slowly) orange to orange-red. (Sterile).

In its habitus the new species, which belongs to sect. *Leucocheilon*, subsect. *Peltophyllum* M. Lamb (in *Canad. Journ. Bot.*, Vol. XXIX, 566–7: 1951), somewhat closely resembles the Jamaican *St. cornutum* Müll. Arg., having the same type of very tall pseudopodetia of markedly cornute growth. It differs from that species, however, in its much more robust and thick pseudopodetia, 2.5–5.0 mm. thick including the phyllocladial covering; in *St. cornutum* the thickness rarely exceeds 2 mm. The dark, verruculose-botryose cephalodia are also different from those of *St. cornutum*, in which they are aeruginose-cinereous and never distinctly botryose.

Field observation showed that this handsome species grows optimally on mossy gravelly soil in the open scrub formations on morainic hills, in Chubut at about 650 m. above sea level. In spite of careful search, no fruiting specimens could be found; this affords another contrast against *St. cornutum*, which is nearly always abundantly fertile. Other specimens seen were from Río Negro in Argentina and Aysén and Llanquihue in Chile.

Type in Herb. Mus. Nat. Canada, Ottawa; isotype in Farlow Herb.

### Var. **surreptans** M. Lamb (n. var.)

Pseudopodetia prostrata, substrato adpressa, haud vel vix affixa, laxe reptantia et intricata, subradiatim vel flabellatim ramosa, crassissima (3–7, rarius ad 10 mm. crassa).—Terricola in Argentina, Patagonia, Río Negro, in cacumine montis Rigi prope lacum Frias: M. Lamb, 1950, no. 6098; etiam e Valdivia et Ecuador visum.

*Exsicc.*: Lich. Austroamer. ex Herb. Regnell. no. 391 ("*Stereocaulon obesum* Th. Fr."), from Ecuador, Prov. León, Cotopaxi, coll. E. Asplund, 1939.

*Description of the type-specimen* (*M. Lamb no. 6098*): Pseudopodetia not or hardly attached to the substratum, lying prostrate, flattened to the ground, loosely spreading or entangled, copiously branched in an irregularly radiating or ± flabellate fashion. Pseudopodetia 3–7 ( –10) mm. thick (including the phyllocladial covering), the upper side closely covered with crowded phyllocladia, towards center of underside without phyllocladia and covered with adherent earth. Tips of pseudopodetia cornute-attenuated. Phyllocladia crowded, covering and concealing the pseudopodetia, verrucose, 0.4–0.9 mm. diam., often ± confluent; whitish or cinereous, matt, often without distinct darker centers; the latter, when present, minute, spot-like, olivaceous-glaucescent. Cephalodia numerous, present chiefly on upper side among the phyllocladia, forming irregular, pulvinate-confluent, brown-blackish masses with obsoletely verruculose surface; containing *Stigonema*. Phyllocladia PD + (slowly) orange to orange-red. (Sterile.)

Found on flat soil beds in slight hollows between rocks and stones in exposed positions on the summit plateau of the Cerro Rigi, apparently sites which are long covered by snow in winter and undoubtedly strongly inundated by snowmelt water in springtime. The scattered or confluent, loosely spreading pseudopodetial mats cover areas up to 2 square meters in extent, and lie prostrate and almost unattached. The specimen from Ecuador distributed in Lich. Austroamer. ex Herb. Regnell. no. 391 is composed of much smaller tufts, but the habitus is the same and the pseudopodetia are quite as thick as in the type material. The Chilean specimens seen (also sterile) are from the Volcán Villarica, coll. Claude Joseph, 1931, and A. Pfister, 1935.

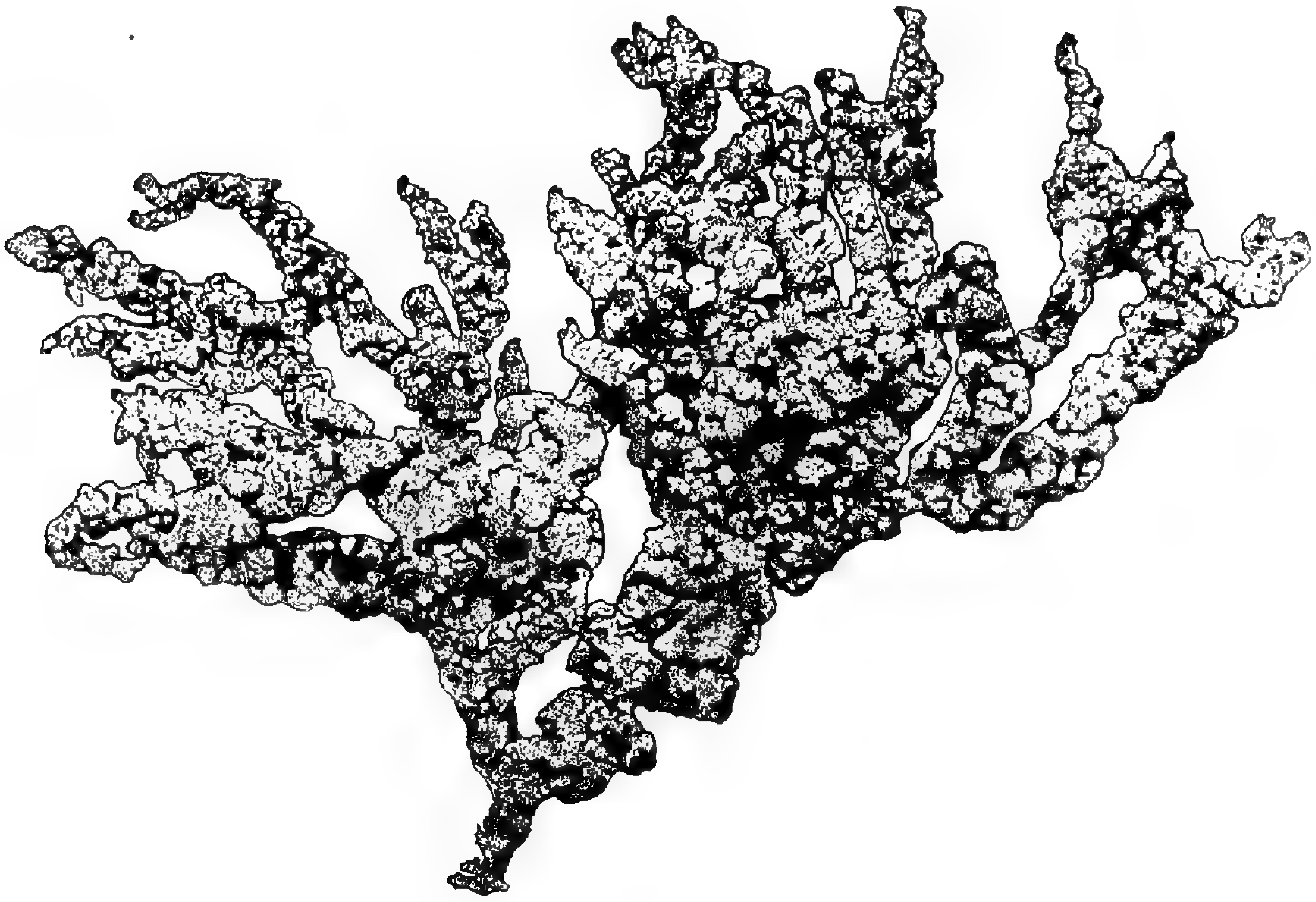


**Fig. 25.** *Stereocaulon speciosum* var. *surreptans* M. Lamb. Part of the type-specimen (× 1).

Type in Herb. Mus. Nat. Canada, Ottawa; isotype in Farlow Herb.

### **Stereocaulon argus** Hook. f. & Tayl. emend Th. Fr., var. **stenospermum** M. Lamb (n. var.)

Sicut species typica, at hypothecio sat hyalino et fere pellucido (ut in *St. implexo*), nec nubilato, et sporis angustioribus, longit. 37–60 μ, crassit. (3.5– ) 4–5 μ (in specie typica sunt crassiores, 5–7 μ). — Saxicola in Argentina, Patagonia, Río Negro, prope amnem glacialem Frias: M. Lamb, 1950, nos. 6088 (typus), 6092, et in Chubut, lacus Menéndez: M. Lamb, 1950, no. 6077.

*Description of the type-specimen* (*M. Lamb no. 6088*): Pseudopodetia forming caespitose tufts, upright, firmly attached to the substratum, moderately branched from near the base and upwards, rigid, the basal portions somewhat woody; 5.0–7.5 cm. high, 1.5–2.5 ( –3.0) mm. thick, thinner at the base, which is decorticate; other parts corticate with a continuous or fissured, smooth to wrinkled-scrobiculate cortex, cinereous-whitish or cinereous-glaucescent, glabrous. Phyllocladial branchlets not abundant, mostly developed towards the base, scanty or absent in upper parts of pseudopodetia, coralloid, cylindrical, 0.25–0.40 ( –0.50) mm. thick, the lower ones irregularly branched, up to 8 mm. long, the upper ones becoming shorter and simple and finally passing into papillate excrescences of the cortex; concolorous with the pseudopodetia, not lighter at tips, their cortex smooth or transversely cracked. The lower phyllocladial branchlets are harmonic, not distinguishable from fine pseudopodetial side-branches. Cephalodia moderately numerous, lateral on pseudopodetia, usually slightly stalked, sacculate, moderately to strongly scrobiculate-indented or cerebriform, irregular in shape, 1.5–2.0 ( –3.5) mm. diam., gray to glaucous-cinereous or brownish-gray, internally loose and arachnoid, bounded by a palisade-cortex 28–35 μ thick, containing *Stigonema*-filaments. Apothecia terminal, abundant, 1.5–3.0 ( –4.0) mm. diam., soon convex, at first with a ± reflexed, paler (pale brownish) proper margin which is foveolate-scrobiculate on the underside, finally ± excluded. Larger apothecia becoming furrowed and finally separating into several imperfectly divided pulvinate portions. Disc dark brown or brown-blackish, ± matt, naked, smooth. Phyllocladial branchlets KHO + yellow, PD + (slowly) sulphur-yellow (not turning red).

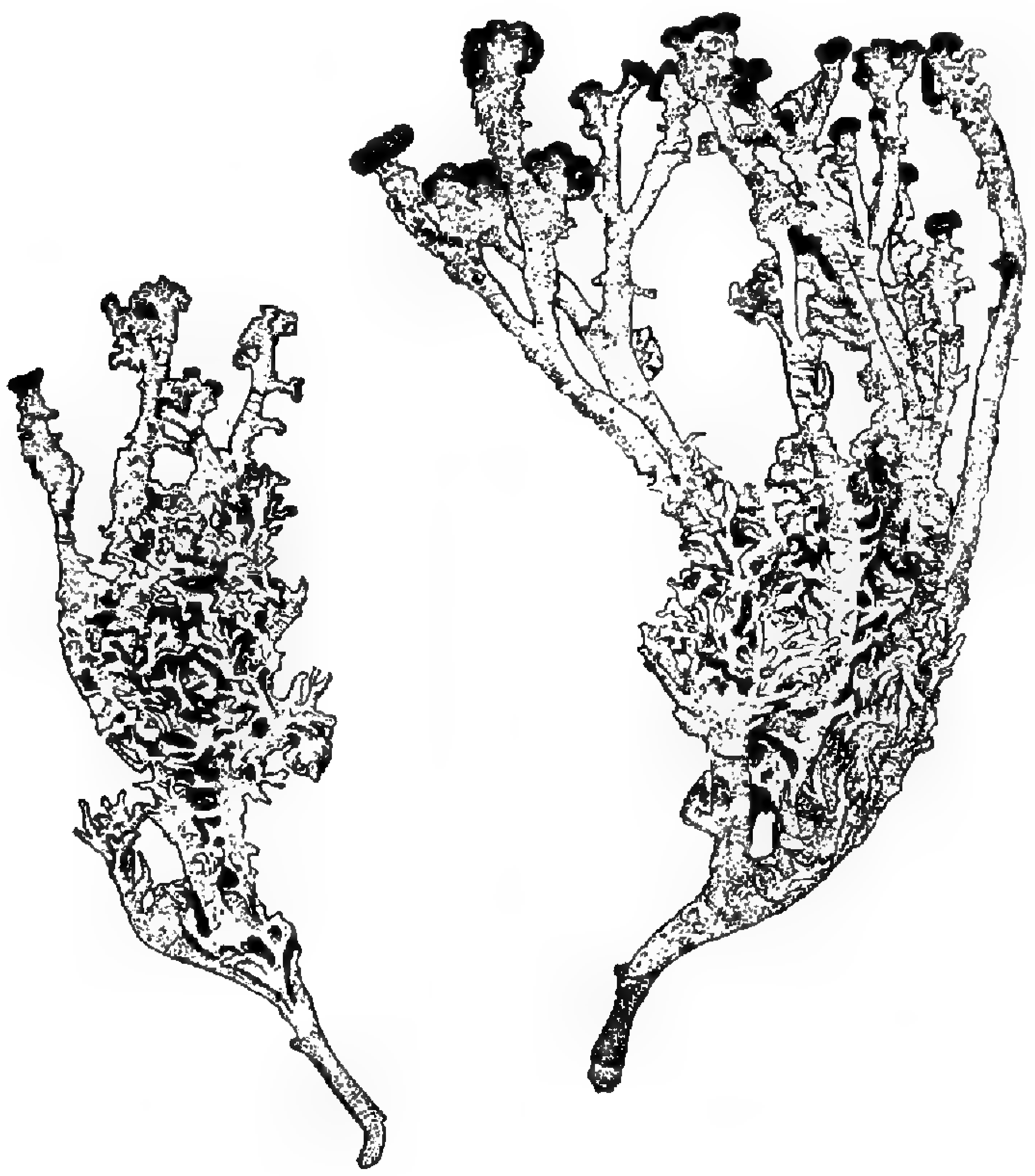


**Fig. 26.** *Stereocaulon argus* var. *stenospermum* M. Lamb. The type-specimen (× 1).

Excipulum reflexed and corrugated, continuous to the pseudopodetium below, 65–100 μ thick, colorless and hyaline in outer part, brownish-gray-nubilated and opaque within; composed of parallel, conglutinated, thick-walled hyphae. Central cone up to 340 μ deep, lax in texture, heavily inspersed with sordid brownish-gray granules and ± opaque in section. Hypothecium 100–135 μ deep, ± sharply limited from central cone, faintly sordid yellowish or ± colorless in section, ± clear and transparent, without granules or inclusions, compact. Hymenium 100–120 μ high, brown in upper 10–13 μ, otherwise ± colorless and hyaline. Paraphyses discrete, 1.5–2.0 μ thick, capitate to 5 μ at the brown tips. Spores seen 4–6 in ascus, not spirally wound; straight or slightly bent, cylindric-fusiform, 3–7 ( –8)-septate, 37–60 × (3.5– ) 4–5 μ, sometimes breaking up into 1–2-septate pieces with rounded ends.

Pycnidia numerous at ends of some of the pseudopodetia, forming botryose clusters of gray or pale brownish verruculae 0.15–0.30 mm. diam. Conidia filiform, arcuate or rarely almost straight, 10–14 μ long, about 0.5 μ thick.

In the type material of *St. argus* from Campbell Island the hypothecium is nubilated and opaque right up to the base of the hymenium, and the spores are (4– ) 5–6 ( –7) μ broad. In other respects the Patagonian variety shows close agreement with it.

The variety has been seen in three localities in Argentine Patagonia, two in Río Negro and one in Chubut, and had also been previously collected from two localities in Río Negro by V. Kull in 1938, as an admixture with other species. It grows firmly attached to rocks in open positions, usually associated with *St. implexum* Th. Fr., but scarce, never forming widespread associations like the latter.

Type in Herb. Mus. Nat. Canada, Ottawa; isotype in Farlow Herb.

### **Stereocaulon corticatulum** Nyl., var. **procerum** M. Lamb (n. var.)

Pseudopodetia altiora quam in specie typica, usque 4 ( –5) cm., laxe caespitosa, apicibus et hinc inde lateribus semper effuse sorediata, pro maxima parte decorticata (cortice tantum passim squamulose evoluto, praesertim in ramulis tenuioribus). — Saxicola in Argentina, Patagonia, Río Negro, prope lacum Frias: M. Lamb, 1950, no. 6086.

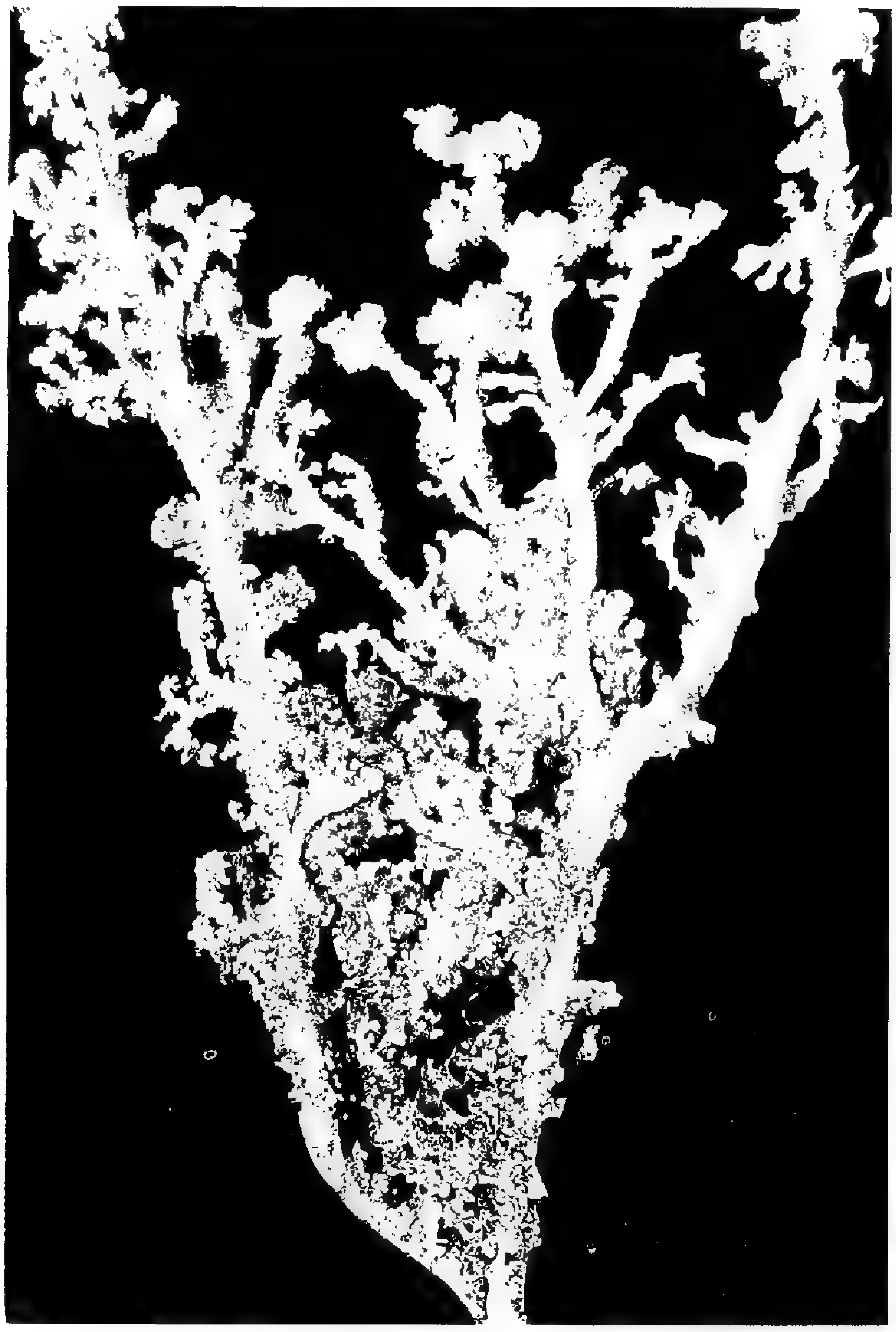


**Fig. 27.** *Stereocaulon corticatulum* var. *procerum* M. Lamb. The type-specimen (× 3).

Pseudopodetia loosely caespitose, upright, firmly attached to the rock, (1.5– ) 2–4 ( –5) cm. high, 0.7–1.0 ( –1.3) mm. thick, irregularly branched from near the base and upwards, almost entirely decorticate, the cortex persisting only in a few places as isolated patches or squamules, chiefly on the finer branches; smooth, ± rigid, subochraceous-whitish or whitish with a faint roseate tinge, glabrous. Soredia effuse, not capitate, mostly terminal on the pseudopodetia and branches, a few also scattered lower down on the sides; minutely granulose, white or glaucous-whitish. The phyllocladial branchlets are indistinct as such, being irregular and harmonic. Cephalodia fairly numerous, laterally sessile on pseudopodetia or terminal on short side-branchlets, whitish to glaucescent, in young stages subglobose with smooth, unicolorous or slightly variegated surface, then becoming larger, up to 1.5 ( –2.0) mm. diam., and distinctly foveolate-indented, almost as in *St. ramulosum* (Sw.) Räusch., occasionally perforated or cracked to reveal the dark reddish algae (apparently *Gloeocapsa*) in the interior. Internal hyphal tissue loose and arachnoid; outer cortex either pseudoparenchymatic and ± nubilated, partly clear and composed of gelatinized, parallel palisade-hyphae. Soredia and corticate parts KHO + yellow, PD + (slowly) sulphur-yellow (not turning red). Apothecia rare, terminal, 0.8–2.0 ( –2.3) mm. diam., pulvinate-convex and immarginate at maturity, brown-blackish, matt, not pruinose.

Excipulum well developed at sides and below, 50–90 μ thick, colorless or faintly sordid yellowish, clear, composed of parallel, conglutinated, thick-walled hyphae. Central cone up to 400 μ deep in center, mostly loose in texture and clear to slightly inspersed, in upper 50–70 μ more compact and more densely sordid yellowish-gray-inspersed. Hypothecium sharply limited from upper central cone, 35–47 μ deep, colorless and hyaline. Hymenium 65–75 μ high, brown in upper 9–14 μ, otherwise colorless and hyaline. Paraphyses discrete, 1.0–1.5 μ thick, capitate to 3.0–3.5 μ at the brown tips. Spores few in ascus, about 4, straight, cylindric-fusiform, 3-septate, 40–60 × 3.0–3.5 μ.

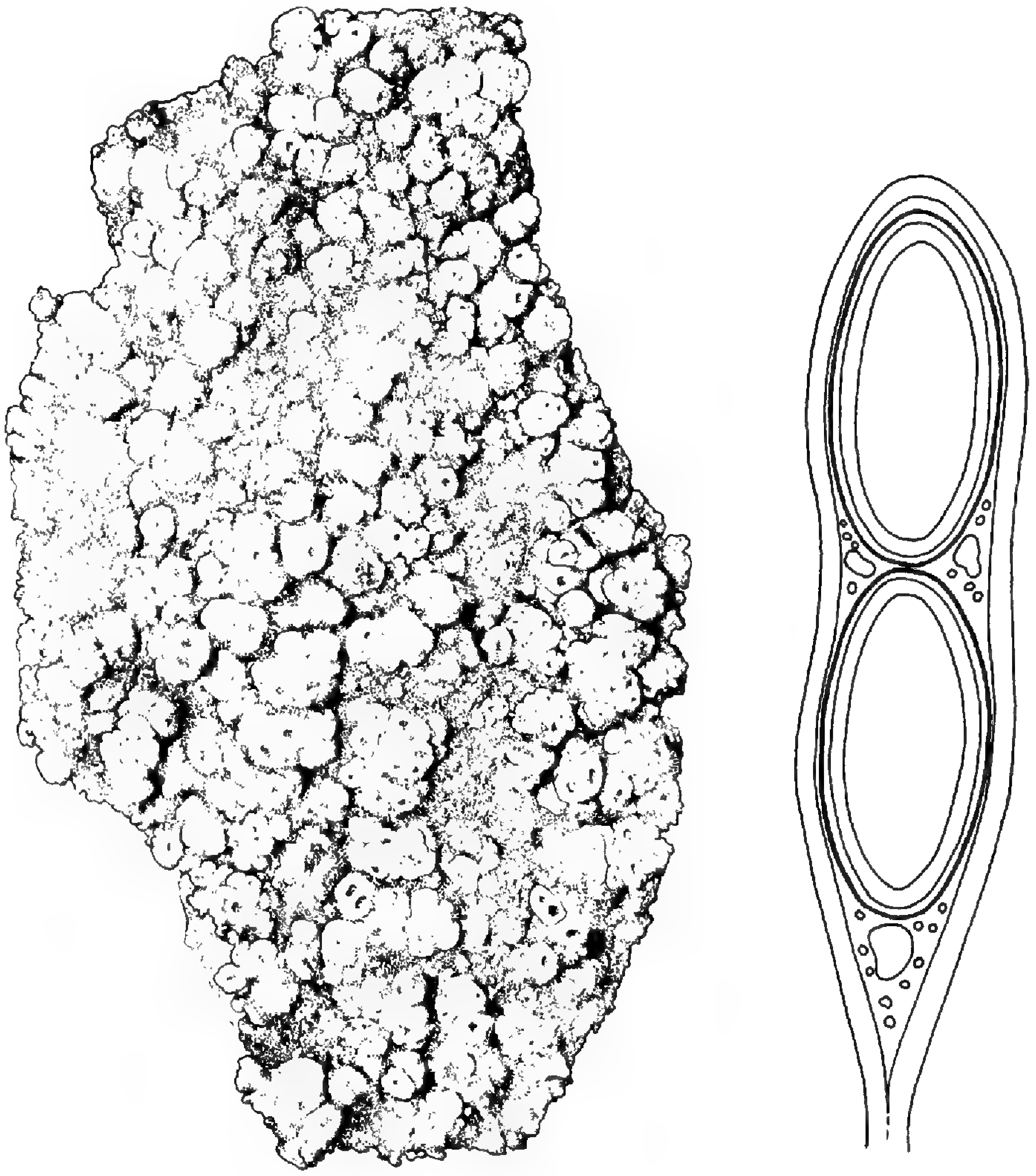
*Stereocaulon corticatulum* was originally described from New Zealand, and has not been recorded in the literature from outside that country. It is, however, apparently not uncommon also in the southern parts of South America, and was found by the present writer in a number of localities along the shores of the lakes of Río Negro and Chubut. *Stereocaulon subcorticatum* Räs. in *Ann. Bot. Vanamo*, Vol. II, no. 1, 24: 1932, from western Fuegia, is conspecific with *St. corticatulum*, and should be called *St. corticatulum* var. *subcorticatum* (Räs.) M. Lamb (in *Canad. Journ. Bot.*, Vol. XXIX, 581: 1951). Other synonyms for the typical species are *Stereocaulon leptaleum* Nyl., *St. corticatulum* subsp. *detergens* Nyl., and *Stereocaulon humile* Müll. Arg., the latter perhaps to be segregated as a distinct variety, but requiring further study. *St. corticatulum* is one of the more primitive members of the subgenus *Holostelidium* (sect. *Sacculata*, subsect. *Aciculisporae,* cfr. M. Lamb, *op. cit.*, p. 565). The var. *procerum* here described is distinguished by its taller pseudopodetia which are loosely caespitose and constantly effusely servediate at the apices and on the sides.

The type material was found growing on rock faces beside a stream in open *Nothofagus* forest, associated with *St. implexum* Th. Fr., along the trail between Lago Frias and the Frias Glacier in Río Negro.

Type in Herb. Mus. Nat. Canada, Ottawa; isotype in Farlow Herb.

### **Pertusaria** (Eupertusaria) **victoriana** M. Lamb (n. sp.)

Thallus effusus, linea nigricante nulla ut videtur limitatus, fere omnino e verrucis fertilibus constans, albidocinereus (apicibus verrucarum interdum pauxillisper ochraceo-tinctis), opacus; isidia et soredia desunt. Verrucae fertiles confertae, subglobosae, 0.8–1.3 mm. latae, passim 2–3 confluentes et dein 1.5–2.0 mm. latae; 1–2-carpicae, basi modice aut bene constrictae, haud pulverulentae; disculis sat profunde impressis, haud annulatis, nigrescentibus, nudatis aut interdum pruina alba superfusis, rotundatis, primo punctiformibus, dein leviter apertis et 0.2–0.3 mm. latis. Epithecium sordide inspersum, hymenium circ. 450 μ altum, paraphyses tenues, filiformes, ramoso-connexae et intricatae. Sporae binae, incolores, ellipsoideae aut ellipsoideo-oblongae, 90–140 × 56–70 ( –75) $\mu$, pariete duplici praeditae, membrana externa amorpha aut subtiliter granuloso-porosa, interna hyalina, laevigata, haud striolata nec costulata. — Thallus extus KHO – aut maculatim rubescens, PD + leviter lutescens, intus KHO + lutescens deinque mox sanguineo-rubescens (crystallis acicularibus praecipitatis), PD + bene et persistenter flavescens; $CaCl_2O_2$ et Iodo haud reagens. Epithecium KHO + subviolascens. — *P. albidopallenti* Nyl., e Fuegia descriptae, forsan maxime affinis. — Saxicola prope lacus litora in Argentina, Patagonia, Río Negro, insula Victoria in lacu Nahuel Huapí: M. Lamb, 1950, no. 5817.



**Figs. 28 & 29.** *Pertusaria victoriana* M. Lamb. The type-specimen (× 3). An ascus with spores (× 230).

Thallus effuse (no peripheral dark line seen), consisting almost entirely of crowded fertile verrucae; the few sterile areolae present between the fertile verrucae tumid and convex, about 0.4 mm. diam. No distinct hypothallus developed. Color whitish-gray, without any yellowish tinge, but the tops of the fertile verrucae sometimes with a faint ochraceous tinge; not shining. No isidia or soredia. Fertile verrucae crowded and often several confluent, irregularly subglobose, 0.8–1.3 mm. diam. (confluent groups of 2–3 are 1.5–2.0 mm. diam.), moderately to well constricted at base, not pulverulent, 1–2-carpic. Discs ± impressed, blackish, naked or occasionally whitish-pruinose, round, at first punctiform, then widening to 0.2–0.3 mm., not surrounded by any annulus. Thallus and verrucae externally KHO– or red in spots, PD + faint yellow; internally KHO + yellow then blood-red (with formation of acicular crystals under the microscope), PD + persistent yellow. $CaCl_2O_2$– , I– , both externally and internally. Symbiotic algae protococcoid, bright or yellowish green, globose, separate, thin-walled, 10–20 μ diam.

Margin of fertile verrucae with abundant algae. Excipular tissue around apothecia 15–60 μ thick at sides, up to 75 μ thick at apex, not pigmented, but ± grayish-nubilated, especially around the ostiole. Hypothecium blackish in section from included air (like the whole of the rest of the thallus). Hymenium subglobose or ± flat and dilated, about 450 μ high, in uppermost 30–50 μ with an irregular, dark gray-nubilated but not or hardly pigmented epithecium (KHO + sordid violet). Paraphyses 1.0–1.5 μ thick, entangled, copiously branched and often anastomosing. Asci clavate, 320–390 × 65–78 μ, with colorless, non-striated wall 5–6 μ thick at sides and up to 10 μ thick in lower part. Spores 2 per ascus, placed end to end, colorless, ellipsoid or oblong-ellipsoid, 90–140 × 56–70 ( –75) μ; wall distinctly double; outer wall 3–5 μ thick, of the same thickness all round, sometimes smooth and structureless, more often minutely granulose-porose (this more distinct in KHO), occasionally indistinctly longitudinally striated; inner wall 3–8 μ thick, sometimes thicker at ends, hyaline, not striated or costulate, smooth on inner side. The boundary between inner and outer walls appears as a highly refractive line. Spore-contents sometimes faintly longitudinally striated. Asci persistently dark blue with Iodine.

From the literature, this species seemed to be closely related to *P. albidopallens* Nyl. (from Fuegia), *P. alterimosa* Darb. (from the Falkland Islands), and *P. subverrucosa* Nyl. (from New Zealand). The type material of these species was therefore obtained and examined. *P. alterimosa* (see revision below), although resembling our species in many respects, is a *Lecanorastrum*, with more irregular, finally lecanorine fertile verrucae and brownish discs up to 0.8 mm. in diameter. Its spores also differ in having a single wall only. *P. albidopallens* (see revision below) has a thinner, verrucose-areolate or rugose-areolate thallus with a distinct pale reddish tinge, less crowded, more flattened, ± lecanorine fertile verrucae with larger, white-farinose discs, and its spores (according to another authentic specimen in Herb. Nylander) have a simple wall. *P. subverrucosa*, as far as can be seen from the minute type fragment in Herb. Nylander (no. 22954), coll. Colenso, no. 4694, stuck down so that the substratum cannot be seen, differs from *P. victoriana* in the thick, smooth, ± continuous or slightly rimose thallus and the absence of distinctly delimited fertile verrucae; the black, naked, impressed-punctiform discs (up to 0.5 mm. diam., including the blackened margin) are immersed in the thallus, not forming distinct separate fertile verrucae. According to Nylander, the specimen probably grew on rock; Zahlbruckner in *Cat. Lich. Univ.* gives it as a corticolous species. Nylander described the thallus as nodulose-crenate at the periphery, but this is not distinctly seen in the type fragment. No microscopic examination was made on account of the scantiness of the material. Of other species known to the writer only from the literature, *P. knightiana* Müll. Arg. (from New Zealand) differs in the ± smooth and rimose thallus and the larger spores with thicker, reticulate-costate wall, and *P. zahlbruckneri* H. Magn. (from Hawaii) is distinguished by the annulate margin of the apothecial discs and the longer spores with transversely rugulose inner wall. *P. victoriana* belongs to subgen. *Eupertusaria*, sect. *Rubescentes* Erichs. (in *Rabh. Krypt.-Fl.*, Vol. IX, Abt. 5, Teil 1, 341: 1935).

Type in Herb. Mus. Nat. Canada, Ottawa; isotypes in Farlow Herb. and Herb. Inst. Bot. Darwinion, San Isidro, Buenos Aires.

### **Pertusaria albidopallens** Nyl.

*Lich. Fueg. et Patagon.*, 22: 1888.

The following is an external description of the type-specimen of *P. albidopallens* Nyl. from Cape Horn, coll. Hariot, 1885 (no. 23817 in Herb. Nyl.): small fragment, about 9 × 6 mm., on chips of rock. Periphery of thallus not present. Thallus of moderate thickness (0.2–0.5 mm.), verrucose-areolate or rugose-areolate, the areolae ± distinct, tumid and convex, of irregular shape, 0.3–0.6 mm. diam., more or less completely separated by narrow or partly closed-up cracks. No dark hypothallus developed. Thallus cream-colored or isabelline with a distinct pale reddish tinge, matt, the surface of the areolae smooth. No isidia or soredia. Medulla macroscopically white, dense. Thallus-fragments crushed out under microscope KHO + yellow mist then forming abundant red spicular crystals. Fertile verrucae numerous, scattered or sometimes 2–3 contiguous, ± lecanoroid, sessile on the thallus and usually distinctly constricted at the base, round or slightly irregular in outline, 0.8–1.2 mm. diam., flattened-subglobose or convex-discoid, flattened at the apex and there ± widely white-farinose with expanded flat disc up to 0.6 mm. diam., which is either entirely white-farinose or sometimes with the blackish epithecium ± visible beneath the pruina. Thalline margin thickish, non-prominent, ± entire, concolorous with the rest of the thallus. The specimen was too scanty to permit any apothecia to be taken for sectioning. Another specimen in Herb. Nylander referred, obviously correctly, to *P. albidopallens* (no. 23818), from Cape Horn, "ex hb. Hook. (nomine 'globulifera')," is somewhat larger and better developed. In habitus it is quite similar to the Hariot type-fragment; the fertile verrucae up to 1.7 mm. diam. Thallus under microscope KHO + yellow mist then red crystals. Spores seen in crushed preparation only outside ascus, colorless, about 165 × 72 μ, with colorless, single, smooth, not striate or costate wall 4–7 μ thick.

The species should perhaps be referred to the subgen. *Lecanorastrum.*

## **Pertusaria alterimosa** Darb.

in *Wiss. Ergebn. Schwed. Südpolar-Exped. 1901–1903,* Vol. IV, Lief. 11, 7, Pl. 1, fig. 11: 1912.

The following is a revision of the type-specimen from the Falkland Islands, Port Louis, coll. C. Skottsberg, 1902 (no. 25) in Herb. Naturhist. Riksmus. Stockholm:

On metamorphic rock, associated with a *Lecidea*-sp. Thallus effuse, indeterminate or bounded by other crustaceous lichens, forming a patch 4 cm. across; cream-colored with a slightly ochraceous tinge, matt, uneven, of very variable thickness (0.3–1.5 mm.), the thinner parts reticulate-rimose or rimose-areolate with plane or slightly tumid, irregular, indistinctly delimited areolae 0.3–0.5 mm. diam.; the thicker parts coarsely rimose-areolate or glebose with irregularly rounded or angulose, almost columnar areolae 1–2 mm. diam. separated by deep and wide cracks, ± flat or verrucose-rugose on their upper surface, with vertical sides (not constricted at base), most of them fertile with 1 or 2 apothecia. No isidia or soredia. Medulla white and dense macroscopically; no trace of any basal dark hypothallus. A black line is developed at the junction with the neighboring lichen (a *Lecidea*), but appears to be produced by the latter. Thallus externally and internally KHO + yellow then soon blood-red, with red spicular crystals under the microscope, PD + persistent intense yellow, $CaCl_2O_2$– , I– . Apothecia ± lecanorine, the disc at first deeply sunken and of ± thelotremoid appearance, then soon expanding and from sunken becoming finally level with the surface of the verruca; at maturity 0.3–0.8 mm. diam., sordid brownish, matt, naked or with a sparse white granulate pruina (possibly mould!), concave to plane, sometimes 2 confluent; the thalline margin surrounding them irregular, finally becoming thin and often ± lacerated, not distinctly crenulate.

Apothecia bounded at the sides by a thin but ± distinct proper margin 20–30 μ thick consisting of tangential, parallel, conglutinated hyphae 1.0–1.5 μ thick; ± sordid yellowish-cloudy in section. On the outside of the proper margin is a thickish or thin thalline margin consisting of heavily sordid yellowish-nubilated tissue of indistinct structure, containing abundant to scanty, pale green protococcoid algae 6–9 μ diam. Hypothecium bowl-shaped or lentiform, thinning out at the sides, 150–170 μ deep in center, heavily yellowish-gray-nubilated and opaque in section. Hymenium 350–375 μ high, clear and colorless or isabelline-cloudy, with an irregular, sordid-yellowish, granulose epithecium in its uppermost 20–35 p. Paraphyses distinct, 1.0–1.3 μ thick, branched and anastomosing. Asci clavate, 350–375 μ long, about 75 μ broad, with hyaline, non-stratified wall 8–15 μ thick, mostly 2-spored, a few 1-spored. Spores lying one above the other, ellipsoid or oblong-ellipsoid, colorless, 100–130 × 55–60 μ (or up to 180 × 85 μ when single in ascus), with grumose-guttulate protoplasm and hyaline, non-striated wall 3–5 μ thick smooth on both inner and outer sides. Asci blue then dark aeruginose with Iodine.

The specimen is not in very good condition; some of the fertile verrucae are hollow, having lost their hymenia. It is distinctly a *Lecanorastrum*. The younger fertile verrucae with deeply sunk hymenium call to mind the appearance of *Thelotrema* or *Lecidea* (*Biatora*) *coarctata*, although no distinctly separate proper margin is visible. Darbishire's photograph of the specimen is very good, but his description is misleading in several respects. "Thallus ad 2 mm latus" must refer to the diameter of the fertile areolae; the whole thallus is 4 cm. across. There is no yellowish tinge in its color. The fertile verrucae hardly exceed 2 mm. in diameter, and the discs now present are not over 0.8 mm. in diameter; they are sordid brownish, not at all concolorous with the thallus. No 3-spored asci were seen by the present author.

### **Usnea** (Euusnea) **kuehnemannii** J. Mot. (n. sp.)

Thallus 11–20 cm. longus, pendulus, tenuis, modice ramosus, sat elasticus, obscure stramineus aut fusco-flavescens, opacus vel parum nitidus; rami primarii 0.5–0.8 mm. crassi, partim laeviuscule teretes, partim foveolato-scrobiculati et rugis angulosis ornati; rami terminales laeves, teretes, tenuiter capillacei. Soredia in ramis tenuioribus haud rara, minuta, farinosa, sparsa aut passim confluentia, haud prominula, flavido-albicantia. Medulla sat crebra, alba; axis chondroideus circ. ⅓ diametri ramorum occupans. Apothecia numerosa, ramis lateraliter insidentia, sessilia, minuta, 0.5–1.0 ( –1.3) mm. lata, concava vel fere plana, margine thallino prominulo, tenui, integro aut obsolete crenato, disco pallido, pruinoso, flavido-albicanti, opaco. Sporae ellipsoideae, simplices, incoloratae, longit. 8–10 μ, crassit. 4.5–5.0 μ. — Medulla

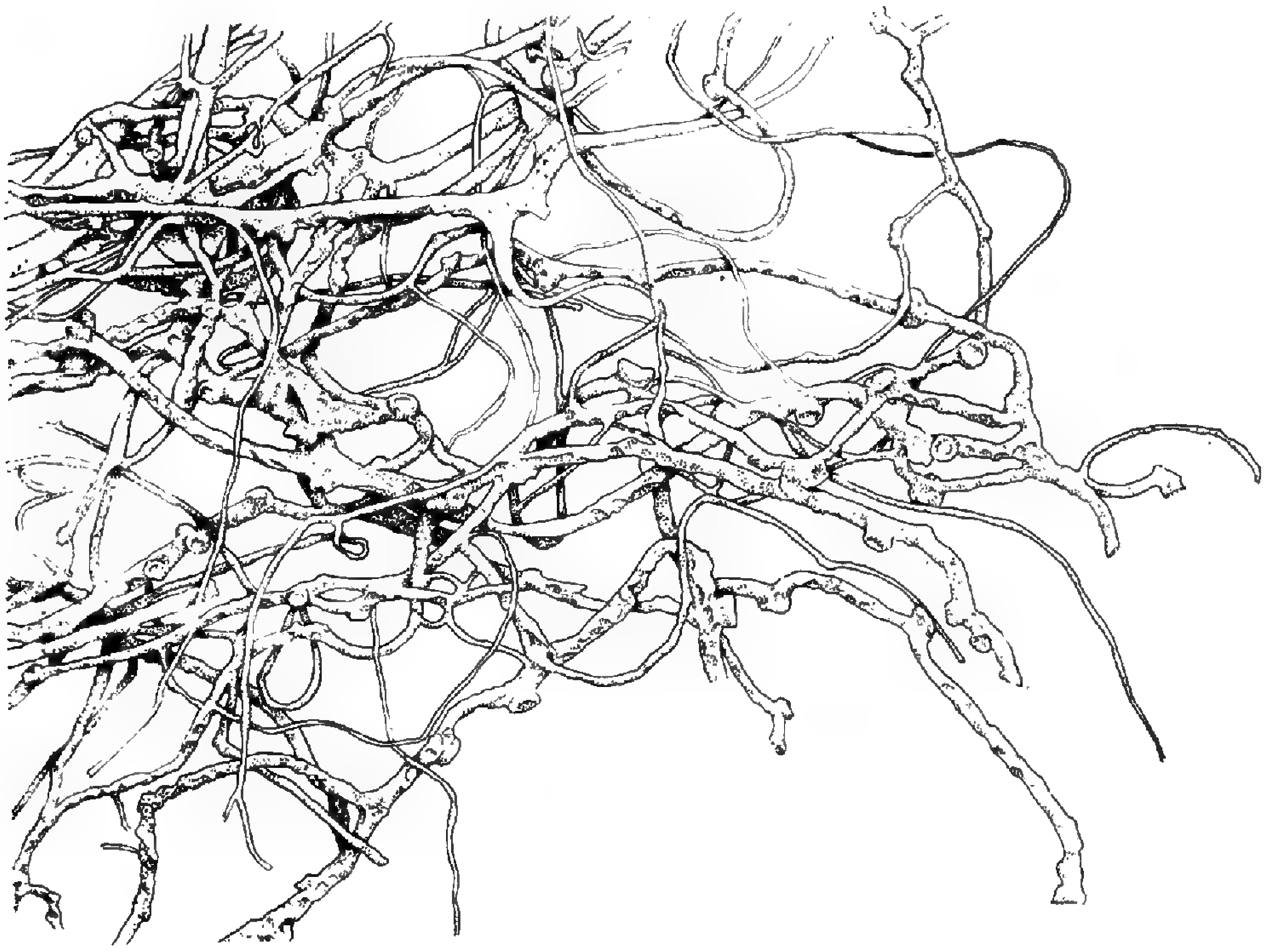


**Fig. 30.** *Usnea kuehnemannii* Mot. Part of the isotype-specimen in Farlow Herb. (× 3).

KHO– , $CaCl_2O_2$– , PD– . — Affinis, ut videtur, speciei austroafricanae *U. primitivae* Mot. Habitu pendulo et apotheciis lateralibus subgeneri *Protousneae* similis, vero autem propter discum pallidum apotheciorum in subgen. *Euusneam* locanda. — Arboricola in Argentina, Patagonia, Neuquén, haud procul e lacu Quillén, socia *Usneae* (*Protousneae*) *poeppigii*: O. Kühnemann, 1943, no. 796 pr. p.

Thallus 11–20 cm. long, pendulous, slender, moderately branched, somewhat elastic, dark stramineous or brownish-yellowish, matt or subnitid; main branches 0.5–0.8 mm. thick, partly smoothly terete, partly foveolate-scrobiculate with angulose ridges; terminal branches smooth, terete, finely capillary. Soredia present on many of the finer branches, minute, farinose, scattered or in places ± confluent, not prominent, yellow-whitish. Apothecia numerous, laterally sessile on the branches, minute, 0.5–1.0 ( –1.3) mm. diam., concave to almost plane, with prominent, thin, entire or obsoletely crenate thalline margin and pale, yellow-whitish-pruinose, matt disc. Spores ellipsoid, simple, colorless, 8–10 × 4.5–5.0 $\mu$.

Related apparently to *U. primitiva* Mot., a South African species described by Motyka in *Lich. Gen. Usnea Stud. Monogr.*, 627: 1936–1938. These two species approach the sect. *Protousnea* in their pendulous habit and lateral apothecia, but are placed in the subgenus *Euusnea* on account of the pale apothecial discs. The material was identified as a new species and named by Dr. J. Motyka.

Type in Herb. J. Motyka, Lublin, Poland; isotypes in Herb. Admin. Parques Nacionales, Avda. Santa Fe 690, Buenos Aires, and Herb. Mus. Nat. Canada, Ottawa.

### **Buellia** (Eubuellia) **tephrodes** M. Lamb (n. sp.)

Thallus effusus, maculas orbiculares aut irregulariter confluentes formans, obscure cinereus (madefactus pallide fuscescens), opacus, areolatus vel verrucoso-areolatus, crassitudine mediocri, areolis vulgo tumidis, 0.2–0.3 mm. latis. Hypothallus indistinctus aut obsoletus. Apothecia copiosa, dispersa, sessilia, rotundata, 0.5–0.8 mm. lata, nigra (aut passim fusconigra), opaca, nuda, diu aut persistenter plana et margine concolori mediocri integro praedita, rarius demum convexo-immarginata (haud alte convexa), disco subtiliter scabrido. Excipulum laterale, cum hypothecio obscure fuscum aut fusconigrescens. Hymenium 90–100 $\mu$ altum, in summa parte obscure

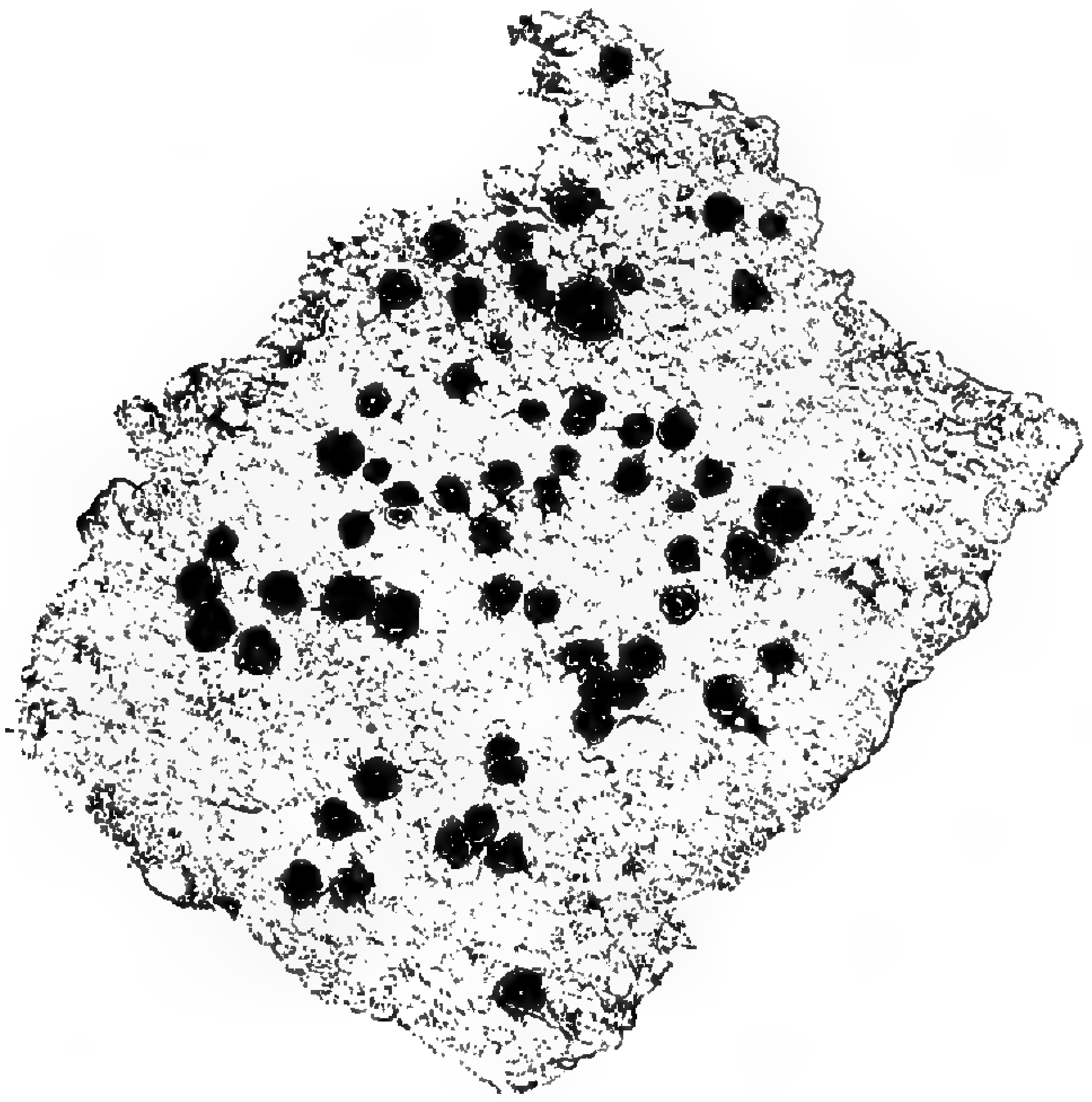


**Fig. 31.** *Buellia tephrodes* M. Lamb. The type-specimen (× 4).

fuscum, caeterum decolor, haud oleoso-inspersum; paraphyses jam in aqua facile liberae, apicibus fusco-capitatae. Sporae (6– ) 8nae, latiuscule oblongo-ellipsoideae, vulgo rectae, fuscae, 1-septatae, 18–24 ( –27) × (8– ) 10–13 μ, ad septum haud vel vix constrictae, septo tenui aut parum incrassato. — Thallus neque KHO, nec $CaCl_2O_2$, nec PD reagens; medulla pro maj. parte I– , passim parce I + caerulescens. — Australiensi *B. arenariae* Müll. Arg. accedit, a qua thallo obscuriore, magis verrucoso-areolato, hymenio altiori etc. recedit. *B. macrospora* Müll. Arg., item e Australia, apotheciis cito valde convexis et nitidis et sporis longioribus et oligotocis differt. — Ad saxa granitoidea in Argentina, Patagonia, Río Negro, insula Victoria in lacu Nahuel Huapí, non procul e littore, inter *Lecideam albidocinerellam* (Vain.) Vain., *Caloplacam pyraceam* (Ach.) Th. Fr., *Candelariellam vitellinam* (Ehrh.) Müll. Arg. et *Rhizocarpon disporum* (Naeg.) Müll. Arg. sat abundanter proveniens: M. Lamb, 1950, nos. 5854 pr. p., 5855 pr. p. (typus speciei).

*Description of the type-specimen (M. Lamb no. 5855 pr. p.)*: thallus effuse, without any trace of effiguration at periphery, forming ± orbicular or irregularly confluent patches 1–2 cm. diam. among other crustaceous lichens. No black hypothallus developed. Thallus dark ash-gray, becoming pale brownish when moistened, matt, 0.2–0.3 mm. thick, composed of crowded, plane to usually tumid-verrucose, irregularly angulose or rounded areolae 0.2–0.3 mm. diam. No isidia or soredia. Thallus KHO– (also under microscope), $CaCl_2O_2$– , PD– , in section covered by a ± developed, brown cortical layer up to 12 μ thick of indistinct gelified structure (in KHO more distinct, of cells 3–5 μ diam. with very thin brown walls). Medulla colorless and clear in section (white macroscopically), for the most part I– , but here and there a few of the hyphae stained violet-blue by Iodine. Apothecia sessile on thallus, well constricted at base, round, 0.5–0.8 mm. diam., numerous, scattered or occasionally two contiguous, black or sometimes brownish-black, matt, not pruinose, for a long time or persistently plane with moderate, entire proper margin, finally sometimes becoming ± convex and immarginate, but not strongly convex. Disc minutely scabrid, rarely umbonate in the center.

Excipulum developed at sides only, but reaching some way down on underside of apothecium; 60–80 μ thick, dark brown in section, more brown-blackish in outermost 5–10 μ, rather grossly pseudoparenchymatic, with ± rounded, isodiametric or slightly radially elongated cells 4.5–6.5 μ diam., their dark brown walls 0.6–1.0 μ thick. Hypothecium lentiform (plano-convex), up to 90 μ deep, dark brown or brown-blackish in lower half to two-thirds, paler brown in upper subhymenial part; distinct from the excipulum which encloses it at the sides; of ± cellular structure with cells up to 5 μ diam.; ± sharply delimited at base, or sometimes forming a ± distinct brownish stipe running down into the thallus tissue. Hymenium 90–100 μ high, somewhat abruptly dark brown or brown-blackish in uppermost 8–12 μ (the epithecial surface uneven), otherwise perfectly clear and hyaline (not inspersed with droplets, without any aeruginose tinge), with Iodine staining blue then dark aeruginose. Paraphyses discrete in water, 1.5–2.5 μ thick, simple or sparingly branched, not articulated except near the tips, which are clavate-capitate up to 4–5 μ and brown-pigmented. Asci clavate, 60–75 × 12–20 μ. Spores 6–8 in ascus, biseriate or irregularly overlapping, broadly oblong-ellipsoid, straight or occasionally bean-shaped, not or hardly constricted at septum, constantly 1-septate, the walls thin (about 0.6 μ), the septum somewhat thicker (1.0–1.5 μ); persistently brown (not becoming blackish or opaque), smooth-walled or finally with the wall extremely subtly granulate-scabrose (this visible only under oil-immersion); 18–22 ( –27) × 11–13 μ. Sections of apothecia unchanged in color by KHO and $HNO_3$.

Symbiotic algae protococcoid, bright green, globose, separable, 12–19 μ diam., thin-walled.

A similar type of thallus, with brown-tipped cortical hyphae but appearing gray or whitish on account of the outermost amorphous layer, is found also in some other species, e.g. *B. notabilis* Lynge.

*B. tephrodes* appears to come closest to the Australian *B. arenaria* Müll. Arg. The type-specimen of the latter was reexamined (see revision below), and it was found to differ from the present species chiefly in the lighter (whitish or cream-colored) thallus without brown-celled cortex, the lower and slightly inspersed hymenium, the thicker hypothecium, the less distinctly cellular excipulum, the somewhat narrower spores, and the more intense and uniform Iodine reaction of the medullary hyphae.

Occurring in the Isla Victoria on granitic rocks at the shore of Lake Nahuel Huapí, about 4 m. above the water level, associated with *Lecidea albidocinerella* (Vain.) Vain., *Caloplaca pyracea* (Ach.) Th. Fr., *Candelariella vitellina* (Ehrh.) Müll. Arg. and *Rhizocarpon disporum* (Naeg.) Müll. Arg.

Type in Herb. Mus. Nat. Canada, Ottawa.

### **Buellia arenaria** Müll. Arg.

in *Bull. Herb. Boissier*, Vol. I, 52: 1893.

The following is a revision of the type-specimen from Australia, Victoria, near Lorne, coll. F. R. M. Wilson, 1892 (no. 1044), in Herb. Müller Arg., Herb. Boissier, Geneva:

On sandstone rock. Thallus apparently effuse and widespread, sordid whitish or cream-colored, matt, not changing color when moistened, areolate, the areolae 0.2–0.5 mm. diam., mostly contiguous but in places ± dispersed with the bare stone showing in between; irregular in outline, obtusely angulose or ± rounded, plane to slightly convex. No isidia or soredia. No distinct dark hypothallus developed. Thallus externally and internally KHO– , $CaCl_2O_2$– , PD– ; medullary hyphae I + intense violet-blue. The thallus has no cortical layer of brown cells as in *B. tephrodes* M. Lamb. Symbiotic algae protococcoid, now very pale green, globose, thin-walled, easily separable, 8–13 μ diam. Apothecia fairly numerous, scattered, sessile on or between the areolae, round, moderately constricted at base, 0.3 0.7 mm. diam., entirely black, not pruinose, matt (only the margin sometimes shiny where rubbed), persistently ± plane with distinct, slightly prominent, moderate, entire proper margin.

Excipulum lateral, 35–75 μ thick, densely dark brown or brown-blackish, confluent with the concolorous hypothecium. Hypothecium thick, up to 200–300 μ deep in center, densely dark brown or brown-blackish, paler brown at the base where it penetrates downwards into the thallus tissue. The structure of these very dark apothecial tissues can be seen only in very thin sections; the excipulum is composed of short, rounded, isodiametric or slightly radially elongated cells 4–5 μ diam., ± indistinct on account of the dense brown pigment, which is especially thick in the outermost 25–30 μ. The hypothecium is of more distinct cellular structure, with rounded or rectangular cells 4–5 μ wide, with brown walls up to 1 μ thick, for the most part obviously formed as cells of vertically parallel hyphae. Both excipulum and hypothecium are KHO– , $HNO_3$ + more reddish. Hymenium 60–75 μ high, colorless (or faint brownish in thicker sections), unevenly dark brown in uppermost part, slightly guttulate-inspersed with some oil-droplets in the lower part; without any aeruginose tinge. Paraphyses in some mucilage but discrete in water, 1–2 μ thick, simple or sparingly branched, not articulated, at tips clavate-capitate to 4.0–4.5 μ and there unevenly capped with dark brown pigment. Asci clavate, 45–55 × 10–17 μ, with gelatinous wall 1.0–1.5 μ thick at sides and 3–10 μ thick at apex. Spores 5–6 ( –8) in ascus, brown to dark brown (not becoming blackish or opaque), ellipsoid to oblong-ellipsoid, 1-septate, often ± constricted at the septum, straight, (14– ) 16–22 × (8– ) 9–11 μ; the cells of equal size, the spore-wall thin, less than 1 μ, smooth, the septum often slightly thicker (1.0–1.5 μ), but sometimes thin like the spore-wall. Hymenium with Iodine blue then greenish-blue.

## ACKNOWLEDGMENTS

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4(4):473–512 FARLOWIA JULY, 1955

# THE LICHEN GENUS BUELLIA IN THE WEST INDIES

HENRY A. IMSHAUG [1]

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The receipt of a Fulbright Research Award from the United States Department of State made possible an intensive field study in Jamaica and I would like to express my appreciation not only to the State Department but also to The United States Educational Commission in the United Kingdom, which made possible additional studies in Grenada. The University College of the West Indies cooperated in making available their facilities while in the West Indies and I would like to express my especial gratitude to Dr. G. Asprey and Dr. R. Loveless who both assisted in making my field work successful.

The final phase of this study was accomplished only through the very kind assistance of many colleagues who offered invaluable help in the procuring of needed type specimens and other critical material. In addition to the directors and curators of the various herbaria consulted I would like to especially acknowledge my indebtedness to Dr. Ove Almborn and Dr. I. Mackenzie Lamb for their many favors. I am also very grateful to Dr. G. Taylor and Mr. Griffiths, who went to considerable trouble to supply me with photographs and microscopic data of the type specimens of *Lecidea remensa* and *L. gerontoides* in the British Museum.

## INTRODUCTION

This study of the West Indian species of *Buellia* follows a similar study of the North American species which was the subject of my doctoral thesis and was "published" only in the form of microfilm (Imshaug, 1952). The material in this thesis is, however, being prepared for regular publication in a revised form.

A separate paper is being published on the morphology and anatomy of the genus. The present paper is, therefore, one of a series of regional re-

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[1] University of Idaho, Moscow, Idaho.

visions which are intended to be used in conjunction with the paper on morphology and anatomy since it expresses my views on the taxonomy of the genus. The ultimate goal is the completion of a monograph of all the species of *Buellia.* It is hoped that the publication of regional revisions will stimulate further collecting and provide more material for the final monograph.

## GEOGRAPHY AND CLIMATE

The West Indies are a group of islands enclosing the Caribbean Sea between SE North America and N South America. They lie between latitudes 10° and 25° N and longitudes 60° and 85° W. The islands are generally grouped in three divisions: GREATER ANTILLES including Cuba, Hispaniola (Haiti and Dominican Republic), Jamaica, and Puerto Rico; LESSER ANTILLES including Virgin Islands, Windward Islands, Leeward Islands, and the islands in the S Caribbean Sea north of Venezuela; BAHAMA ISLANDS. Included also in this study are a few islands (Swan Islands, San Andrés, and Providencia) in the Caribbean Sea off the coast of Central America.

The largest island is Cuba with an area of 44,164 sq. miles. The remaining islands, listed according to size, are Hispaniola (29,979 sq. miles), Jamaica (4,450 sq. miles), Puerto Rico (3,435 sq. miles), Trinidad (1,862 sq. miles), Guadeloupe (619 sq. miles), Martinique (380 sq. miles), Dominica (304 sq. miles), St. Lucia (233 sq. miles), Barbados (166 sq. miles), St. Vincent (130 sq. miles), Grenada (120 sq. miles) and Antigua (108 sq. miles). All the other islands, except some of the Bahama Islands, have an area of less than 100 sq. miles.

Many of the islands are mountainous, either of volcanic origin as in the Lesser Antilles, or as a result of uplifting accompanied by folding, thrusting, and faulting as in the Greater Antilles. The Bahama Islands, however, are of very low relief, rising to a maximum elevation of 400 ft. on Cat Island. The outliers in the Lesser Antilles are also of low relief, varying from hilly to practically flat. These latter islands are composed principally of sedimentary rocks which lie horizontally or are somewhat tilted. Elevations of about 1000 feet are attained on these outliers.

The highest elevation in the West Indies, 10300 feet, is found in Hispaniola. Blue Mountain Peak, in Jamaica, is the next highest mountain, with an elevation of 7402 ft. The highest elevations in Cuba and Puerto Rico are, respectively, 6560 ft. and 4398 ft. In the Lesser Antilles Guadeloupe has the highest elevation with a dormant volcano of 4800 ft.

TEMPERATURE[2]: The temperature throughout the West Indies is rather uniform at sea level. The mean annual temperature (below 500 ft.) varies from 74°–81° F. The mean annual range of temperatures is from 3°–7°F, except in Cuba and the Bahamas where the mean range is

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[2] The climatological data were obtained mostly from W. W. Reed, Climatological data for the West Indian Islands, Monthly Weather Review 54(4): 133–160. 1926. It has been supplemented, however, with more recent local reports.

greater (8°–11° F). Extreme temperatures are from 51°–101° F except in Cuba where the extremes vary from 40°–104° F. The temperature, however, decreases with an increase in elevation. In Jamaica, for example, there is a drop of 1° F for each 320 ft. rise in altitude. A recording of the elevation of the collection is, therefore, an indication of the temperature.

The highest elevation for a *Buellia* in the West Indies is on Blue Mountain Peak (7402 ft.) in Jamaica. The mean annual temperature here is 56° F and frost has not been recorded. Higher elevations occur in Hispaniola but meteorological data are not available.

PRECIPITATION: Precipitation is entirely in the form of rain, except for an occasional hail storm. The minimum yearly mean for the region is approximately 20 inches, in Hispaniola, while 252 inches, in Jamaica, represents the maximum yearly mean. The characteristic feature of the mountainous islands is the remarkable difference in the amount of rainfall received on windward and leeward exposures and in low and elevated areas. Striking contrasts can be found between stations separated by only a few miles. The greatest difference occurs in Jamaica where there is a gradient of 190 inches (mean annual rainfall) in a distance of 30 miles. An even more striking example is recorded for Dominica with a change from 78 inches to 185 inches (mean annual rainfall) occurring in a distance of only three miles. In general the low islands are rather arid while the mountainous islands have a wet windward side and a dry leeward side. The opposite condition may, however, prevail if the mountains are on the leeward side as in Grenada.

The mean annual rainfalls for the driest and wettest parts of the main islands included in this study follow. There may be drier or wetter parts on the islands, but if so there are no meteorological data available for them.

Bahamas: 46 inches is the yearly mean at Nassau.
Cuba: 28 to 79 inches.
Isle of Pines: 71 inches is the yearly mean at Nueva Gerona.
Jamaica: 27 to 252 inches.
Hispaniola: 20 to 103 inches.
Puerto Rico: 36 to 135 inches.
Virgin Islands: 41 to 46 inches are the yearly means at Charlotte Amalie (St. Thomas) and Christiansted (St. Croix), respectively.
Guadeloupe: 50 to 156 inches.
Dominica: 70 to 193 inches.
Martinique: 45 to 120 inches.
St. Vincent: 70 to 91 inches.
Grenada: 39 to 147 inches.
Trinidad: 45 to 108 inches (but possibly as high as 200 inches on summit of Aripo).

EVAPORATION: Evaporation is influenced by temperature, vapor pressure, and wind velocity under 20 miles per hour. These are relatively constant in the West Indies. Data are available from localities near sea level in Jamaica, Puerto Rico, and St. Croix (Ray, 1931). They show that evaporation exceeds precipitation throughout the year, except in the height of the rainy season. This excessive evaporation is largely the result of the steady trade winds throughout the year and the long daily periods of sunshine and high temperature. More rain is, therefore, needed to support a given type of vegetation than in cooler regions.

## ECOLOGY

Local usage speaks of "dry belt," "middle belt," and "mountain belt" climates. These climatic zones have also been used in referring to the vegetation. Stehlé (1945) thus uses the terms "forêt xérophile," "forêt mésophile," and "forêt hygrophile" for the vegetation in the dry, middle, and mountain belts respectively. As pointed out by Beard (1949) this is an unsatisfactory basis for an ecological classification of the vegetation as a whole. Attention should be directed on the physiognomy of the forest. The present writer believes, in addition, that more attention should be given to the nonvascular plants and their use in a life-form classification. A purely floristic system is of little value in the tropics (Richards, 1952).

There is, however, very little natural vegetation left in the West Indies. Almost all of the available land has been used at one time or another for the cultivation of sugar cane. The practice of shifting cultivation has further destroyed much of the natural vegetation on slopes too steep for sugar cane. The genus *Buellia*, however, is not limited to the natural vegetation and may be collected wherever trees are cultivated and wherever rock outcroppings occur. Although the bark of many tropical trees is too smooth to support many lichens the common Coconut and Mango trees provide an excellent habitat. There are no terricolous *Buelliae* in the West Indies. Although I could find no *Buelliae* on the various limestones in Jamaica there is a collection of *B. dejungens* from limestone in Cuba, and a collection of *B. posthabita* from limestone in Puerto Rico.

It appears best to classify the species as regards their moisture requirements. In Jamaica the lichens can be readily grouped into three classes. This was done by plotting the annual mean rainfalls of 317 Jamaican weather stations on topographic maps and estimating the annual mean rainfall of each collection locality. The three classes are called xerophytic, mesophytic, and hygrophytic and are used in reference to the three main climatic belts. As Beard (1949, p. 14) points out "all climatic changes are a gradual progression and human classification is entirely arbitrary." For the distribution of lichens, however, this is a very convenient and practical classification.

Xerophytic lichens are found in areas receiving a mean of 40–60 inches of rainfall per year. Mesophytic lichens are found in areas receiving 60–100 inches. Hygrophytic lichens are those found only in areas with more than 100 inches of rain annually. Some species are able to grow under both xerophytic and mesophytic conditions. The rainfall figures given for the three classes were developed for Jamaica but should apply generally throughout the West Indies where temperature and evaporation are similar. In the Bahamas and parts of Cuba, however, the figures would probably be lower.

An especial effort was made to collect lichens in the most arid parts of Jamaica. That is, in the Thorn Scrub Woodland and Cactus-Thorn Scrub vegetation of the south coast and on the outlying cays.[3] This region has a mean annual rainfall of less than 40 inches, with a minimum recorded yearly mean of 27 inches. Not a single species of *Buellia* was found in this extremely arid region.

In Jamaica the species are classified as follows:

XEROPHYTIC: *B. leucomela* and *B. yaucoensis.*

XEROPHYTIC-MESOPHYTIC: *B. efflorescens*, *B. gerontoides*, and *B. modesta.*

MESOPHYTIC: *B. bahiana*, *B. catasema*, *B. glaziouana*, *B. lauricassiae*, *B. melanochlora*, *B. proximata*, *B. subsensitiva*, and *B. trachyspora.*

HYGROPHYTIC: *B. atrofuscata*, *B. callispora*, *B. glaucotheca*, *B. jamaicensis*, *B. placodiomorphoides*, *B. posthabita*, *B. remensa*, and *B. rufofuscescens.*

In Grenada only six species were collected, *B. catasema*, *B. efflorescens*, *B. gerontoides*, *B. placodiomorpha*, *B. posthabita*, and *B. remensa.* All of these must be classed as mesophytic. The most arid part of Grenada (Point Saline) has a 19 year (broken) average of 49 inches mean annual rainfall. This figure is exceedingly variable throughout the years, ranging from 22 inches to 92 inches. It appears doubtful if a true dry belt climate occurs in Grenada because of the frequency of years with means exceeding 60 inches. No *Buellia* was found in the mountain belt climate of Grenada.

For the other islands an attempt has been made to determine the climatic belt the species was collected in from the locality data given on the herbarium label. This was done through the use of the rainfall maps published for the various islands. The results are given under the individual species in the taxonomic section.

## DISTRIBUTION

The West Indies have been visited by a number of lichenologists. C. C. Plitt and C. E. Cummings both collected in the Blue Mountains of Jamaica, and Bruce Fink spent two months collecting in Puerto Rico. The only species reported in the literature from Fink's collections are some new species but Fink (1918) has written a general account of his sojourn in Puerto Rico. The entire collection has been prepared for publication by Joyce Hedrick Jones as a portion of Volume VII, Part 4 (unpublished) of the Scientific Survey of Porto Rico and the Virgin Islands. The present writer has made extensive collections in Jamaica and Grenada.

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[3] For a description of the vegetation of Jamaica see Asprey and Robbins, 1953.

There are, in addition, a number of other collectors who, although not specialists on lichens, have collected many lichens and their collections show a considerable field knowledge of the group. Britton and his associates have collected very extensively in the Bahama Islands, Isle of Pines (off Cuba), Puerto Rico, and the Virgin Islands.

As a result of all the collecting up to the present time it can be said that the lichen floras of the Bahamas, Cuba, Jamaica, Puerto Rico, Virgin Islands, and Grenada are well represented in herbaria. Guadeloupe, Dominica, Martinique, St. Vincent, and Trinidad are also represented, but less completely. The remaining islands are represented by few, if any, collections. It is most unfortunate that so little material is available from Hispaniola.

ENVIRONMENTAL FACTORS: The distribution of the species of Buellia in the West Indies is governed both by environmental and historic factors. Thus a hygrophytic species would be expected to occur only where the annual rainfall is in excess of 100 inches (mean annual). Not all islands can supply this condition. Two species, *B. atrofuscata* and *B. rufofuscescens*, formerly known only from Brazil have been found in Jamaica in a locality with over 150 inches of rainfall. The only other island with comparative rainfall is Dominica and, unfortunately, the collections from this island are rather meager. On the other hand, some islands (e.g., Grenada) may not have the arid conditions necessary for the xerophytic species. *Buellia modesta*, for example, does not seem to occur on this island.

The temperature, although fairly constant near sea level for most of the region under consideration, appears to differ enough in Cuba and the Bahamas to be considered as a factor. These islands, or portions of them, are usually excluded from the tropical part of Middle America. Four species are known from the Bahamas, *B. bahiana*, *B. catasema*, *B. gerontoides*, and *B. modesta*. All four of these are found in Jamaica where they are classed as mesophytic or xerophytic-mesophytic. It is probable that in a cooler climate the moisture requirements as expressed by annual mean rainfall would be less. Thus some species common to both the Bahamas and Jamaica would require less annual rainfall in the former islands. The terms xerophytic, mesophytic, and hygrophytic actually represent a precipitation/evaporation index rather than mean annual rainfall alone. Evaporation figures, however, are not generally available.

*Buellia callispora* is found in Jamaica in areas receiving from 80 inches to 200 (or more) inches of rain. The only other West Indian collection is from Guadeloupe. This species is, however, found along the coast of eastern North America as far north as Latitude 35° N, and in South America, along the eastern coast as far south as Latitude 35° S. Temperature would appear to be the limiting factor, as well as moisture, in this case.

HISTORIC FACTORS: Theories on migration within the West Indies have largely been based upon continuous land connections. An excellent review of the historical geology of the region is given by Schuchert (1935).

The Greater Antilles seem never to have been connected by dry land to North America. Likewise, there is no evidence that the Lesser Antilles were ever connected with South America.[4] Furthermore, there is no evidence that there was a continuous land connection from the Greater Antilles to Grenada. Two Central American – Greater Antillean land bridges have been postulated, one from the Honduran peninsula to the Greater Antilles and one from the Yucatan peninsula to Cuba. Schuchert (1935) recognizes only the first one. The islands in the Greater Antilles appear to have been connected at one time or another and this land bridge extended as far east as the Virgin Islands or, possibly, Antigua.[5]

It is apparent, then, that the distribution of many species is the result of long distance migration. The corticolous species of *Buellia* are on the whole widely distributed, with only 2 out of 17 endemic to the West Indies. As for the saxicolous species, however, 8 out of 10 (*B. dispersula* is not considered West Indian) are endemic to the West Indies, with all but 3 limited to one island. All 8 endemics are, however, limited to the Greater Antilles and Virgin Islands which were at one time connected to Central America. Of the 3 endemics which are found on more than one island: *B. trachyspora* is common to all the Greater Antilles[6] and Virgin Islands; *B. dejungens* has apparently bypassed Jamaica but is found on all the other Greater Antilles and Virgin Islands; *B. prospersa* is limited to the Virgin Islands.

It seems that long distance migration must account for the wider distribution of many of the corticolous species. Long distance migration is apparently not so effective in the dispersal of saxicolous species. A suitable habitat for saxicolous species is not so common as a suitable habitat for corticolous species. What rock is found in the West Indies is frequently protected by the canopy (or canopies) of the forest. Many of the rocks also disintegrate very rapidly.

Two saxicolous species, however, are widely distributed. These are *B. glaziouana* and *B. posthabita*. The absence of *B. glaziouana* from the Windward Islands and Cuba indicate that this species, widely distributed in SE United States, Central America and South America entered the West Indies by the former land connection with Central America. *Buellia posthabita* is the most widely distributed saxicolous species within the West Indies. It is known from South America but not from North America, nor from Central America. It is the only definite saxicolous example of long distance migration.

Many of the corticolous species are known not only from North America, Central America, and South America but also from the Pacific

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[4] Trinidad is strictly speaking not to be considered a part of the West Indies since it is geologically and biologically a part of the South American continent. It is included in this study merely as a matter of convenience.

[5] See figs. 5 & 6 in Beard (1949) which outline the conjectural geography of the Lesser Antilles in early Miocene and early Pliocene times.

[6] Where a species is found on both Cuba and Puerto Rico it is assumed that it also occurs on Hispaniola.

Islands and tropical Asia. Since this genus has not yet been critically studied outside the Western Hemisphere no attempt will be made to discuss the broader aspects of their distribution at this time.

The two corticolous species which are endemic to the West Indies are *B. placodiomorphoides* and *B. yaucoensis*. Like the saxicolous, endemic species, these are limited to the Greater Antilles. *Buellia gerontoides*, although not endemic to the West Indies is nevertheless limited in its distribution to low elevations in the Caribbean area.

The distribution of the West Indian species of *Buellia* is summarized in Table I.

## TAXONOMIC SECTION

### HERBARIA CONSULTED

The symbols used are those in the Index Herbariorum.

BM — British Museum (Natural History), London, Great Britain.
BPI — Plitt Herbarium in Bureau of Plant Industry, Beltsville, Maryland, U. S. A.
C — Botanical Museum & Herbarium, Copenhagen, Denmark.
F — Chicago Natural History Museum, Chicago, Illinois, U. S. A.
FH — Farlow Herbarium, Harvard University, Cambridge, Massachusetts, U. S. A.
G — Müller Arg. Herbarium in Conservatoire et Jardin botaniques, Genève, Switzerland.
H — Nylander Herbarium in Botanical Museum, Helsinki, Finland.
Imsh — Private herbarium of author, H. A. Imshaug.
M — Krempelhuber Herbarium in Botanische Staatssammlung, München, Germany.
MICH — University of Michigan, Ann Arbor, Michigan, U. S. A.
MO — Missouri Botanical Garden, St. Louis, Missouri, U. S. A.
NY — New York Botanical Garden, New York, New York, U. S. A.
PC — Laboratoire de Cryptogamie, Muséum National d'Histoire Naturelle, Paris, France.
PH — Academy of Natural Sciences, Philadelphia, Pennsylvania, U. S. A.
TUR — Vainio Herbarium in Botanical Institute of the University, Turku, Abo, Finland.
US — U. S. National Museum, Smithsonian Institution, Washington, D. C., U. S. A.

### KEY TO SPECIES

#### A. SAXICOLOUS SPECIES

1\. Spores incompletely 3-septate (secondary septa not completely formed) ........ *B. jamaicensis*
1\. Spores 1-septate.
  2\. Spore wall or septum thickened, either evenly or unevenly.
    3\. Spore wall thin but septum thickened.
      4\. Thallus thin & continuous, KOH — ........ *B. prospersa*
      4\. Thallus of large verrucae, occasionally sublobate, KOH + (red, crystals) ........ *B. boergesenii*
    3\. Spore wall thickened; spores not polarilocular.
      5\. Hypothecium and stipes colorless; spores mischoblastiomorph ........ *B. posthabita*
      5\. Hypothecium and stipes brown.

6. Thallus thin & continuous, becoming rimose-areolate; stipes & exciple KOH + (purple out in solution); spore wall ± evenly thickened; no oil drops in hymenium .... *B. dejungens*
6. Thallus composed of granules, scattered or confluent; stipes & exciple KOH – ; spores mischoblastiomorph; oil drops in hymenium .... *B. subdispersula*
Granules cinereous .... var. *subdispersula*
Granules yellow .... var. *flavogranulosa*
2. Spore wall and septum thin and even.
7. Spore surface prominently verrucose .... *B. trachyspora*
7. Spore surface smooth.
8. Thallus continuous, becoming rimulose or rimose-areolate. *B. glaziouana*
Thallus section KOH –
Thallus yellowish .... var. *glaziouana*
Thallus cinereous or white .... var. *poliocheila*
Thallus section KOH + (red, crystals) .... var. *sensitiva*
8. Thallus not continuous.
9. Epithecium green; hypothallus continuous, gray or dark cinereous; thallus of thin, scattered, cinereous areoles, KOH + (red, crystals) .... *B. subsensitiva*
9. Epithecium brown; hypothallus consists of a few scattered black specks.
10. Thallus dispersed areolate in center, radiate-laciniate at periphery, brown, KOH – .... *B. brittoniae*
10. Thallus consists of scattered, small, cinereous areoles, freq. narrow & elongated, KOH + (red, crystals) .... *B. dispersula*

### B. CORTICOLOUS AND LIGNICOLOUS SPECIES

1. Spores 3-septate.
2. Exciple brown; hypothecium KOH – ; spores 21–26 × 8–10 μ .... *B. proximata*
2. Exciple pallid; hypothecium KOH + (red, crystals); spores 17–21 × 6–9 μ .... *B. lauricassiae*
1. Spores 1-septate.
3. Spore wall or septum thickened, either evenly or unevenly.
4. Hymenium inspersed with oil drops.
5. Spores mischoblastiomorph .... *B. atrofuscata*
5. Spores not mischoblastiomorph.
6. Epithecium green, KOH + (violet); thallus and hypothecium KOH + (red, crystals); spores 14–19 × 6–9μ .... *B. bahiana*
6. Epithecium yellow-orange, KOH – ; thallus and hypothecium KOH – ; spores 29–42 × 14–21 μ .. *B. callispora*
4. Hymenium not inspersed with oil drops.
7. Spore wall not thickened at apex but thickened in center (spores ± polarilocular).
8. Spores 14–18 × 6–9 μ; exciple brown .... *B. placodiomorpha*
8. Spores 21–28 × 9–10 μ; exciple pallid and with oil drops .... *B. placodiomorphoides*
7. Spore wall ± evenly thickened, leaving one small spherical sporoblast in each cell.

9. Disk of apothecium naked; epithecium brown, KOH — ; thallus KOH — ; exciple KOH + (red-violet out in solution) ................................ *B. yaucoensis*
9. Disk of apothecium ± white pruinose; epithecium green, KOH + (violet); thallus KOH + (red, crystals); exciple KOH — ............................ *B. remensa*
3. Walls of spores thin & uniform in thickness.
10. Asci polysporous ................................ *B. efflorescens* var. *diminutiva*
10. Asci octosporus.
11. Disk of apothecium pruinose.[7]
12. Pruina red or red-brown; exciple KOH + (red-violet out in solution) ........................ *B. rufofuscescens*
12. Pruina white or yellow-green.
13. Pruina white; thallus & hypothecium KOH + (red, crystals)
14. Epithecium brown, KOH — ; spores 18–28 × 7–9 μ .................................... *B. glaucotheca*
14. Epithecium green, KOH + (violet); spores 13–17 × 6–8 μ ................................ *B. remensa*
13. Pruina yellow or yellow-green.
15. Spores 12–17 × 5–7 μ; hypothecium KOH + (red, crystals); epithecium KOH — .......... *B. gerontoides*
15. Spores 19–28 × 8–12 μ; hypothecium KOH + (red out, but no crystals); epithecium KOH + (layer of yellow granules) .................. *B. melanochlora*
11. Disk of apothecium naked.
16. Hymenium inspersed with oil drops; epithecium green, KOH + (violet) ......................... *B. bahiana*
16. Hymenium not inspersed with oil drops.
17. Spores verruculose ......................... *B. leucomela*
17. Spores smooth.
18. Thallus soraliate, KOH — ; exciple brown; spores 11–14 × 5–7 μ ..................... *B. efflorescens*
18. Thallus not soraliate.
19. Exciple pallid; hypothecium & thallus KOH + (red, crystals); thallus continuous to ± rimose .................................. *B. modesta*
19. Exciple brown; hypothecium & thallus KOH — ; thallus granulose ..................... *B. catasema*
Thallus not red inside ........... var. *catasema*
Thallus red inside ................ var. *sanguinariella*

### **Buellia atrofuscata** Wainio, Étude Lich. Brésil 1: 169. 1890.

*Buellia conformis* Wainio, Étude Lich. Brésil 1: 168. 1890.

Type collections: *Buellia atrofuscata* — "Ad terram humosam in Carassa (circ. 1500 metr. s. m.) in civ. Minarum, n. 1416." (Brazil) Holotype in TUR (Vainio Herb.); isotype in FH.

*Buellia conformis* — "Ad corticem arboris prope Sitio (1000 metr. s. m.) in civ. Minarum, n. 1093." (Brazil) Holotype in TUR (Vainio Herb.); isotype in FH.

HYPOTHALLUS not seen. THALLUS scant, occasionally absent. APOTHECIA

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[7] Note that the pruina may be scant, in which case it is best seen when the disk is moistened with water.

0.2–0.4 mm. across, scattered. Disk black, dull, naked, plane to somewhat convex. Margin thin and concolorous.

Hypothecium and stipes brown, confluent. Exciple thin and concolorous. Hymenium 85–105 μ thick, colorless but inspersed with small oil drops; paraphyses forming a brown epithecium. Spores 8 in ascus, mischoblastiomorph, fumose to brown, 18–24 × 10–12 μ.

Chemical Reactions: Apothecial tissues KOH – ; thallus section KOH – .

A hygrophytic, corticolous and lignicolous species known in the West Indies only from the Blue Mountains of Jamaica.

*Material seen*: JAMAICA — The Triangle, *Cummings 312*, Feb. 28, 1905 (FH); *Cummings 126*, March 1905 (FH); hut at Murdocks Gap, 3300 ft., *Imshaug 15299a*, March 19, 1953 (Imsh).

Wainio used two names for this species. *Buellia conformis* was described from corticolous material and *B. atrofuscata* was described from material on debris. Although *B. conformis* has "page priority," Malme (1927) used the epithet *atrofuscata* for this species. It should also be noted that the excipular differences apparent in Wainio's descriptions do not exist.

### **Buellia bahiana** Malme, Ark. Bot.
21A(14): 17. 1927.

*Buellia eckfeldtiana* Steiner in Magn. & Zahlbr. Ark. Bot. 32A(2): 51. 1945.

Type collections: *Buellia bahiana* — Collected on bark by Malme at Rio Vermelho, Bahia, Brazil. Three numbers (12, 15, & 35) are cited but none is designated as holotype. I have seen only one of these in MO.

*Buellia eckfeldtiana* — Collected on bark by Eckfeldt and Bailey at Hilo, Hawaii (Hawaiian Islands). Holotype in W (not seen).

HYPOTHALLUS not seen except as black delimiting line around thallus. THALLUS glaucous-cinereous (occasionally somewhat sulphureous), continuous to somewhat rimulose with surface smooth or ± verrucose. Well-developed thalli are rather thick and rimose-areolate, the areoles composed of many verrucae. APOTHECIA scattered, superficial, constricted at base, 0.3–0.7 mm. across, occasionally conglomerate. Disk black, naked, dull, plane to slightly convex. Margin thin and concolorous, occasionally becoming wavy.

Hypothecium, stipes and exciple confluent, dark brown; stipes well developed to base of thallus. Hymenium 55–88 μ thick, colorless, inspersed with many oil drops; paraphyses forming a green epithecium. Apical cells of paraphyses only slightly enlarged and fusco-capitate. Spores 8 in ascus, pale fuscous, callisporoid, 14–19 × 6–9 μ.

Chemical Reactions: Epithecium KOH + (lavender); hypothecium and exciple KOH – ; thallus KOH + (red, crystals).

A mesophytic, corticolous species of wide distribution in tropical and subtropical regions. In addition to the West Indian material collections have been examined from Bermuda, United States (Florida), Central America, South America, and the Hawaiian Islands.

*Material seen*: BAHAMAS — New Providence, *Brace 9566*, Aug. 5, 1918 (NY).

CUBA — locality unknown, *Wright II 131* (US); locality unknown, *Wright II 130* (US); on *Cocothrinax*, La Cañada, Isle of Pines, *Britton, Britton & Wilson 14423a*, Feb. 16, 1916 (FH-Riddle); on *Cocothrinax*, La Cañada, Isle of Pines, *Britton, Britton & Wilson 14426*, Feb. 16, 1916 (FH-Riddle, NY); on *Colpothrinax*, San Pedro, Isle of Pines, *Britton & Wilson 14550 & 14549*, Feb. 12–March 22, 1916 (FH-Riddle, NY).

JAMAICA — Wareika House, summit of Long Mountain, 1350 ft., *Imshaug 13501*, Nov. 29, 1952 (Imsh); sea level, Long Bay, *Imshaug 15584, 15589 & 15597*, April 21, 1953 (Imsh); White River Bay, 30 ft., *Imshaug 15761a*, May 4, 1953 (Imsh); Hollymount, Mt. Diablo, 2750 ft., *Imshaug 14236*, Jan. 28, 1953 (Imsh).

PUERTO RICO — Manato, *Fink 2075*, Jan. 13, 1916 (FH).

ST. THOMAS — Crown, *Raunkiaer 421*, Nov. 31, 1905 (C); *Boergesen*, Jan. 1896 (C).

MARTINIQUE — Between Fort de France & Montmartre, *Evans 524*, Sept. 2, 1927 (FH & MO–70731).

This species is rather variable as regards some of its diagnostic characters and care must be used in ascertaining the presence or absence of a particular feature. For example, the KOH reaction of the thallus is frequently limited to scattered spots in the thallus. Also, the callisporoid appearance of the spores is not so apparent at first glance as it is in *B. callispora*. In doubtful cases allow section to stand awhile in KOH. Shadows of incipient secondary septation frequently appear even if definite callisporoid cells are not visible.

The greenish epithecium, presence of oil drops in the hymenium, dark brown exciple and smooth, continuous thallus are perhaps the most reliable characters.

### **Buellia boergesenii** sp. nov.

Hypothallus nigricans, parum conspicuus, e maculis formatus minutissimus, dispersis. Thallus crassus aut mediocris, e verrucis formatus semiglobosis vel irregularibus, interdum sublobatis, dispersis, KOH sanguineorubens, solutione mox cristalla acicularia formante; hyphis J non coerulescentibus. Apothecia 0.3–0.5 mm. lata, basi constricta, disco plano, nigro, nudo aut cinereo-pruinoso, margine tenui, nigro. Hypothecium, stipes et excipulum fusconigricans, KOH sanguineo rubens, solutione mox cristalla acicularia formante. Hymenium 60 $\mu$ altum, haud oleoso-inspersum, superne fuligineum. Sporae 8:nae, fuscae, 1-septatae, septo crasso, membrana ceterum parum incrassata, 13–17 $\mu$ longae, 6–7 $\mu$ crassae. Specimen typicum in saxo, Cruz-Bay, insula St. John, legit F. Boergesen, Mar. 11, 1906. Holotypus in C conservatus.

HYPOTHALLUS consists of a few scattered black specks. THALLUS composed of large verrucae (0.25–0.50 mm. across) which become flattened and occasionally lobate. Verrucae tan, but usually covered with a light cinereous pruina. APOTHECIA 0.3–0.5 mm. across, superficial, constricted at the base. Disk black, frequently covered with a cinereous pruina, plane. Margin black, thin to moderate.

Hypothecium, stipes and exciple confluent, dark brown. Hymenium 60 $\mu$ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium. Apical cells of paraphyses enlarged and fusco-capitate. Spores 8 in ascus, brown, 1-septate with septum thickened to form a central isthmus, 13–17 × 6–7 $\mu$. (See fig. 2I)

Chemical Reactions: Hypothecium and stipes KOH + (red, crystals); thallus section I – ; KOH + (red, crystals).

Known only from one collection on rock from the Virgin Islands.

*Material seen*: ST. JOHN — Cruz-Bay, on coastal rocks, *F. Boergesen*, March 11, 1906 (C-mixed with holotype of *Buellia orcularia*).

This collection was published by Wainio (1915) as *Buellia conspirans*. It differs from the holotype of *B. conspirans* (Herb. Nylander no. 10547), however, in the dark brown exciple and in the better developed thallus. The exciple in *B. conspirans* is pallid and the thallus consists of crowded, irregularly shaped granules.

### **Buellia brittoniae** Riddle, Mycologia 15: 86. 1923.

Type collection: Collected on sandstone at La Cañada on Isle of Pines (off Cuba) in West Indies by N. L. Britton, E. G. Britton, & Percy Wilson, no. 14579, Feb. 16, 1916. Holotype in FH (Riddle Herb.); isotype in NY.

HYPOTHALLUS scant, consisting of a few scattered black specks. THALLUS consists of narrow (0.2–0.3 mm.), slightly convex, dark brown laciniae which grow centrifugally and fork repeatedly. At a distance of 0.6 to 1.3 mm. from the tips the laciniae become rimose and areoles develop. The original pattern of the laciniae is visible for a considerable distance but at the very center of the thallus the areoles become very irregular and no definite pattern is discernible. APOTHECIA 0.3–0.5 mm. across, superficial, constricted at the base. Disk black, dull, rather scabrid, somewhat convex. Margin thin, at first brownish but becoming concolorous, at length excluded.

Hypothecium pallid or very pale brown (in thick sections); stipes colorless; exciple pallid but brown at margin. Hymenium ca. 85 μ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium. Apical cells of paraphyses enlarged and fusco-capitate. Spores 8 in ascus, brown, 1-septate, but frequently exhibiting shadowy secondary septation indicative of an incipient 3-septate condition, 10–12 × 5–6 μ.

Chemical Reactions: Epithecium KOH + (yellow), other apothecial tissues KOH − ; thallus section KOH + (yellow), I − .

A saxicolous species known only from Isle of Pines.

*Material seen*: CUBA (ISLE OF PINES) — on sandstone, La Cañada, *Britton, Britton & Wilson 14579*, Feb. 16, 1916 (FH-Riddle, NY); Las Tunas Mts., on quartz, Las Tunas, *Britton, Britton & Wilson 15518*, Feb. 22, 1916 (FH, FH-Riddle, NY).

### **Buellia calispora** (Knight) Steiner, Bull. Herb. Boissier, ser. 2. 7: 645. 1907.

*Lecidea callispora* Knight, Trans. Linn. Soc. London, ser. 2, Bot. 2: 45. 1882.
*Karschia fraudans* Starb. Bih. K. Svensk. Vet.-Akad. Handl. 25 (III,1): 10. 1899.
*Buellia didyma* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 91. 1915.
*Buellia rinodinospora* Riddle, Bull. Torrey Bot. Club. 44: 321. 1917.
*Buellia blasteniospora* Zahlbr. Ann. Mycol. 33: 45. 1935.

Type collections: *Lecidea callispora* — Collected on bark of trees in Sidney, New South Wales by Knight. I have not located the type specimen.

*Karschia fraudans* — I have not located the type specimen but Nannfeldt (1932, p. 323) cites Malme's study of the type specimen as reason for putting *K. fraudans* in synonymy with *B. callispora*.

*Buellia didyma* — Collected by P. Duss, no. 161, at Basse-Terre, Guadeloupe (West Indies). Holotype in TUR (Vainio Herb. no. 9530).

*Buellia rinodinospora* — Collected by J. A. Cushman, no. 155, March 19, 1912, at Newcastle (4000 ft. elevation), Jamaica (West Indies). Holotype in FH (Riddle Herb.); isotypes in FH and MICH.

*Buellia blasteniospora* — Collected by Rapp, no. 95, on oak at Sanford, Florida (U.S.A.). An isotype is in FH. I have not seen the holotype.

HYPOTHALLUS not seen except as a black line delimiting thallus. THALLUS glaucous-cinereous, soon continuous from coalescent granules or patches; surface frequently somewhat verrucose and, when thick, becoming rimose. APOTHECIA 0.4–1.2 mm. across, scattered, superficial. Disk black, dull, naked, plane to somewhat convex. Margin concolorous and moderately thick.

Hypothecium, stipes and exciple ± confluent, dark brown. Hymenium 100–200 μ thick, colorless, inspersed with oil drops; paraphyses forming a pale yellow-brown epithecium. Apical cells of paraphyses only slightly enlarged and fusco-capitate. Spores 8 in ascus (occ. 4 or 6), 1-septate, with walls thickened at septum (forming isthmus) and also just below the apex, sometimes slightly curved, 29–42 × 14–21 μ, germinating at both ends. Young spores more or less colorless, non-septate and with a slight halo. (See fig. 2G)

Chemical Reactions: Apothecial tissues KOH − ; thallus section KOH − .

A hygrophytic, corticolous and lignicolous species of wide distribution. In addition to the West Indian material collections have been examined from the United States, South America and the Hawaiian Islands.

*Material seen*: JAMAICA — Newcastle, 4000 ft., *Cushman 155*, March 19, 1912 (FH, FH-Riddle, MICH); Cinchona, 1500 m., *Maxon & Killip 1275*, March 20, 1920 (FH); Goshen, 1000 ft., *Imshaug 15984*, May 8, 1953 (Imsh); Coopers Hill, 2450 ft., *Imshaug 14126*, Jan. 27, 1953 (Imsh); Bellevue to Mt. Rosanna, 3800 ft., *Imshaug 14465 & 14482*, Feb. 4, 1953 (Imsh); Birchs Hill, 1809 ft., *Imshaug 15704*, April 24, 1953 (Imsh); Farm Hill, 4000 ft., *Imshaug 14785*, Feb. 21, 1953 (Imsh); ridge northwest of Murdocks Gap, 3600 ft., *Imshaug 15337*, March 15, 1953 (Imsh); Guava Ridge, 2900 ft., *Imshaug 14335a*, Feb. 3, 1953 (Imsh); forest hut above Corn Puss Gap, 3550 ft., *Imshaug 13455*, Nov. 20, 1952 (Imsh); forest hut at Murdocks Gap, 3300 ft., *Imshaug 15299a*, March 15, 1953 (Imsh).

GUADELOUPE — Basse-Terre, *Duss 510*, 1897 (NY); Basse-Terre, *Duss 161* (Tur-Vainio 9530).

### **Buellia catasema** (Tuck.) Tuck. Syn. N. Am. Lich. 2: 161. 1888.

*Lecidea catasema* Tuck. Proc. Am. Acad. Arts & Sci. 6: 283. 1866.
*Buellia hiorami* B. de Lesd. Bull. Soc. Bot. France 87: 140. 1940.

Type collections: *Lecidea catasema* — Collected on tree in Cuba (West Indies) by Wright, no. 242. Holotype in FH (Tuckerman Herb. 3296).

*Buellia hiorami* — The original description is based on two collections made in Cuba by Frère Hioram in 1930. The two localities (El Palenque, alt. 400 m., and Loma San Juan, alt. 1000 m.) are both in Province de Oriente. A holotype was not designated and both collections were destroyed in World War II. No duplicates have been located.

HYPOTHALLUS seen only as a black delimiting line between a thallus of *B. catasema* and a thallus of another species. THALLUS composed of small (0.05–0.15 mm. across), cinereous or very pale sulphureous granules which are scattered over the bark or are ± coalescent to form a rather continuous but granulose crust. APOTHECIA 0.2–0.4 mm. across, scattered or occasionally conglomerate, narrowly constricted at base. Disk black, dull, naked, ± plane. Margin concolorous, rather thin and inconspicuous.

Hypothecium and stipes brown, confluent. Exciple thin, brown. Hymenium 40–65 $\mu$ thick, not inspersed with oil drops, usually colored with shades of green, yellow and brown; paraphyses forming a brown epithecium, with apical cells enlarged and fusco-capitate. Spores brown, 1-septate, smooth, walls thin and even, (9) 11–14 (15) × 4–6 (7) $\mu$.

Chemical Reactions: Apothecial tissues KOH – (or, occasionally, hypothecium KOH +, red out in solution, but no crystals formed); thallus section KOH – (except for red areas in var. *sanguinariella*).

A mesophytic, corticolous species found also in the United States, Central America and South America.

### var. **catasema**

Medulla white, KOH – .

*Material seen*: CUBA — *Wright 242* (FH-Tuckerman 3296); on *Conocarpus*, Isle of Pines, Siguanea, *Britton, Britton & Wilson 14940*, Feb. 26, 1916 (FH-Riddle, NY).

JAMAICA — Flora River, 2700 ft., *Imshaug 14379*, Feb. 3, 1953 (Imsh); gap southeast of Catherines Peak, 4500 ft., *Imshaug 13893*, Jan. 12, 1953 (Imsh).

GRENADA — Tree on cultivated slope of Mt. Maitland, 1050 ft., *Imshaug 16204*, July 15, 1953 (Imsh); on Coconut in cultivated area along Grand Etang Road near Good Hope Water Works, 950 ft., *Imshaug 16238*, July 19, 1953 (Imsh).

### var. **sanguinariella** (Nyl.) comb. nov.

*Lecidea parasema* var. *endococcina* Tuck. Proc. Am. Acad. Arts & Sci. 4: 283. 1866.
*Lecidea sanguinariella* Nyl. Ann. Sci. Nat. V. 7: 328. 1867.
*Buellia sanguinariella* (Nyl.) Zahlbr. in Rechinger, Denkschr. Math.-Nat. Kl. Akad. Wiss. Wien 81: 275. 1907.
*Buellia endococcodes* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 92, 1915.

Type collections: *Lecidea parasema* var. *endococcina* — Collected on bark in Cuba (West Indies) by Wright. Holotype in FH (Tuckerman Herb. 3296).

*Lecidea sanguinariella* — Collected on a tree at Rio Negro, alt. 1200 m., in New Granada by Lindig in 1863. Holotype in H (Nylander Herb. 10642).

*Buellia endococcodes* — Collected on *Byrsonima* near Sofaga in Guadeloupe (West Indies) by P. Duss no. 1413. Holotype in TUR (Vainio Herb. 9446).

Medulla frequently bright red. The red areas are KOH + (lavender color out in solution, no crystals).

*Material seen*: BAHAMAS — Crooked Island, *Brace* (MICH); Jingo Hill, Crooked Island, *Brace 4758*, Jan. 18, 1906 (FH-Riddle, NY); Vauxhall, Crooked Island, *Brace 4726*, Jan. 16, 1906 (FH-Riddle, NY).

CUBA — *Wright* (FH-Tuckerman 3296); on *Cocothrinax*, La Canada, Isle of Pines, *Britton, Britton & Wilson 14423a*, Feb. 16, 1916 (NY); on *Colpothrinax*, San Pedro, Isle of Pines, *Britton & Wilson 14827*, Feb. 12–March 22, 1916 (FH-Riddle, NY); Isle of Pines, *Britton & Wilson* (MICH).

JAMAICA — north slope of Montpelier, 2100 ft., *Imshaug 14271*, Jan. 29, 1953 (Imsh).

GUADELOUPE — Sofaga, *Duss 1413* (TUR-Vainio 9446).

GRENADA — Mt. Maitland, 1050 ft., *Imshaug 16201 & 16203*, July 15, 1953 (Imsh).

I have been unable to detect any difference between *B. catasema* and *B. sanguinariella* other than the red color of the medulla. This color appears quite variable, at times even in the same thallus. My collections from Mt. Maitland in Grenada were a mixture of the two varieties.

It seems reasonably certain from the original description that *B. hiorami* is this species.

### **Buellia dejungens** (Nyl.) Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 79. 1915.

*Lecidea dejungens* Nyl. Ann. Sci. Nat. IV. 19: 355. 1863.
*Buellia dejungens* var. *chrysophaea* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 80. 1915.
*Buellia dejungens* var. *chrysochlora* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 81. 1915.
*Buellia dejungens* var. *chrysochroa* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 82. 1915.
*Buellia endochrysea* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 83. 1915.
*Buellia finkii* Merrill in Hedrick, Mycologia 22: 255. 1930.

Type collections: *Lecidea dejungens* — Collected by C. Wright "ad rupes calcareas" in Cuba (West Indies). Holotype in H (Nylander Herb. 5726b).

*Buellia dejungens* var. *chrysophaea* — Collected at Magensbay Estate in St. Thomas (West Indies) by F. Boergesen, Dec. 28, 1905. Holotype in C.

*Buellia dejungens* var. *chrysochlora* — Wainio cited two collections. The St. Jan collection is the only one in C but no spores could be found in it. The St. Croix collection in TUR (Vainio Herb. 9525) consists of one fragment and I have selected it as the lectotype.

*Buellia dejungens* var. *chrysochroa* — Collected at Rustenberg in St. John (West Indies) by F. Boergesen, March 15, 1906. Holotype in C.

*Buellia endochrysea* — Collected at 800 ft. elevation on Magensbay Estate in St. Thomas (West Indies) by F. Boergesen. Holotype in C; a fragment is in TUR (Vainio Herb. 9539), but it does not have well-developed *B. endochrysea* on it.

*Buellia finkii* — Collected at Aibonito (eastward exposure at 2100 ft.), Puerto Rico (West Indies) by Bruce Fink, no. 1884, Jan. 4, 1916. Holotype in MICH; isotypes in FH & NY.

HYPOTHALLUS usually evident only at periphery as a thin black border. When the thallus is exceptionally well-developed a black hypothallus may be seen occasionally between the areoles. THALLUS usually very thin and continuous, becoming somewhat rimulose. Surface smooth and somewhat nitidous. Color variable, from cinereous to somewhat greenish or sordid yellowish or brownish; frequently blackening along the cracks. When well-developed the thallus becomes thick and areolate. Medulla usually white but occasionally yellow or orange in spots. APOTHECIA 0.2–0.7 mm. across, narrowly constricted at base. Disk usually black, but occasionally ± reddish brown, dull, naked, plane (rarely convex on well-developed specimens). Margin moderately thick (although excluded when disk becomes convex) and raised, concolorous.

Hypothecium pallid or yellowish; stipes orange or reddish-brown; exciple dark brown. Hymenium 60–85 (100–120) μ thick, colorless, not inspersed with oil drops; paraphyses forming a conspicuous dark brown epithecium. Apical cells of paraphyses enlarged and fusco-capitate. Spores 8 in ascus, pale fuscous, 1–septate with very thick walls (not mischoblastiomorph), 14–18 (21) × (6) 7–9 (11) μ. (See fig. 2C)

Chemical Reactions: Stipes, hypothecium and exciple KOH + (deep lavender purple out in solution), other apothecial tissues KOH – ; thallus section I – , Pd – , portions KOH + (deep lavender purple out in solution).

A mesophytic, saxicolous species known only from the West Indies.

*Material seen*: CUBA — locality unknown, *Wright* (H-Nylander 5726b).

PUERTO RICO — Rio Cuyan, *Britton 8565*, Feb. 13, 1926 (NY); Dos Bocas above Corozal, *Britton, Britton & Chardon 8948 & 8952*, Feb. 25, 1927 (MICH, NY); 2100 ft., Aibonito, *Fink 1884*, Jan. 4, 1916 (FH, MICH, NY); 2200 ft., Aibonito, *Fink 1940*, Jan. 5, 1916 (FH, MICH).

ST. THOMAS — Water Bay, *Britton, Britton & Kemp 14*, March 10–16, 1923 (MICH, NY); Tutu, *Britton, Britton & Kemp 26*, March 10–16, 1923 (MICH, NY); Tutu, *Britton, Britton & Marble 469b*, Feb. 8–9, 1913 (FH-Riddle, MICH, NY); Botany Bay, *Britton, Britton & Kemp 36*, March 10–16, 1923 (MICH, NY); Magensbay Estate, Boergesen, Dec. 28, 1905 (TUR-Vainio 9539 & C); Loevenlund, *Raunkiaer 404*, Dec. 15, 1905 (C).

ST. CROIX — Hams Bluff, *Boergesen*, Feb. 6, 1906 (C); summit of Mt. Eagles, *Boergesen*, Jan. 28, 1906 (C); Caledonia Dal, *Boergesen*, Feb. 16, 1906 (TUR-Vainio 9525).

ST. JOHN — Esperance, *Boergesen*, March 7, 1906 (C); Rustenburg, *Boergesen*, March 15, 1906 (C).

This species is rather common in Puerto Rico and the Virgin Islands and Wainio has described three varieties and one closely related species from this region. These appear to the present writer to be merely ecological variations and are not recognized nomenclaturally.

The original material collected in Cuba by Wright has a very thin, continuous thallus, quite green in color (due to the absence of a cortex) and is nitidous. It is only barely becoming somewhat rimulose. The green color is apparently from the algal layer.

Most material collected of this species has a thicker thallus with a sordid cinereous-fuscescent color and not so nitidous. The thallus is also noticeably rimose-areolate. The cracks in the thallus frequently blacken and the thallus has a variegated appearance. This brown, areolate variation was described by Wainio as var. *chrysophaea*.

Occasionally the disk of the apothecium appears rusty in color, rather than black. This is due to a development of the orange-yellow pigment, typical of the hypothecium, in the epithecium. This variation was described by Wainio as var. *chrysochroa*.

*Buellia dejungens* var. *chrysochlora* and var. *chrysochroa* were both characterized by Wainio as "thallus cinereo-glaucescens, nitidulus." The original material, however, is fragmentary and, in part, overgrown by other species. In some instances it is possible that there was confusion with an adjacent sterile thallus.

In the type collection of *B. finkii* the thallus is exceptionally well-developed with thick, cinereous areoles. The areoles are occasionally somewhat dispersed. A transition, however, can be observed from a thin, continuous, sordid yellow-brown thallus on one face of the rock to a thick, areolate, cinereous thallus on another side of the rock. Isotype material of *Buellia finkii* was annotated by Wainio as *Buellia dejungens*.

The original collection of *B. endochrysea* is rather fragmentary and my impression is that it represents an interesting case of regeneration in *B. dejungens*. The thallus consists of an areolate form of *B. dejungens* which has blackened completely in several places. Small squamules appear on the surface of the blackened areoles. In another place a thin, branching, brown, laciniate thallus also is growing on the blackened areoles. There are no apothecia on the laciniate thallus. The apothecia on the squamulose thallus are typical of *B. dejungens*.

### **Buellia dispersula** Müll. Arg. Bull. Soc. Bot. Belg. 32: 144. 1893.

Type collection: The only specimen in the Müller-Arg. Herb. (G) was collected by Tonduz in 1893 at San Marcos, Costa Rica.

HYPOTHALLUS scant, consists of only a few scattered black specks. THALLUS consists of scattered, small (up to 0.2 mm. long), frequently elongated areoles which occasionally form branching linear rows. At times the areoles are abundant and then are more or less contiguous. Areoles are white to cinereous, or speckled dark gray. APOTHECIA large for size of areoles, 0.4–0.6 mm. across, scattered, superficial, narrowly constricted at base. Disk black, naked, dull, plane. Margin concolorous and rather thick.

Hypothecium and stipes confluent, brown; exciple thick, ± pallid but brown at margin. Hymenium 50–60 μ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells enlarged and fusco-capitate. Spores 8 in ascus, brown, 1-septate, walls thin and even, (11) 13–17 (19) × 6–7 μ.

Chemical Reactions: Hypothecium and stipes KOH + (red, crystals); thallus section I – ; KOH + (red, crystals).

A saxicolous, Central American species known from the Caribbean only from one island off the coast of Nicaragua.

*Material seen*: ISLA DE PROVIDENCIA — outcrop of volcanic rock, *Proctor*, May 1–9, 1948 (PH).

The above description is taken from the Caribbean collection which differs from the type from Costa Rica only in the smaller spores and thinner hymenium. The holotype of *B. dispersula* has spores 18–21 (33) × 8–10 (17) μ, and hymenium 85–100 μ thick.

### **Buellia efflorescens** Müll. Arg. Hedwigia 32: 129. 1893.

*Buellia tuamotensis* Herre, Bryologist 56: 281. 1953.

Type collections: *Buellia efflorescens* — Collected on trees near Singapore by Maingay, no. 158. Holotype in K (not seen).

*Buellia tuamotensis* — Collected on trees on Raroia Atoll, Tuamotu Archipelago, by M. S. Doty in 1952. Preserved in BISH and private herbarium of A. W. Herre (not seen).

HYPOTHALLUS not seen. THALLUS at first in scattered patches but later coalescent into a continuous, smooth, cinereous to pale yellow-green or pale sulphureous crust, occasionally rimulose with age. Soralia either widely scattered or, occasionally, abundant and ± confluent, pale yellow, 0.1–0.3 mm. across. APOTHECIA 0.2–0.6 mm. across, narrowly constricted at base. Disk black, naked, dull, plane to convex. Margin thin, concolorous.

Hypothecium and stipes light brown. Exciple dark brown-black. Hymenium 50–60 μ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells much enlarged and prominently fusco-capitate. Spores 1-septate, smooth, walls thin and even, 10–14 × 5–7 μ. Immature spores with many small oil droplets.

Chemical Reactions: Apothecial tissues KOH – ; thallus section KOH – .

A xerophytic and mesophytic, corticolous species of wide distribution on tropical islands.

### var. **efflorescens**

Spores 8 in ascus.

*Material seen*: JAMAICA — White River Bay, 30 ft., *Imshaug 15765*, May 4, 1953 (Imsh); summit of Catherines Peak, 5000 ft., *Imshaug 13319*, Nov. 11, 1952 (Imsh); north slope of Portland Ridge, 200 ft., *Imshaug 13269*, Oct. 24, 1952 (Imsh); Montego Bay, *Cushman 91*, Feb.–March 1912 (FH, MICH, NY, F-1142406); Silver Hill Gap, 3450 ft., *Imshaug 14090*, Jan. 21, 1953 (Imsh).

ST. THOMAS — Crown, *Raunkiaer 421*, Nov. 31, 1905 (C — no apothecia).

GUADELOUPE — on *Coccoloba uvifera*, Basse-Terre, *Duss 1502* (TUR-Vainio 9229).

GRENADA — sea level, Grenade Bay, *Imshaug 16302*, July 24, 1953 (Imsh); sea level, Coconut Grove, Grand Anse Beach, *Imshaug 16068, 16073 & 16074*, July 4, 1953 (Imsh); sea level, Coconut Grove, Levera Bay, *Imshaug 16156 & 16158*, July 12, 1953 (Imsh); sea level, south coast of Point Saline, *Imshaug 16128 & 16129*, July 9, 1953 (Imsh); dry scrub woodlands, 100 ft., Morne Rouge Cove, *Imshaug 16136*, July 9, 1953 (Imsh).

This variety is probably more common than its present known distribution would indicate. The soralia are easily overlooked and many tropical records of *B. punctata* or *B. myriocarpa* probably refer to this species. It is doubtful if *B. punctata* occurs in the tropics.

If soralia are abundant the apothecia are scarce; likewise, if the soralia are scarce, apothecia are abundant. Occasionally, the thallus may be very scant, in which case the soralia are more difficult to detect.

### var. **diminutiva** (Wainio) comb. nov.

*Buellia polyspora* var. *diminutiva* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 93. 1915.

Type collection: Collected on a tree at Cane Bay in St. Croix (West Indies) by Raunkiaer, no. 467, Jan. 4, 1906. Holotype in C; isotype in TUR (Vainio Herb. 9494).

Thallus scant and soralia not so abundant as in var. *efflorescens*. Apothecia minute, 0.1–0.2 mm. across. Spores ca. 32 in ascus, pale fuscous, 6–10 × ca. 3 $\mu$.

*Material seen*: PUERTO RICO — shrubs on dry open hill, Yauco, *Fink 1428*, Dec. 28, 1915 (FH); shrubs on dry hill top, Yauco, *Fink 1455*, Dec. 30, 1915 (F-1271625, FH, MICH, NY, US).

ST. CROIX — Cane Bay, *Raunkiaer 467*, Jan. 4, 1906 (C, TUR-Vainio 9494).

Soralia, although definitely present in the holotype from St. Croix, are not definitely present in the material from Puerto Rico.

### **Buellia gerontoides** (Stirton) comb. nov.

*Lecidea gerontoides* Stirton, Trans. Glasgow Soc. Field Naturalists 4: 165. 1876.

*Catillaria gerontoides* (Stirton) Zahlbr. Cat. lich. univ. 4: 17. 1926.

Icones: Botany of the Maya Area, Miscellaneous Papers VI. Lichens from the Yucatan Peninsula by Joyce Hedrick. Plate 4, fig. b (photograph sub *B. aeruginascens*). Carnegie Inst. Wash. Publ. 461. 1936.

Type collection: Collected by Rev. G. Brodie on a tree near Port of Spain, Trinidad (West Indies). Holotype in BM.

HYPOTHALLUS not seen. A black delimiting line is seen only when thallus is adjacent to a thallus of a different species. THALLUS composed of small patches which soon coalesce to form a continuous, yellow-green or bright sulphureous (rarely pale sulphureous) crust. Thick thalli become somewhat rimose. APOTHECIA 0.3–1.5 mm. across, constricted at base. Disk covered with an aeruginose, yellow-green pruina, plane to occasionally ± convex. Margin black, frequently wavy or crenulate, occasionally pruinose on inside (near disk); thick, raised and conspicucus.

Hypothecium and stipes brown, confluent. Exciple occasionally ± pallid but usually brown. Hymenium 60–85 μ thick, colorless, not inspersed with oil drops; paraphyses not forming a colored epithecium, apical cells only slightly enlarged and scarcely fusco-capitate. Spores 8 in ascus, 1-septate, brown, smooth, walls thin and even, frequently germinating at both ends, 12–17 (21) × 5–7 μ.

Chemical Reactions: Epithecium KOH — (or occasionally producing balls of colorless crystals as in thallus), hypothecium KOH + (red, crystals); thallus section KOH + (balls of colorless crystals).

A xerophytic-mesophytic, corticolous species known only from the West Indies and Central America.

*Material seen*: ISLAND UNKNOWN — on Coconut, *Breutel* (M).

BAHAMAS — on *Cocothrinax jucunda*, Great Exuma, Stocking Island, *Britton & Millspaugh 3065*, Feb. 22–28, 1905 (FH-Riddle); on *Mimusops parvifolia*, Ship Channel Cay, Exuma Chain, *Britton & Millspaugh 2765*, Feb. 17, 1905 (FH-Riddle); Fortune Island, *Hitchcock 3*, Nov. 27, 1890 (MO–32455).

CUBA — bark of Red Mangrove, Cayo Largo, Prov. of Havana, *Proctor*, April 4–9, 1948 (PH).

JAMAICA — north slope of Portland Ridge, 200 ft., *Imshaug 13254*, Oct. 24, 1952 (Imsh); SE slope of Hellshire Hummock, 300–400 ft., *Imshaug 13685*, Dec. 16, 1952 (Imsh); sea level, Long Bay, *Imshaug 15582*, April 21, 1953 (Imsh); Montego Bay, *Cushman 89*, Feb.–March 1912 (FH, FH-Riddle, MICH, NY); sea level between Runaway Bay and Dry Harbour, on Coconut, *Imshaug 15998, 15999 & 16001*, May 9, 1953 (Imsh); White River Bay, 30 ft., *Imshaug 15761*, May 4, 1953 (Imsh); Dunn's River, 150 ft., *Imshaug 15739 & 15751*, May 4, 1953 (Imsh); stump of Coconut, Galina Point, sea level, *Imshaug 13863*, Dec. 27, 1952 (Imsh); sea level, Rocky Point, *Imshaug 15399, 15402, 15404*, April 7, 1953 (Imsh).

ST. CROIX — *Breutel* (H-Nylander 10289, M).

ST. THOMAS — on Coconut, Charlotte Amelia, *Britton, Britton & Marble 489a*, Feb. 8–9, 1913 (FH-Riddle, MICH, NY).

PETER ISLAND — *Britton & Shafer 862a*, Feb. 13–17, 1913 (FH-Riddle, NY).

ANEGADA — west end of island, *Britton & Fishlock 989a*, Feb. 19–20, 1913 (FH-Riddle, NY).

SAINT BARTHÉLEMY — sur écorces de Mapores, Camaruche, *LeGallo 404*, Aug. 26, 1951 (MO–174107).

GRENADA — sea level in Coconut Grove, Levera Bay, *Imshaug 16156, 16159, 16160 & 16161*, July 12, 1953 (Imsh); Coconut Grove, 200 ft., La Sagesse Little River, *Imshaug 16289 & 16291*, July 22, 1953 (Imsh); cultivated slope of Mt. Maitland, 1050 ft., *Imshaug 16197*, July 15, 1953 (Imsh).

SAN ANDRÉS — bark of Mango & Coconut, *Proctor*, April 22–27, 1948 (PH).

SWAN ISLAND — Nelson, April 1912 (FH).

In numbers 16197, 16289 & 16291 (all from Grenada) the color of the thallus was a very pale sulphureous and the pruina on the apothecial disk was almost white. In all other respects they agreed well with the description given.

This species has generally been called *B. aeruginascens*. These two species are not, however, identical, nor is *B. aeruginascens* identical with *B. melanochlora*. The differences between these and other species with pruinose disks are summarized in Table II.

I am indebted to Dr. I. M. Lamb for calling my attention to this species which was erroneously transferred to *Catillaria* by Zahlbruckner.

### **Buellia glaucotheca** (Fée) Malme, Ark. Bot. 21A (14): 20. 1927.

*Lecidea glaucotheca* Fée, Suppl. Essai Crypt. Écorces Exot. Offic. 109. 1837.

*Buellia subdisciformis* (Leight.) Wainio f. *caesiopruinosa* Tuck. in Wainio, Étude Lich. Brésil 1: 167. 1890.

Type collections: *Lecidea glaucotheca* — "Habitat in corticibus Cinchonae Condamineae, H. et B." (Humboldt & Bonpland). The collection probably came from Peru since that is where Humboldt & Bonpland list the host plant from. I have not located the type collection.

*Buellia subdisciformis* f. *caesiopruinosa* — Collected by Wright, no. 240, in Cuba (West Indies). Holotype in FH (Tuckerman Herb. 3298).

HYPOTHALLUS not seen except as a black delimiting line around thallus. THALLUS cinereous or slightly sulphureous, soon continuous from coalescent patches, moderately thick and becoming somewhat rimose; surface rather rough. APOTHECIA 0.4–0.8 mm. across, scattered, superficial. Disk black but usually covered with a white pruina, plane. Margin black, moderately thick and slightly raised.

Hypothecium and stipes confluent, brown. Exciple ± pallid. Hymenium 80–100 μ thick, colorless, not inspersed with oil drops; paraphyses not forming a colored epithecium but epithecium appears gray due to pruina. Paraphyses filiform, apices neither enlarged nor fusco-capitate. Spores 8 in ascus, brown, 1-septate, walls thin and even, surface smooth, 18–28 × 7–10 (12) μ.

Chemical Reactions: Hypothecium KOH + (red, crystals), other apothecial tissues KOH – ; thallus section KOH + (red, crystals).

A hygrophytic, corticolous and lignicolous species known from the West Indies and South America.

*Material seen*: CUBA — *Wright 240* (FH-Tuck. 3298).

JAMAICA — *Cummings 316*, Feb.–March 1905 (FH); ridge NW of Murdocks Gap, 3600 ft., Blue Mountains, *Imshaug 15313*, March 15, 1953 (Imsh); Farm Hill, 4000 ft., S slope of Blue Mts., *Imshaug 14772*, Feb. 21, 1953 (Imsh); forest hut at Murdocks Gap, 3300 ft., *Imshaug 15299a*, March 15, 1953 (Imsh); forest hut at Corn Puss Gap, 3550 ft., *Imshaug 13455*, Nov. 20, 1952 (Imsh); summit of Blue Mt. Peak, 7400 ft., *Imshaug 13015*, Oct. 8, 1952 (Imsh); Belle View, *Plitt J–145*, July 8, 1919 (BPI).

As with most species whose thallus gives a KOH + (red, crystals) reaction the medulla is occasionally (but rarely) reddish in color.

This species is not identical with *B. aeruginascens*. For the differences between these two and other species with pruinose disks see Table II.

### **Buellia glaziouana** (Krmphbr.) Müll. Arg.

Flora 63. 19. 1880.

*Lecidea glaziouana* Krmphbr. Flora 59: 317. 1876.

*Rinodina thomae* Tuck. Syn. N. Am. Lich. 1: 209. 1882.

*Rinodina contiguella* Wainio, Étude Lich. Brésil 1: 164. 1890.

*Lecidea cohibilis* Nyl. Sertum Lich. Trop. Labuan et Singapore 42. 1891.

*Buellia contiguella* (Wainio) Malme, Bih. K. Svenska Vet.-Akad. Handl. 28(III, 1): 5. 1902.

*Buellia moreliiensis* B. de Lesd. Lich. Mex. 26. 1914.

*Melanaspicilia contiguella* (Wainio) Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 79. 1915.

*Melanaspicilia contiguella* var. *vegetior* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 79. 1915.

*Buellia cohibilis* (Nyl.) Zahlbr. Cat. lich. univ. 7: 344. 1931.

*Buellia contiguella* var. *vegetior* (Wainio) Zahlbr. Cat. lich. univ. 7: 346. 1931.

Type collections: *Lecidea glaziouana* — Collected "ad saxa granitica" in Prov. Rio de Janeiro, Brazil, by D. A. Glaziou, no. 3506. Holotype and two isotypes in M.

*Rinodina thomae* — Collected by T. M. Peters on sandstone rocks at Moulton, Alabama (U. S. A.). Holotype in FH (Tuckerman Herb. 2125); isotype in MICH.

*Rinodina contiguella* — Collected "ad rupem quartziticam" near Rio de Janeiro, Brazil, by E. A. Wainio, no. 59. Holotype in TUR (Vainio Herb. 9078).

*Lecidea cohibilis* — Collected on sandstone at Lookout Mt., Tennessee (U. S. A.) by

W. W. Calkins. Holotype in H (Nylander Herb.). Portions of this collection are in F–30152, FH, MICH, MO–34678, NY, and US.

*Buellia moreliiensis* — The original material was collected by Frère Arsène Brouard in Morelia, Mexico, on volcanic rocks. No holotype was designated and most of the material was destroyed in World War II. I have seen one of the collections from the private herbarium of A. H. Magnusson. Additional material may be in the unmounted collections at US.

*Melanaspicilia contiguella* var. *vegetior* — Collected on rock at Magensbay Estate, St. Thomas (West Indies) by F. Boergesen, Dec. 28, 1906. Holotype in C; isotype in TUR (Vainio Herb. 9081).

HYPOTHALLUS absent except as a narrow black margin delimiting the thallus from neighboring thalli. THALLUS thin to moderately thick, pale creamy yellow, continuous, becoming rimose-areolate. APOTHECIA 0.2–0.7 mm. across, immersed to emergent, not constricted at base. Disk black, naked, dull, plane. Margin moderately thick and raised, at first concolorous with thallus but soon blackening.

Hypothecium and stipes confluent, brown; the stipes often very poorly developed. Exciple pallid but brown at margin. Hymenium 60–70 $\mu$ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells enlarged and fusco-capitate. Spores 8 in ascus, brown, 1-septate with thin, uniform walls, (10) 11–15 (16) × (5)6–7(8) $\mu$.

Chemical Reactions: Apothecial tissues KOH – ; thallus section KOH + (clear yellow out in solution), C – , K(C) – , Pd + (cinnabar), I + (blue, in spots).

A mesophytic, saxicolous species of wide distribution in South America, North America, Central America and the West Indies.

The type specimen of *B. glaziouana* showed a blue reaction with iodine in the medulla. This is contrary to the statements of Wainio and Malme.

This is a common and variable lichen in the warmer regions of the Western Hemisphere. There are three main lines of variation:

1) Apothecia remain more or less immersed due to the poor development of the stipes. This variation was described as *Rinodina contiguella* by Wainio.

2) Thallus whitens and apothecial initials are frequently abortive. It is possible that these are responses to some nutritional deficiency. This variation has been called *B. poliocheila* (also, *B. antillarum*). *B. glaziouana* f. *albinea* Räs., however, represents an entirely different species.

3) Thallus contains a depsidone giving the reaction KOH + (red, crystals). This variation has been called *B. recepta* and *B. sensitiva*.

The last two variations are quite distinctive and are regarded as varieties.

### var. **glaziouana**

Thallus yellowish, KOH + (yellow out in solution). Apothecia either adnate on surface of thallus or immersed in thallus.

Material seen: JAMAICA — SW slope near summit of Mt. Rosanna, 4000 ft., *Imshaug 13985 & 14005*, Jan. 14, 1953 (Imsh); Bellevue, 3800 ft., *Imshaug 14454*, Feb. 4, 1953 (Imsh); Halberstadt to Bloxburgh, 2800 ft., *Imshaug 15038*, March 3, 1953 (Imsh); NE slope of Catherines Peak, 4500 ft., *Imshaug 13808*, Dec. 26, 1953 (Imsh).

PUERTO RICO — Publito del Rio, *Britton & Britton 9426a*, Jan. 6, 1930 (MICH, NY); Naranjito, 2000 ft., *Fink 219*, Nov. 27, 1915 (MICH).

ST. CROIX — Cotton Valley, *Britton, Britton & Kemp 170*, March 17–25, 1923 (MICH, NY).

### var. **poliocheila** (Wainio) comb. nov.

*Buellia poliocheila* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 85. 1915.

*Buellia antillarum* B. de Lesd. Bull. Muséum Hist. Nat. Paris II. 15: 470. 1943.

Type collections: *Buellia poliocheila* — Collected on rocks at Ma Folie, St. Thomas (West Indies) by Biese. Holotype in C; isotype in TUR (Vainio Herb. 9541).

*Buellia antillarum* — Collected on volcanic rock at sea level at Anse du Sud de Bouillante, Guadeloupe (West Indies). Holotype in PC.

Thallus white or cinereous. Apothecial initials frequently abort, leaving shallow, ochraceous pits. Hymenium 50–65 μ thick; spores 10–12 (14) × 5–7 μ.

*Material seen*: JAMAICA — NE slope of Catherines Peak, 4500 ft., *Imshaug 13808 & 13815*, Dec. 26, 1952 (Imsh).

PUERTO RICO — Publito del Rio, *Britton & Britton 9425*, Jan. 6, 1930 (MICH, NY).

ST. CROIX — Cotton Valley, *Britton, Britton & Kemp 59*, March 17–25, 1923 (MICH, NY).

ST. THOMAS — Magensbay Estate, *Boergesen*, Dec. 28, 1906 (C); Ma Folie, *Biese* (C).

ST. JOHN — Cruz-Bay, Strandklipper, *Boergesen*, March 11, 1906 (C).

GUADELOUPE — Anse du Sud de Bouillante (PC).

*Buellia antillarum* was described as differing from *B. poliocheila* by virtue of a white hypothecium. The hypothecium in the type material of both species is, however, brown.

### var. **sensitiva** (Zahlbr.) comb. nov.

*Buellia sensitiva* Zahlbr. Mycologia 22: 78. 1930.
*Lecidea recepta* Krmphbr. Flora 59: 318. 1876.
*Buellia recepta* (Krmphbr.) Müll. Arg. Linnaea 43: 36. 1880.

Type collections: *Buellia sensitiva* — Collected on rocks in an open field at Naranjito, Puerto Rico (West Indies) by Bruce Fink, no. 102, Nov. 25, 1915. Holotype in MICH.

*Lecidea recepta* — Collected "ad saxa granitica" in Prov. Rio de Janeiro, Brazil, by D. A. Glaziou, no. 3295, in 1869. Holotype and one isotype are in M.

Thallus somewhat duller and darker than in var. *glaziouana*; KOH + (red, crystals). Hymenium 60–75 μ thick; spores 12–16 (18) × 6–7 μ.

*Material seen*: PUERTO RICO — open field, Naranjito, *Fink 102*, Nov. 25, 1915 (MICH); Naranjito, *Fink 274*, Nov. 27, 1915 (FH, MICH, NY).

ST. THOMAS — Magensbay Estate, *Boergesen*, Dec. 28, 1905 (C).

The reaction of the thallus in the original material collected by Glaziou in Brazil is quite variable.

### **Buellia jamaicensis** sp. nov.

Hypothallus nigricans, ad ambitum solum visus. Thallus tenuis, continuus, demum saepe rimulosus, leviter verruculoso-inaequalis aut partim sat laevigatus, ochraceus, intus interdum aurantiacus, KOH sanguineo-rubens, solutione mox cristalla acicularia formante; hyphis J coerulescentibus. Apothecia 0.3–0.6 mm. lata, basi constricta, disco plano, opaco, nudo, nigro, margine fuscescens, vulgo parum prominente, crassitudine mediocri. Hypothecium et stipes fusconigricans; excipulum extus fusconigricans, intus pallidum. Hypothecium, stipes et excipulum KOH sanguineo-rubens, solutione mox cristalla acicularia formante. Hymenium 65–70 μ altum, haud oleoso-inspersum, superne fuligineum. Sporae 8:nae, verruculosae, fuscae, 1-septatae, paene 3-septatae, (13) 14–19 μ longae, 7–10 μ crassae. Specimen typicum in saxo, prope Clifton Mount, 1341 m., insula Jamaica, legit H. A. Imshaug, no. 13591, Dec. 3, 1952. Holotypus in FH conservatus.

HYPOTHALLUS seen only as a narrow, black, delimiting zone at periphery of thallus. THALLUS ochraceous, frequently blackening, rather thin, continuous, becoming rimose and occasionally somewhat verrucose. Medulla orange-red in spots. APOTHECIA 0.3–0.6 mm. across, constricted at base. Disk black, dull, naked, plane. Margin rather thick and raised, usually brownish but occasionally showing an orange-red tint.

Hypothecium and stipes confluent, brown; exciple pallid, but brown at margin, occasionally somewhat orange-red above. Hymenium 65–70 μ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells enlarged and fusco-capitate. Spores 8 in ascus, brown, somewhat verruculose, 1-septate but walls thickened so as to approach a 3-septate condition, (13) 14–19 × 7–10 μ.

Chemical Reactions: Hypothecium, stipes, and exciple KOH + (red, crystals); thallus section KOH + (red, crystals); medulla I + (blue).

A hygrophytic species found only on non-calcareous rock in Jamaica.

*Material seen*: JAMAICA — summit of Catherines Peak, 5000 ft., *Imshaug 13370*, Nov. 11, 1952 (Imsh); near Clifton Mount, 4400 ft., *Imshaug 13591*, Dec. 3, 1952 (Imsh); SW slope of Mossmans Peak, 5200 ft., *Imshaug 14935*, Feb. 23, 1953 (Imsh).

The spores are unique in that they give a vague appearance of being 3-septate. They are apparently 1-septate with an incipient secondary septation which appears as a vague shadow. A similar type of spore has been observed in a Mexican species, *B. jajalpae* B. de Lesd.

### **Buellia lauricassiae** (Fée) Müll. Arg.

Rev. Mycol. 9: 85. 1887.

*Lecidea lauricassiae* Fée, Suppl. Essai Cryptog. Écorc. Officin. 101. 1837.
*Mannia lauri* Trevis. Rivista Period. Lavori Accad. Padova 5: 77. 1857. (*nomen novum*)

Type collection: "Habitat frequenter supra corticem Lauri Cassiae (cortex Cassiae ligneoe officinarium), et verosimilliter in Indiis supra cortice variarum arborum." I have been unable to locate the type collection.

HYPOTHALLUS seen only as black line at margin and at junction of thalli. THALLUS continuous, white to glaucescent, occasionally becoming somewhat verrucose; thickened thalli become somewhat rimose-areolate. APOTHECIA scattered, 0.3–1.0 mm. across, somewhat constricted at the base. Disk black, naked, dull, ± plane. Margin moderately thick and raised, concolorous.

Hypothecium and stipes confluent, brown; stipes extending into thallus. Exciple pallid but brown at margin. Hymenium 60–80 μ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells enlarged and fusco-capitate. Spores 8 in ascus, brown, 3-septate, walls thin and even, 17–21 × 6–8 μ.

Chemical Reactions: Hypothecium and stipes KOH + (red, crystals); thallus section KOH + (red, crystals).

A mesophytic, corticolous species common in tropical and subtropical regions. Known in the Western Hemisphere from United States, West Indies, and South America, but not from Central America.

*Material seen*: CUBA — locality unknown, *Wright II 133* (US); *Wright 239* (FH, US); *Wright* (MICH).

JAMAICA — locality unknown, *Cummings 253*, Feb.–March 1905 (FH); Kalorama to Halberstadt, 2250 ft., *Imshaug 15004*, March 3, 1953 (Imsh); N slope of Montpelier, 2100 ft., *Imshaug 14256*, Jan. 29, 1953 (Imsh); sea level, Long Bay, *Imshaug 15592*, April 21, 1953 (Imsh); Guava Ridge, 2900 ft., *Imshaug 14338a*, Feb. 3, 1953 (Imsh); Prospect Estate, White River, 300 ft., *Imshaug 15770*, May 5, 1953 (Imsh).

PUERTO RICO — open places, on posts, Aibonito, *Fink 1875 & 1876*, Jan. 4 (MICH); on Inga, Rio Portugues, N. of Prince, *Britton & Britton 7429*, Feb. 12, 1923 (MICH, NY); on *Terminalia*, San German, *Britton 4007*, Feb. 9, 1915 (FH-Riddle, MICH, NY).

ST. CROIX — Spotless Bay, *Evans 534*, Sept. 1927 (FH, MO–70746); Jolly Hill, *Raunkiaer 436*, Jan. 22, 1906 (C); Fair Plane, on Manchinil & Hematoxylin, *Boergesen*, Feb. 4, 1906 (C); Krauses Lagoon, *Raunkiaer 542*, Feb. 4, 1906 (C).

DOMINICA — Botanical Garden, Roseau, *Evans 63*, Sept. 5, 1926 (FH, NY).

This species is not synonymous with *B. triphragmia*, *B. geophila*, or *B. triphragmioides*. *Buellia lauricassiae* can be distinguished from these species by its pallid exciple and the KOH + (red, crystals) reaction of the thallus.

### **Buellia leucomela** sp. nov.

Hypothallus nigricans, ad ambitum solum visus. Thallus tenuis, continuus, demum saepe rimulosus, laevigatus, sulphureus aut ochraceus, KOH non reagens. Apothecia 0.3–0.4 mm. lata, adnata, disco plano, opaco, nudo, nigro, margine tenui, nigro. Hypothecium et excipulum fusconigricans, KOH non reagens. Stipes pallidum, KOH non reagens. Hymenium 65–70 μ altum, haud oleoso-inspersum, superne fuligineum. Sporae 8:nae, fuscae, 1-septatae, verruculosae, 14–16 μ longae, 7 μ crassae. Specimen typicum in cortice arboris, Portland Ridge, 61 m., legit H. A. Imshaug, no. 13269, Oct. 24, 1952. Holotypus in FH conservatus.

HYPOTHALLUS seen only as a black delimiting line. THALLUS continuous, becoming somewhat rimulose, smooth, ± sulphureous or ochraceous. APOTHECIA 0.3–0.4 mm. across, break through thallus with remnants of thallus persisting around margin, adnate. Disk black, naked, dull, plane. Margin thin and concolorous.

Hypothecium and exciple confluent, brown. Stipes pallid, forming a pale layer between exciple and hypothecium. Hymenium 65–70 μ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells somewhat enlarged and fusco-capitate. Spores 8 in ascus, 1-septate, surface verruculose, 14–16 × ca. 7μ.

Chemical Reactions: Apothecial tissues and thallus section KOH – .

A xerophytic species growing on bark in association (in Jamaica) with *B. yaucoensis* and *B. efflorescens*. Material has also been seen from the Gulf Coast of SE United States.

*Material seen*: JAMAICA — N. slope of Portland Ridge, 200 ft., *Imshaug 13269* Oct. 24, 1952 (Imsh).

The spores are not as markedly verrucose as in *B. trachyspora* but their roughened surface can nevertheless be seen under high power without the use of an oil immersion objective. The latter is, however, helpful in doubtful cases.

### **Buellia melanochlora** (Krmphbr.) Müll. Arg.

Flora 68: 510. 1885.

*Lecidea melanochlora* Krmphbr. Flora 59: 250. 1876.

Type collection: Collected by Glaziou in "provincia brasiliensi Rio Janeiro." Two collection numbers are cited in the original description, no. 6293 and 6326. I have examined both numbers in the Krempelhuber Herb. (M) and only no. 6293 has notes by Krempelhuber. Number 6293 is, therefore, selected as the lectotype.

HYPOTHALLUS black, present only at periphery of the thallus where it is soon covered by the coalescing granules. THALLUS composed of small granules which are soon confluent, forming a continuous, pale sulphureous crust which is rather rough and occasionally somewhat rimose. APOTHECIA 0.4–1.2 mm. across, scattered, constricted at base. Disk black but covered with a yellow-green pruina, plane. Margin thick, black, raised and prominent.

Hypothecium and stipes confluent, brown. Exciple frequently ± pallid. Hymenium 75–100 μ thick, colorless, inspersed with very tiny oil drops or granules; apices of paraphyses scarcely enlarged and scarcely fusco-capitate, not forming a colored epithecium. Spores 8 in ascus, brown, 1-septate, smooth, walls thin and even, (17)19–28(31) × (7)8–10(12) μ.

Chemical Reactions: Epithecium KOH + (layer of yellow granules), hypothecium KOH + (red out in solution but no crystals); thallus section KOH – .

A mesophytic, corticolous species known outside the West Indies from United States (Florida) and South America.

*Material seen*: CUBA — *Wright 241* (FH-Tuck.).

JAMAICA — *Hart 15* (FH-Tuck., NY); *Cummings 283*, Feb.–March 1905 (FH); Mandeville, *Wight* (MICH); Mandeville, *Wight 83*, Jan. 28, 1909 (FH-Riddle); Mandeville, *Wight 107*, Feb. 11, 1909 (FH-Riddle); Bamboo, 2000 ft., *Imshaug*

*15973*, May 7, 1953 (Imsh); Albion, 2400 ft., *Imshaug 15897*, May 7, 1953 (Imsh); Coopers Hill, 2450 ft., *Imshaug 14143, 14157 & 14160*, Jan. 27, 1953 (Imsh); between Bellevue and summit of Mt. Rosanna, 3800 ft., *Imshaug 14485*, Feb. 4, 1953 (Imsh); gap SE of Catherines Peak, 4500 ft., *Imshaug 13901*, Jan. 12, 1952 (Imsh).

PUERTO RICO — open hill top, Aibonito, *Fink 1903*, Jan. 5, 1916 (FH, MICH, NY).

This species is not identical with *B. aeruginascens*. For the differences between these two species and other species with pruinose disks, see Table II.

**Buellia modesta** (Krmphbr.) Müll. Arg.

Flora 64: 524. 1881. (non Darb. 1923)

*Lecidea modesta* Krmphbr. Vidensk. Meddel. Naturhist. Foren. Kjobenhavn 5(1873): 23. 1874. (non Hue 1915)

*Buellia granularis* Müll. Arg. Rev. Mycol. 10: 68. 1888.

Type collections: *Lecidea modesta* — Collected on trees in Serra d'Estrella, central Brazil. I have been unable to locate the type specimen. It is not in the Krempelhuber Herb. (M), nor is it in C.

*Buellia granularis* — Collected on trees at Guarapi in Paraguay by Balansa, no. 4195, in 1887. Holotype in G.

HYPOTHALLUS visible only as a black border and delimiting line between thalli. THALLUS a moderately thick, glaucous-cinereous, continuous crust. Surface usually rather smooth but occasionally appearing somewhat verrucose, ± areolate in age. APOTHECIA 0.3–1.5 mm. across. Disk black, naked, plane (rarely somewhat convex). Margin thick and concolorous.

Hypothecium and stipes brown, confluent. Exciple pallid. Oil drops are commonly found in the upper part of the hypothecium and occasionally in the hymenium. Hymenium (50)70–100 μ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells enlarged and fusco-capitate. Spores 8 in ascus, 1-septate, brown, end walls frequently somewhat thickened, especially on young spores. Young spores occasionally have oil droplets inside. (10)12–17(19) × 5–8(9) μ. (See fig. 2B)

Chemical Reactions: Hypothecium KOH + (red, crystals); thallus section KOH + (red, crystals).

A xerophytic-mesophytic, corticolous species which is very common in the tropical part of South America, Central America and the West Indies.

*Material seen*: BAHAMAS — on *Acacia coriophylla*, Eleuthera Point, *Britton & Millspaugh 5638*, Feb. 24, 1907 (FH-Riddle, NY); on *Exostema caribaeum*, Eleuthera Point, *Britton & Millspaugh 5642*, Feb. 24, 1907 (FH-Riddle, NY); Fortune Island, *Hitchcock 3*, Nov. 27, 1890 (MO–32455); on *Torrubia longifolia*, Rose Island, *Britton & Millspaugh 2165*, Jan. 27–28, 1905 (FH-Riddle, NY); on *Coccothrinax jucunda*, Great Exuma, Stocking Island, *Britton & Millspaugh 3068*, Feb. 22–28, 1905 (FH-Riddle, NY); on *Pseudophoenix sargentii*, Little San Salvador, *Britton & Millspaugh 5672*, Feb. 25–26, 1907 (FH-Riddle, NY); on *Torrubia longifolia*, Long Island, Clarence Town, *Britton & Millspaugh 6341*, March 16–19, 1907 (FH-Riddle, NY); on *Inaba caribaea*, Watling's Island, Cockburn Town, *Britton & Millspaugh 6062*, March 12–13, 1907 (FH-Riddle, NY); New Providence, *Brace 9781*, Dec. 19, 1918 (FH-Riddle, NY).

CUBA — locality unknown, *Wright* (US); *Wright 450 & 448* (FH-Tuck. 3295); on *Poinciana regia*, Artemisa, *Ames*, Jan. 8, 1902 (FH); Prov. Las Villas olim Santa Clara, Cienfuegos, Soledad, Atkins Botanical Garden, *Welch 9196*, Aug. 12, 1948 (MO–169602); Palmas San Juan, *Hioram 5569*, April 7, 1922 (BPI); Confluente Estate, *Hioram 5758*, March 9, 1922 (BPI); Nogueras Hill, *Hioram 5744*, Oct. 6, 1921 (BPI); on *Lysiloma*, Isle of Pines, Vivijagua, *Britton, Britton & Wilson 15034*, Feb. 28–29, 1916 (FH-Riddle, NY); on *Oxandra*, Isle of Pines, Sierra de los Caballos, *Britton & Wilson 15145*, March 2, 1916 (FH-Riddle, NY).

JAMAICA — locality unknown, *Cummings 147*, Feb.–March 1905 (FH-Riddle, NY); Kalorama to Halberstadt, 2250 ft., *Imshaug 14999 & 15004a*, March 3, 1953 (Imsh); Cane River Falls, 400 ft., on Coconut & Akee, *Imshaug 14517 & 14521*, Feb. 10, 1953 (Imsh); near summit of Coopers Hill in Red Hills, 2500 ft., *Imshaug 13749*, Dec. 17, 1952 (Imsh); SE slope of Hellshire Hummock, 300 to 400 ft., *Imshaug 13691*, Dec. 16, 1952 (Imsh); N slope of Montpelier, 2100 ft., *Imshaug 14252, 14269 & 14274*, Jan. 29, 1953 (Imsh); Hollymount, Mt. Diablo, 2750 ft., *Imshaug 14236*, Jan. 28, 1953 (Imsh); N slope of Portland Ridge, 200 ft., *Imshaug 13257, 13258 & 13269*, Oct. 24 1952 (Imsh); hill near Malvern Hill, Malvern, *Britton 472*, Sept. 5, 1907 (FH-Riddle, NY); Potsdam, Malvern, *Britton 481*, Sept. 9, 1907 (FH-Riddle); Birchs Hill, 1809 ft., *Imshaug 15683*, April 24, 1953 (Imsh); Montego Bay, *Cushman 103*, Feb.-March 1912 (FH); Clarks Town, 750 ft., *Imshaug 16046 & 16038*, May 10, 1953 (Imsh); Albion, 2400 ft., *Imshaug 15908*, May 7, 1953 (Imsh); Bamboo, 2000 ft., *Imshaug 15974*, May 7, 1953 (Imsh); Claremont, 1800 ft., *Imshaug 15886*, May 7, 1953 (Imsh); Hopewell, 1400 ft., *Imshaug 15817*, May 6, 1953 (Imsh); Dunns River, 150 ft., *Imshaug 15750*, May 4, 1953 (Imsh); sea level, on Coconut, between Runaway Bay & Dry Harbour, *Imshaug 15997*, May 9, 1953 (Imsh); stump of Coconut near mouth of Bog River, Port Antonio, *Wight*, Dec. 30, 1905 (FH); Port Antonio, *Wight 31*, Dec. 30, 1905 (FH-Riddle); NE Point, sea level, *Imshaug 15382, 15385, 15387, 15392, 15395*, March 31, 1953 (Imsh); Rocky Point, sea level, *Imshaug 15396 & 15407*, April 7, 1953 (Imsh).

HAITI — on small dead tree in arid thicket, Mt. La Mine, St. Michel de l'Atalaye, Dept. du Nord, 350 m., *Leonard 8015f*, Dec. 15, 1925 (FH).

PUERTO RICO — locality unknown, *Britton & Brown* (MICH); on *Pithecolobium unguiscati*, Coamo Springs, *Britton 8563*, Feb. 13, 1926 (MICH, NY); on *Pithecolobium unguiscati*, Montalva, Punta Penones, *Britton, Cowell & Brown 4844*, March 2–4, 1915 (FH-Riddle, NY); bark of shrubs on dry hill top, Yauco, *Fink 1488*, Dec. 29, 1915 (FH, MICH, NY, US); bark of shrubs on exposed hill, Yauco, *Fink 1463*, Dec. 29, 1915 (FH); on *Cephalocereus*, Guanica, Salinas de Guanica, *Britton, Cowell & Brown 4932*, March 5–8, 1915 (FH-Riddle, NY); on *Pithecolobium unguiscati*, Guanica, *Britton, Cowell & Brown 4957*, March 5–8, 1915 (FH-Riddle, NY); on *Eugenia*, Guanica, Salinas de Guanica, *Britton, Cowell & Brown 4936*, March 5–8, 1915 (FH-Riddle, MICH, NY); on *Pithecolobium*, Desecheo Island, *Britton, Cowell & Hess 1611*, Feb. 18–19, 1914 (MICH, NY); Rio de Maricao, *Britton 4055a*, Feb. 10, 1915 (FH-Riddle).

ST. THOMAS — Mt. Crown, *Raunkiaer 419*, Nov. 31, 1905 (C).

ST. CROIX — Krauses Lagoon, *Raunkiaer 542*, Feb. 4, 1906 (C); near Frederiksted, *Evans 12*, Aug. 25, 1926 (FH).

GUADELOUPE — on *Mangifera indica* in Ravine-Chaude, *Duss 1416* (TUR-Vainio 9346).

Spore size is apparently related to elevation in Jamaica. Collections from localities of less than 400 ft. measure (10)11–14(17) × 5–7(8) $\mu$, while collections from 750–2400 ft. measure 14–19(20) × 7–8(9) $\mu$. This does not conform to a xerophytic-mesophytic distinction.

Extra large spores were found in Cuba (Wright 450 & 448) and Puerto Rico (Britton 4055a). These measured 20–32 × 11–12(14) $\mu$.

### **Buellia placodiomorpha** Wainio, Étude Lich. Brésil 1: 172. 1890.

Type collection: Collected by Wainio "ad corticem arboris prope Sepitiba in civ. Minarum, n. 473" in Brazil. Holotype in TUR (Vainio Herb.); isotype in FH.

HYPOTHALLUS absent. THALLUS scant, frequently apparently absent. When present indefinite or somewhat furfuraceous, cinereous to dark gray. APOTHECIA 0.2–0.4 mm. across, scattered, somewhat constricted at base. Disk black, naked, dull, plane to ± convex. Margin very thin, concolorous.

Hypothecium brown or reddish brown; stipes brown; exciple thin and brown.

Hymenium 50–75 μ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells enlarged and fusco-capitate. Spores 8 in ascus, pale fuscous, walls unevenly thickened but not strictly polarilocular, 14–17 × 6–8 μ. (See fig. 2H)

Chemical Reactions: Apothecial tissues KOH – ; thallus section KOH – .

A mesophytic species known also from Bermuda and South America.

*Material seen*: GRENADA — sea level, Antoine Bay, *Imshaug 16297*, July 24, 1953 (Imsh); sea level, Grenade Bay, *Imshaug 16304*, July 24, 1953 (Imsh); sea level, Coconut Grove, Levera Bay, *Imshaug 16157 & 16166*, July 12, 1953 (Imsh).

The West Indian material agrees well with the isotype at FH. It is possible that this species is identical with *Rinodina insperata* (Nyl.) Malme. Although first described by Nylander as a *Lecanora*, Nylander later (Crombie 1877) called it a *Lecidea*. Malme (1902) and Riddle (1916), however, place it in *Rinodina*, although Riddle states (p. 159) "An examination of an apothecium from an original specimen in Lindig's Lich. Nov. Gran. No. 2616 shows beyond doubt that Zahlbruckner's disposition of the species is correct, in spite of the thalline exciple having disappeared." I have not seen the type collection of *Lecanora insperata* Nyl. and so am unable to reach a decision at the present time.

### **Buellia placodiomorphoides** sp. nov.

Hypothallus incertus. Thallus cinereus, tenuis, verrucoso-inaequalis, verrucis dispersis, 0.06–0.12 mm. latis, KOH lutescens. Apothecia 0.3–0.5 mm. lata, basi constricta, disco nigro, nudo, opaco, plana, margine nigro, vulgo parum prominente, crassitudine mediocri. Hypothecium et stipes fusconigricans, KOH non reagens. Excipulum intus pallidum oleoso-inspersum, extus fusconigricans; KOH non reagens. Hymenium 65–100 μ altum, haud oleoso-inspersum, superne aurantiaco-rufescens. Sporae 8:nae, fumoso-fuscescentes, 1-septatae, membranis lateralibus sat inaequaliter incrassatis, membranis apicibus parum incrassatis, 21–28 μ longae, 9–10 μ crassae. Specimen typicum in cortice arboris, Catherines Peak, 1524 m., insula Jamaica, legit H. A. Imshaug, no. 13343, Nov. 11, 1952. Holotypus in FH conservatus.

HYPOTHALLUS not seen, except perhaps as a black line delimiting thallus from neighboring thalli of other species. THALLUS a thin cinereous film over bark with rather widely scattered verrucae 0.06–0.12 mm. across. APOTHECIA scattered, superficial, constricted at base, 0.3–0.5 mm. across. Disk black, naked, dull, plane. Margin concolorous, moderately thick and somewhat raised.

Hypothecium brown; stipes brown and well-developed; exciple pallid with many oil drops and brown at margin. Hymenium 65–100 μ thick, colorless, not inspersed with oil drops; paraphyses forming an orange-brown epithecium, apical cells enlarged and fusco-capitate. Spores 8 in ascus, pale fuscous, 1-septate, with walls unevenly thickened, but not strictly polarilocular, germ pore at each end, 21–28 × 9–10 μ. (See fig. 2F)

Chemical Reactions: Apothecial tissues KOH – ; thallus section KOH + (yellow).

A hygrophytic, corticolous species known only from the Blue Mountains of Jamaica.

*Material seen*: JAMAICA — summit of Catherines Peak, 5000 ft., *Imshaug 13343*, Nov. 11, 1952 (F.H.).

This species is similar to *Buellia callispora* except that the spores are smaller and not thickened at the septum. Also, in *B. placodiomorphoides*, the oil drops are confined to the exciple, which is pallid. The spores are similar to those in *B. placodiomorpha* except that they are much larger. *Buellia placodiomorpha* does not have a pallid exciple.

### **Buellia posthabita** (Nyl.) Zahlbr.

Cat. lich. univ. 7: 390. 1931.

*Lecidea posthabita* Nyl. Lich. Nov. Zeland. 111. 1888.
*Buellia parachroa* Wainio, Étud. Lich. Brésil 1: 175. 1890.
*Buellia parachroa* var. *interrupta* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 86. 1915.

*Buellia pachydermatica* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 87. 1915.
*Buellia naranjitana* Zahlbr. Mycologia 22: 79. 1930.

Type collections: *Lecidea posthabita* — Collected on rock at Honda, New Granada, by Lindig in 1861. Holotype in H(Nylander Herb. 10546).

*Buellia parachroa* — Collected on granite near Rio de Janeiro, Brazil, by Wainio, no. 104, in 1885. Holotype in TUR (Vainio Herb. 9443).

*Buellia parachroa* var. *interrupta* — Collected at Magensbay (800 ft.) in St. Thomas (West Indies) by F. Boergesen. Holotype in C; isotype in TUR (Vainio Herb 9522).

*Buellia pachydermatica* — Collected at Ma Follie in St. Thomas (West Indies) by Biese. Holotype in C; isotype in TUR (Vainio Herb. 9532).

*Buellia naranjitana* — Collected on rock in open field at Naranjito in Puerto Rico (West Indies) by Bruce Fink, no. 236, Nov. 27, 1915. Holotype in MICH; isotype in NY.

HYPOTHALLUS not evident except as a black delimiting line. THALLUS in form of scattered patches which may coalesce to cover a large area. Each individual patch retains a black delimiting margin. Patches generally ochraceous but occasionally whitening or becoming cinereous; thin and continuous, but becoming rimose-areolate. APOTHECIA 0.2–0.4 mm. across, adnate, only slightly constricted at base. Disk black, naked, plane. Margin concolorous, moderately thickened and somewhat raised.

Hypothecium and stipes colorless or pallid. Exciple very dark brown, occasionally tinted somewhat green, confined to sides. Hymenium 75–100 $\mu$ thick, colorless, not inspersed with oil drops; paraphyses forming a light brown epithecium, apical cells somewhat enlarged and fusco-capitate. Spores 8 in ascus, pale fuscous (darkening with age), mischoblastiomorph, occasionally swollen at center, (14)17–24 × (8)9–12(13) $\mu$. (See fig. 2E)

Chemical Reactions: Apothecial tissues KOH – ; thallus section I – , KOH – , Pd – .

A mesophytic species widely distributed on rock in tropical West Indies and South America.

*Material seen*: JAMAICA — gap SE of Catherines Peak, 4500 ft., *Imshaug 13899*, Jan. 12, 1953 (Imsh); SW slope of Catherines Peak, 4450 ft., *Imshaug 13920*, Jan. 12, 1953 (Imsh); NE slope of Catherines Peak, 4500 ft., *Imshaug 13817 & 13813*, Dec. 26, 1952 (Imsh); SW slope of Mossmans Peak, 5200 ft., *Imshaug 14927*, Feb. 23, 1953 (Imsh); Galloway Lodge Trail above Mavis Bank Road, 2950 ft., *Imshaug 14444*, Feb. 4, 1953 (Imsh); Bellevue, 3800 ft., *Imshaug 14458*, Feb. 4, 1953 (Imsh); Birchs Hill, 1809 ft., *Imshaug 15696 & 15720*, April 24, 1953 (Imsh).

PUERTO RICO — Mannato, *Britton & Britton 8769*, Feb. 4, 1927 (MICH, NY); on serpentine, Indiera Fria near Maricao, 430–800 m., *Britton, Cowell, & Brown 4559 & 4561*, Feb. 19–22, 1915 (MICH, NY); on shale, Punta Guaniquilla, *Britton, Cowell, & Brown 4591*, Feb. 24, 1915 (MICH, NY); on limestone, hills between Cabo Rojo & San German, 100–350 m., *Britton, Cowell, & Brown 4329*, Feb. 17, 1915 (MICH, NY); Yauco, *Fink 1678*, Jan. 1, 1916 (F-1271784, FH, MICH); Yauco, *Fink 1387*, Dec. 28, 1915 (FH, MICH); open field, Naranjito, *Fink 236*, Nov. 27, 1915 (FH, NY).

ST. THOMAS — Ma Folie, *Biese* (TUR-Vainio 9532, C); Magensbay, 800 ft., *Boergesen* (TUR-Vainio 9522, C); no locality (C); locality unknown, *Forel*, 1878 (H-Nylander 28667).

ST. CROIX — Cotton Valley, *Britton, Britton, & Kemp 175*, March 17–25, 1923 (NY); Canebay, *Boergesen*, Jan. 26, 1906 (C); Hams Bluff, *Boergesen*, Feb. 6, 1906 (C).

ST. JOHN — Reef Bay, *Boergesen*, March 7, 1906 (TUR-Vainio 9533).

GUADELOUPE — locality & collector unknown (PC).

GRENADA — Piton near Levera, 700–750 ft., *Imshaug 16307 & 16316*, July 24, 1953 (Imsh).

In the collection from Hams Bluff (St. Croix) the thallus is very scant and the specimen appears athalline. Also, the epithecium is very dark. In all other respects, however, it agrees with *B. posthabita.*

This species may be recognized by the colorless hypothecium and mischoblastiomorph spores. The spores are very similar to those in *B. atrofuscata*, which species, however, has a brown hypothecium and is not saxicolous.

### **Buellia prospersa** (Nyl.) Riddle, Brookl.
Bot. Gard. Memoirs 1: 114. 1918.

*Lecidea prospersa* Nyl. Flora 63: 127. 1880.
*Buellia pachyphragma* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 93. 1915.
*Buellia orcularia* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 94. 1915.
*Buellia substigmatea* Fink in Hedrick, Mycologia 22: 255. 1930. (non Müll. Arg. Proc. Roy. Soc. Edinburgh 11: 465. 1882).
*Rinodina prospera* (Nyl.) Zahlbr. Cat. Lich. Univ. 7:544. 1931.

Type collections: *Lecidea prospersa* — Collected on rock in St. Thomas (West Indies) by Dr. Forel in 1878. Holotype in H (Nylander Herb. 9312).

*Buellia pachyphragma* — Collected at Reef Bay in St. John (West Indies) by F. Boergesen, March 7, 1906. Holotype in C. A fragment from this collection in TUR (Vainio Herb. 9533) consists only of *B. posthabita.*

*Buellia orcularia* — Collected on littoral rocks at Cruz-Bay, St. John (West Indies) by F. Boergesen, March 11, 1906. Holotype in C; isotype in TUR (Vainio Herb. 9531).

*Buellia substigmatea* — Collected on rock on rocky hill, Christiansted, St. Croix (West Indies) by Britton, Britton, and Kemp, no. 79, in 1923. Holotype in MICH; isotype in NY.

HYPOTHALLUS frequently not observed on herbarium specimens but occasionally seen as a continuous, cinereous to pale fuscous film, black at periphery. THALLUS develops on hypothallus as small patches which coalesce to form a thin, continuous crust. Crust generally ochraceous but occasionally whitening, surface somewhat uneven, perhaps exhibiting a granulose tendency, and becoming rimose-areolate. APOTHECIA 0.2–0.5 mm. across, superficial on thallus, constricted at base. Disk black, naked, plane (occasionally convex in older apothecia). Margin concolorous, moderately thick and raised but becoming somewhat excluded in older apothecia.

Hypothecium and stipes confluent, brown. Exciple a very distinct dark brown layer. Hymenium 50–65 μ thick, colorless, not inspersed with oil drops; paraphyses forming a conspicuous dark brown epithecium, apical cells swollen and prominently fusco-capitate. Spores 8 in ascus, fuscons, polarilocular, 10–14 × 5–7 μ.

Chemical Reactions: Apothecial tissues KOH – ; thallus section I – , Pd – , KOH – (or yellow).

A saxicolous species endemic to the Virgin Islands.

*Material seen*: ST. CROIX — on hill, Christiansted, *Britton, Britton, & Kemp 79*, March 17–25, 1923 (MICH, NY).

ST. THOMAS — *Forel*, 1878 (H–Nyl. 9312); Ma Folie, *Biese* (TUR-Vainio 9532, with type of *B. pachydermatica*); Nordsidebugt, on maritime rocks, *Boergesen*, Dec. 28, 1905 (C, TUR-Vainio 11951).

ST. JOHN — Cruz-Bay, *Boergesen*, March 11, 1906 (TUR-Vainio 9531, C); Reef Bay, *Boergesen*, March 3, 1906 (C).

### **Buellia proximata** Magn. in Magn. & Zahlbr.
Ark. Bot. 32A(2): 52. 1945.

Type collection: Collected on bark by the Hawaiian Bog Survey in 1938 (no. 6023) at Kokee (ca. 1100 m.) on Kauai (Hawaiian Islands). Holotype in S (not seen).

HYPOTHALLUS seen only as a black delimiting line. THALLUS white to glaucescent, continuous, becoming somewhat verrucose. APOTHECIA 0.3–0.8 mm. across, constricted at base. Disk black, plane, dull, naked. Margin moderately thick, somewhat raised, concolorous.

Hypothecium, stipes and exciple confluent, brown. Stipes extends to base of thallus. Hymenium 60–100 μ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells enlarged and fusco-capitate. Spores 8 in ascus, brown, 3-septate, walls thin and even, (16)21–32 × (7)8–11 μ. Young spores ± colorless and 1-septate with end walls thickened.

Chemical Reactions: Apothecial tissues KOH – ; thallus section KOH – .

A mesophytic, corticolous species known only from Jamaica, outside of the Hawaiian Islands.

*Material seen*: JAMAICA — locality unknown, *Cummings 88 & 394*, Feb.-March 1905 (FH); Flora River, 2700 ft., *Imshaug 14411*, Feb. 3, 1953 (Imsh); Guava Ridge, 2900 ft., *Imshaug 14338b*, Feb. 3, 1953 (Imsh).

### **Buellia remensa** (Stirton) comb. nov.

*Lecidea remensa* Stirton, Trans. Glasgow Soc. Field Naturalists 4: 166. 1876.
*Catillaria remensa* (Stirton) Zahlbr. Cat. lich. univ. 4: 23. 1926.

Type collection: Collected on bark near Pork of Spain, Trinidad (West Indies) by Rev. G. Brodie. Holotype and an isotype in BM.

HYPOTHALLUS not seen. THALLUS of many small, scattered patches (or flattened verrucae), soon coalescent into a cinereous-glaucescent, smooth or occasionally remaining ± granulose, continuous crust which becomes somewhat areolate. APOTHECIA 0.3–0.9 mm. across, scattered, somewhat constricted at base. Disk black but generally covered with a white pruina, plane to convex. Margin black, thin, becoming excluded.

Hypothecium, stipes and exciple confluent, dark brown. Hymenium 45–70 μ thick, colorless, not inspersed with oil drops; paraphyses forming a greenish epithecium, apical cells somewhat enlarged and fusco-capitate. Spores 8 in ascus, brown, 1-septate, with walls evenly thickened leaving 1 spherical sporoblast in each cell, 13–17 × 6–8 μ.

Chemical Reactions: Epithecium KOH + (violet), hypothecium KOH + (red, crystals); thallus section KOH + (red, crystals).

A mesophytic-gygrophytic, corticolous species known only from the Caribbean area.

Material seen: JAMAICA — forest hut above Corn Puss Gap, 3550 ft., *Imshaug 13455 & 13462*, Nov. 20, 1952 (Imsh).

PUERTO RICO — Yunque, 1000 ft., *Fink 742*, Sept. 12, 1915 (MICH).

GRENADA — sea level in Coconut Grove, Levera Bay, *Imshaug 16160 & 16161*, July 12, 1953 (Imsh); S shore of Point Saline, sea level, *Imshaug 16127, 16124 & 16128*, July 9, 1953 (Imsh); summit of Morne Rouge, 275 ft., *Imshaug 16191 & 16194*, July 15, 1953 (Imsh).

The pruina is often difficult to see or may even be lacking in material from the wettest localities. In doubtful cases the pruina is best seen when a drop of water is put on the apothecium. The green color of the epithecium is also frequently rather obscure and the KOH reaction of the hypothecium is not very strong.

It is possible that *B. isabellina* Malme is synonymous with this species. The spores in *B. isabellina*, however, measure 11–14 × 7–8 μ.

For an outline of the differences between *B. remensa* and the other species with pruinose apothecia see Table II.

I am indebted to Dr. I. M. Lamb for calling my attention to this species which was erroneously transferred to *Catillaria* by Zahlbruckner.

### **Buellia rufofuscescens** Wainio, Étude Lich. Brésil 1: 172. 1890

Type collection: Collected "ad lignum in Carassa (1400 metr. s. m.) in civ. Minarum, n. 1167 b" (Brazil). Holotype in TUR (Vainio Herb.); isotype in FH (only isotype seen).

HYPOTHALLUS not seen. THALLUS composed of scattered, flattened, cinereous granules (not constricted at base) which often coalesce to form a ± continuous crust. APOTHECIA 0.2–0.6 mm. across, scattered, narrowly constricted at the base. Disk black but usually covered with a reddish or red-brown pruina, plane. Margin black, thin and raised.

Hypothecium, stipes and exciple confluent, dark brown. Hymenium 45–55 μ thick, a very pale diffuse green (more conspicuously green in KOH), not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells only slightly enlarged and fusco-capitate. Spores 8 in ascus, brown, 1-septate, smooth, walls thin, 10–13 × 4–5 μ.

Chemical Reactions: Exciple KOH + (violet out in solution), rest of apothecial tissues KOH – ; thallus section KOH – .

A hygrophytic, corticolous species known only from Brazil and Jamaica.

*Material seen*: JAMAICA — ridge NW of Murdocks Gap in Blue Mountains, 3600 ft., *Imshaug 15319*, March 15, 1953 (Imsh).

Similar to *B. elisae* except for the KOH reaction of the exciple. *Buellia epimarta* Malme, from Brazil, has larger spores and different chemical reactions.

### **Buellia subdispersula** Riddle, Mycologia 15: 87. 1923.

Type collection: Collected on sandstone at La Cunagua on Isle of Pines (off S coast of Cuba) in the West Indies by N. L. Britton, E. G. Britton, & Percy Wilson, no. 14577, Feb. 19, 1916. Holotype in FH (Riddle Herb.); isotypes in MICH & NY.

HYPOTHALLUS consists of a few scattered black specks. THALLUS consists of cinereous or yellow granules which are either scattered or aggregated into clusters, occasionally forming small granulose-continuous patches. APOTHECIA 0.2–0.7 mm. across, superficial, base somewhat constricted. Disk black, naked, dull, plane to slightly convex. Margin thin and concolorous, at length excluded.

Hypothecium, stipes and exciple confluent and dark brown. Hymenium 75–95 μ thick, colorless, inspersed with oil drops; paraphyses forming a brown epithecium, apical cells enlarged and fusco-capitate. Spores 8 in ascus, pale fuscous, mischoblastiomorph, (13) 14–20 × 7–9 μ.

Chemical Reactions: Apothecial tissues KOH – ; thallus section KOH – (or, with balls of colorless crystals), I – .

A saxicolous species known only from the Isle of Pines.

Riddle described this species and *B. flavogranulosa* from two collections made the same day at the same locality. The differences between these two collections are slight and, considering the paucity of the material, they scarcely warrant the recognition of two separate species. The differences, however, do warrent recognition as varieties.

### var. **subdispersula**

Thallus consists of scattered, cinereous granules, 0.06–0.23 mm. across. The granules frequently aggregate into masses and may form ± continuous granulose areas. Spores 15–20 × 7–9 μ.

Chemical Reactions: Thallus KOH — (no balls of colorless crystals).

*Material seen*: CUBA (ISLE OF PINES) — La Cunagua, *Britton, Britton & Wilson 14577*, Feb. 19, 1916 (FH-Riddle, MICH, NY).

### var. **flavogranulosa** (Riddle) comb. nov.

*Buellia flavogranulosa* Riddle, Mycologia 15: 86. 1923.

Type collection: Collected on sandstone at La Cunagua on Isle of Pines (off S coast of Cuba) in the West Indies by N. L. Britton, E. G. Britton, & Percy Wilson, no. 14578, Feb. 19, 1916. Holotype in FH (Riddle Herb.); isotypes in MICH & NY.

Thallus consists of scattered clusters (up to 0.43 mm. across) of small (0.06–0.14 mm. across) yellow granules. Spores 13–17 × 7–9 μ.

Chemical Reactions: Thallus KOH + (balls of colorless crystals).

*Material seen*: CUBA (ISLE OF PINES) — La Cunagua, *Britton, Britton & Wilson 14578*, Feb. 19, 1916 (FH-Riddle, MICH, NY).

### **Buellia subsensitiva** sp. nov.

Hypothallus bene evolutus, continuus, cinereus aut cinereonigricans. Thallus tenuis e areolis formatus, cinereis, dispersis aut subcontiguis, planis, laevigatis, opacis; KOH sanguineo-rubens, solutione mox cristalla acicularia formante; hyphis J coerulescentibus. Apothecia 0.3–0.6 mm. lata, basi constricta, disco nigro, nudo, opaco, plano, margine crassitudine mediocri, nigro, vulgo parum prominente. Hypothecium et stipes fusconigricans; excipulum extus fusco-fuligineum aut olivaceofuligineum, intus pallidum. Stipes et excipulum KOH sanguineorubens, mox cristalla acicularia formante. Hymenium 45-70 μ altum, haud oleoso-inspersum, superne viride. Sporae 8: nae, fuscae, 1-septatae, membrana aequaliter modice incrassata, 9–12(13) μ longae, 5–6 μ crassae. Specimen typicum in saxo, Mt. Rosanna, 1219 m., insula Jamaica, legit H. A. Imshaug, no. 14002, Jan. 14, 1953. Holotypus in FH conservatus.

HYPOTHALLUS visible between the areoles as a gray or dark cinereous layer over the substratum. THALLUS consisting of thin, scattered, cinereous areoles. Areoles occasionally contiguous, forming small patches of a rimose-areolate crust; ± plane, smooth, dull. APOTHECIA 0.3–0.6 mm. across, somewhat constricted at base. Disk black, naked, dull, plane. Margin rather thick, soon concolorous with disk, somewhat raised.

Hypothecium and stipes confluent, brown; stipes well developed, extending to substratum. Exciple pallid but brown (or with tint of green) at margin. Hymenium 45-70 μ thick, colorless, not inspersed with oil drops; paraphyses forming a dark green epithecium (HCl –, KOH –), apical cells somewhat enlarged and fusco-capitate. Spores 8 in ascus, brown, 1-septate, with thin and uniform walls, 9–12(13) × 5–6 μ.

Chemical Reactions: Stipes and exciple frequently KOH + (red, crystals), rest of apothecial tissues KOH – ; thallus section KOH + (red, crystals), I + (blue at base).

A mesophytic species found only on non-calcareous rocks in Jamaica.

*Material seen*: JAMAICA — Halberstadt to Bloxburgh, 2800 ft., *Imshaug 15026, 15039 & 15046*, March 3, 1953 (Imsh); SW slope near summit of Mt. Rosanna, 4000 ft., *Imshaug 13985 & 14002*, Jan. 14, 1953 (Imsh).

*Buellia subsensitiva* differs from *B. sensitiva* Zahlbr. in that the thallus consists of scattered areoles on a well-developed hypothallus. Also, the stipes is a darker brown and is better developed; the epithecium is green and the spores are smaller. *Buellia subsensitiva* is not closely related to *B. glaziouana.*

### **Buellia trachyspora** Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 84. 1915.

*Buellia gyrosa* Wainio, Ann. Acad. Sci. Fenn. ser. A. 6(7): 85. 1915.

Type collections: *Buellia trachyspora* — Collected by Boergesen "in rupem ad cataractam prope Reef-Bay in insula S. Jan" (West Indies). Holotype in C.

*Buellia gyrosa* — Collected on rock in St. John (West Indies) by Boergesen on March 15, 1906. Holotype in C; isotype in TUR (Vainio Herb. 9538).

HYPOTHALLUS not evident. THALLUS thin, continuous but becoming somewhat rimose-areolate, glaucous albescent to pale cream; surface smooth and even but not nitidous. APOTHECIA 0.4 1.0 mm. across, constricted at base. Disk black, naked, plane, dull. Margin rather thick and frequently raised above the disk, concolorous.

Hypothecium and stipes confluent, brown. Exciple pallid but brown at margin. Hymenium 75–100 μ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells enlarged and fusco-capitate. Spores 8 in ascus, brown, 1-septate, strongly verrucose, 15–20(23) × 7–9(10) μ.

Chemical Reactions: Apothecial tissues KOH – ; thallus section KOH –, I –.

A mesophytic, saxicolous species known only from the Greater Antilles.

*Material seen*: CUBA — locality unknown, *Wright* (H-Nylander 5726, with type of *B. dejungens*).

JAMAICA — between Halberstadt and Bloxburgh, 2800 ft., *Imshaug 15047*, March 3, 1953 (Imsh).

PUERTO RICO — open field at 2000 ft., Aibonito, *Fink 1947*, Jan. 5, 1916 (BPI, FH, MICH, NY, US); exposed places at 2100 ft., Aibonito, *Fink 1846*, Jan. 4, 1916 (FH, MICH).

ST. THOMAS — *Boergesen*, March 7, 1906 (TUR-Vainio 9521).

ST. JOHN — Rustenburg, *Boergesen*, March 15, 1906 (TUR-Vainio 9538, C); Reef Bay, *Boergesen*, March 7, 1906 (C).

The original material of *B. gyrosa* is rather fragmentary and differs from *B. trachyspora* only in the gyrose nature of the apothecia. This condition occurs in almost all species with a thick, pallid exciple and scarcely warrants species recognition.

### **Buellia yaucoensis** Vainio. Mycologia 21: 33. 1929.

Type collection: Collected on old log on open hill top at Yauco in Puerto Rico (West Indies) by Bruce Fink, no. 1460, Dec. 29, 1915. Holotype in MICH; isotypes in F (1270211), FH and NY.

HYPOTHALLUS not seen. THALLUS thin and continuous, cinereous glaucescent, smooth but becoming roughened or somewhat verrucose. APOTHECIA 0.3–0.6 mm. across, scattered, constricted at base, occasionally emergent with adherent thallus fragments. Disk black, naked, dull, plane to somewhat convex. Margin thin and concolorous.

Hypothecium and stipes confluent, light brown; exciple thin and dark brown. Hymenium 70–90 $\mu$ thick, colorless, not inspersed with oil drops; paraphyses forming a brown epithecium, apical cells of paraphyses enlarged and fuscocapitate. Spores 8 in ascus, brown, 1-septate, surface smooth, secondary walls evenly thickened so as to leave one small, spherical sporoblast in each cell, (13)14–18 $\times$ 6–9 $\mu$. (See fig. 2D)

Chemical Reactions: Apothecial tissues KOH $-$, except exciple is frequently KOH $+$ (red-violet out in solution); thallus KOH $-$.

A xerophytic, corticolous species known only from the Greater Antilles.

*Material seen*: JAMAICA — N slope of Portland Ridge, 200 ft., *Imshaug 13269a*, Oct. 24, 1952 (Imsh); SE slope of Hellshire Hummock, 300 to 400 ft., *Imshaug 13710, 13703, 13702 & 13706*, Dec. 16, 1952 (Imsh).

PUERTO RICO — old log on open hill top, Yauco, *Fink 1460*, Dec. 29, 1915 (F-1270211, FH, MICH, NY).

## SPECIES OF BUELLIA REPORTED IN THE LITERATURE FROM THE WEST INDIES

An asterisk (*) preceding a name indicates that the taxon was originally described from material collected in the West Indies. In those cases where I have examined the collection, or collections, upon which the reference is based I have indicated my revision in parentheses immediately following the reference citation.

*Buellia* sp.
  JAMAICA: Johnson 1927 (The specimen is presumably in the undetermined collections at BPI and was not available for revision.)
*Buellia aeruginascens* (Nyl.) Zahlbr.
  BAHAMAS: Riddle 1920, sub *B. parasema* var. *aeruginascens* (Nyl.) Müll. Arg. ( = *B. gerontoides*)
  BAHAMAS (Fortune Island): Hitchcock 1898 ( = *B. gerontoides*)
  ST. THOMAS: Riddle 1918, sub *B. parasema* var. *aeruginascens* ( = *B. gerontoides*)
**Buellia antillarum* B. de Lesd.
  GUADELOUPE: Type collection ( = *B. glaziouana* var. *poliocheila*)

TABLE I — Distribution of the West Indian species of *Buellia*.

| | United States | Bahamas | Cuba | Jamaica | Hispaniola | Puerto Rico | Virgin Islands | Guadeloupe | Dominica | Martinique | St. Vincent | Grenada | Trinidad | Islands off Central America | Central America | South America | Endemic to West Indies |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B. atrofuscata | | | | x | | | | | | | | | | | | x | |
| B. bahiana | x | x | x | x | | x | x | | | x | | | | | x | x | |
| B. boergesenii | | | | | | | x | | | | | | | | | | x |
| B. brittoniae | | | x | | | | | | | | | | | | | | x |
| B. callispora | x | | | x | | | | x | | | | | | | | x | |
| B. catasema | x | x | x | x | | | | x | | | | x | | | x | x | |
| B. dejungens | | | x | | | x | x | | | | | | | | | | x |
| B. dispersula | | | | | | | | | | | | | | x | x | | |
| B. efflorescens | | | | x | | x | x | x | | | | x | | | | | |
| B. gerontoides | | x | x | x | | | x | x | | | | x | x | x | x | | |
| B. glaucotheca | | | x | x | | | | | | | | | | | | x | |
| B. glaziouana | x | | | x | | x | x | x | | | | | | | x | x | |
| B. jamaicensis | | | | x | | | | | | | | | | | | | x |
| B. lauricassiae | x | | x | x | | x | x | | x | | | | | | | x | |
| B. leucomela | x | | | x | | | | | | | | | | | | | |
| B. melanochlora | x | | x | x | | x | | | | | | | | | | x | |
| B. modesta | x | x | x | x | x | x | x | x | | | | | | | x | x | |
| B. placodiomorpha | x | | | | | | | | | | | x | | | | x | |
| B. placodiomorphoides | | | | x | | | | | | | | | | | | | x |
| B. posthabita | | | | x | | x | x | x | ? | | ? | x | | | | x | |
| B. prospersa | | | | | | | x | | | | | | | | | | x |
| B. proximata | | | | x | | | | | | | | | | | | | |
| B. remensa | | | | x | | x | | | | | | x | x | | | | |
| B. rufofuscescens | | | | x | | | | | | | | | | | | x | |
| B. subdispersula | | | x | | | | | | | | | | | | | | x |
| B. subsensitiva | | | | x | | | | | | | | | | | | | x |
| B. trachyspora | | | x | x | | x | x | | | | | | | | | | x |
| B. yaucoensis | | | | x | | x | | | | | | | | | | | x |

TABLE II — West Indian species of *Buellia* with pruinose apothecia. *Buellia aeruginascens* is included for comparison.

|  | spores | epithecium hymenium | hypothecium exciple | thallus | pruina |
|---|---|---|---|---|---|
| *B. aeruginascens* TYPE Nylander Herb. No. 10292 | $\frac{17\text{–}24}{(7)8\text{–}10}\,\mu$<br>isthmus in young spores | epi. KOH –<br>hym. without oil; 85–110 μ | hypo. KOH –<br>exc. dark brown | continuous with surface ± granular; dull stramineous; KOH – | whitish or very pale yellow-green |
| *B. gerontoides* | $\frac{12\text{–}17(21)}{5\text{–}7(9)}\,\mu$<br>walls thin | epi. KOH – or occ. balls of colorless crystals<br>hym. without oil; 60–85 μ thick | hypo. KOH + red, crystals or occ. KOH –<br>exc. ± dark, or occ. ± pallid | sulphureous or yellow-green; KOH + balls of colorless crystals; separate granules do not develop at margin over a black hypothallus. | yellow-green |
| *B. glaucotheca* | $\frac{18\text{–}28}{7\text{–}9(12)}\,\mu$<br>walls thin | epi. ± colorless; KOH –<br>hym. without oil; 80–100 μ thick | hypo. KOH + red, crystals<br>exc. ± pallid | Cinereous to very slightly pale sulphureous; continuous from coalescent patches, becoming rimose; KOH + red, crystals. | white, freq. very slight |
| *B. melanochlora* | $\frac{(17)19\text{–}28(32)}{(7)8\text{–}12(14)}\,\mu$<br>walls thin | epi. KOH + layer of yellow granules<br>hym. with minute oil drops; 80–110 μ thick | hypo. KOH + red out in solution but usually no crystals<br>exc. ± pallid | separate granules develop over the black hypothallus at margin; soon continuous; KOH – | yellow-green |
| *B. remensa* | $\frac{13\text{–}17}{6\text{–}8}\,\mu$<br>walls evenly thickened | epi. greenish, KOH + violet<br>hym. without oil; 45–70 μ thick | hypo. KOH + red, crystals (freq. weak)<br>exc. dark brown | cinereous-glaucescent scattered patches soon continuous, becoming rimose; KOH + red, crystals | white, freq. very slight |

**Buellia brittoniae* Riddle
CUBA (Isle of Pines): Type collection ( = *B. brittoniae*)
**Buellia catasema* Tuck.
CUBA: Type collection ( = *B. catasema*)
Welch 1950 ( = *B. modesta*)
*Buellia conspirans* (Nyl.) Wainio
BAHAMAS: Riddle 1920 ( = *B. modesta*)
ST. JOHN: Wainio 1915 ( = *B. boergesenii*)
**Buellia contiguella* var. *vegetior* (Wainio) Zahlbr.
ST. THOMAS: Type collection, sub *Melanaspicilia contiguella* var. *vegetior* ( = *B. glaziouana* var. *poliocheila*)
**Buellia dejungens* Nyl.
CUBA: Type collection ( = *B. dejungens*)
**Buellia dejungens* var. *chrysochlora* Wainio
ST. CROIX: Wainio 1915 ( = *B. dejungens*)
ST. JOHN: Wainio 1915 ( = *B. dejungens*)
**Buellia dejungens* var. *chrysochroa* Wainio
ST. CROIX: Wainio 1915 ( = *B. dejungens*)
ST. JOHN: Wainio 1915 ( = *B. dejungens*)
ST. THOMAS: Wainio 1915 ( = *B. dejungens*)
**Buellia dejungens* var. *chrysophaea* Wainio
ST. CROIX: Wainio 1915 ( = *B. dejungens*)
ST. THOMAS: Wainio 1915 ( = *B. dejungens*)
**Buellia didyma* Wainio
GUADELOUPE: Type collection ( = *B. callispora*)
*Buellia disciformis* var. *insignis* (Naeg.) Wainio
GUADELOUPE: Wainio 1915 ( = *B. callispora*)
*Lecidea discolor* Hepp
ST. THOMAS: Nylander 1880 ( = *B. posthabita*)
Riddle 1918 ( = *B. dejungens*)
**Buellia endochrysea* Wainio
ST. THOMAS: Type collection ( = *B. dejungens*)
**Buellia endococcodes* Wainio
GUADELOUPE: Type collection ( = *B. catasema* var. *sanguinariella*)
**Buellia finkii* Merrill in Hedrick
PUERTO RICO: Type collection ( = *B. dejungens*)
**Buellia flavogranulosa* Riddle
CUBA (Isle of Pines): Type collection ( = *B. subdispersula* var. *flavogranulosa*)
**Lecidea gerontoides* Stirton
TRINIDAD: Type collection ( = *B. gerontoides*)
*Buellia glaucotheca* (Fée) Malme
CUBA: Malme 1927 ( = *B. glaucotheca*)
**Buellia gyrosa* Wainio
ST. JOHN: Type collection ( = *B. trachyspora*)
**Buellia hiorami* B. de Lesdain
CUBA: Type collection destroyed in World War II, but is presumed to be *B. catasema.*
*Buellia lauricassiae* (Fée) Müll. Arg.
CUBA: Malme 1927 ( = *B. lauricassiae*)
ST. CROIX: Wainio 1915 ( = *B. lauricassiae*)
ST. THOMAS: Wainio 1915 ( = *B. bahiana*)
*Buellia modesta* (Krmph.) Müll. Arg.
CUBA: Malme 1927
ST. THOMAS: Wainio 1915 ( = *B. modesta*)
ST. CROIX: Wainio 1915 ( = *B. modesta* and *B. lauricassiae*)
GUADELOUPE: Wainio 1915 ( = *B. modesta*)

*Buellia myriocarpa* (DC.) Mudd
  DOMINICA: Wainio 1896 (Specimen not in Herb. Vainio)
  ST. VINCENT: Wainio 1896 (Specimen not in Herb. Vainio)
**Buellia naranjitana* Zahlbr.
  PUERTO RICO: Type collection ( = *B. posthabita*)
**Buellia orcularia* Wainio
  ST. THOMAS: Wainio 1915 ( = *B. prospersa*)
  ST. JOHN: Wainio 1915 ( = *B. prospersa*)
**Buellia pachydermatica* Wainio
  ST. THOMAS: Type collection ( = *B. posthabita*)
**Buellia pachyphragma* Wainio
  ST. JOHN: Type collection ( = *B. prospersa*)
*Buellia parachroa* Wainio
  DOMINICA: Wainio 1896 (Specimen not in Herb. Vainio)
  ST. VINCENT: Wainio 1896 (Specimen not in Herb. Vainio)
**Buellia parachroa* var. *interrupta* Wainio
  ST. THOMAS: Type collection ( = *B. posthabita*)
*Buellia parasema* (Ach.) Th. Fr.
  BAHAMAS (Fortune Island): Hitchcock 1898 ( = *B. modesta*)
  CUBA (Isle of Pines): Riddle 1923 ( = *B. catasema*)
**Buellia parasema* f. *endococcina* Tuck.
  CUBA: Type collection ( = *B. catasema* var. *sanguinariella*)
**Buellia poliocheila* Wainio
  ST. THOMAS: Wainio 1915 ( = *B. glaziouana* var. *poliocheila* and var. *sensitiva*)
  ST. JOHN: Wainio 1915 ( = *B. glaziouana* var. *poliocheila*)
**Buellia polyspora* var. *diminutiva* Wainio
  ST. CROIX: Type collection ( = *B. efflorescens* var. *diminutiva*)
**Buellia prospersa* (Nyl.) Riddle
  ST. THOMAS: Type collection ( = *B. prospersa*)
*Buellia punctiformis* f. *punctata* (Koerb.) Wainio
  GUADELOUPE: Wainio 1915 ( = *B. efflorescens*)
**Lecidea remensa* Stirton
  TRINIDAD: Type collection ( = *B. remensa*)
**Buellia rinodinospora* Riddle
  JAMAICA: Type collection ( = *B. callispora*)
*Buellia sanguinariella* (Nyl.) Wainio
  BAHAMAS: Riddle 1920 & 1923 ( = *B. catasema* var. *sanguinariella*)
  CUBA: Riddle 1920 & 1923 ( = *B. catasema* var. *sanguinariella*)
  CUBA (Isle of Pines): Riddle 1923 ( = *B. catasema* var. *sanguinariella*)
**Buellia sensitiva* Zahlbr.
  PUERTO RICO: Type collection ( = *B. glaziouana* var. *sensitiva*)
  PROVIDENCIA: Dix 1953 ( = *B. dispersula*)
**Buellia stipitata* Riddle
  JAMAICA: Type collection ( = *Karschia stygia*)
*Buellia subdisciformis* (Leight.) Wainio
  CUBA (Isle of Pines): Riddle 1923 ( = *B. bahiana* and *B. modesta* and *B. catasema* var. *sanguinariella*)
  JAMAICA: Riddle 1912 ( = *B. modesta*)
**Buellia subdisciformis* f. *caesiopruinosa* Tuck. in Wainio
  CUBA: Type collection ( = *B. glaucotheca*)
**Buellia subdispersula* Riddle
  CUBA (Isle of Pines): Type collection ( = *B. subdispersula*)
**Buellia substigmatea* Fink in Hedrick (non Müll. Arg.)
  ST. CROIX: Type collection ( = *B. prospersa*)
**Buellia trachyspora* Wainio
  CUBA: Malme 1927

ST. JOHN: Type collection ( = *B. trachyspora*)

*Buellia versicolor* Müll. Arg.

SAN ANDRÉS: Dix 1953 ( = *B. gerontoides*)

**Buellia yaucoensis* Wainio

PUERTO RICO: Type collection ( = *B. yaucoensis*)

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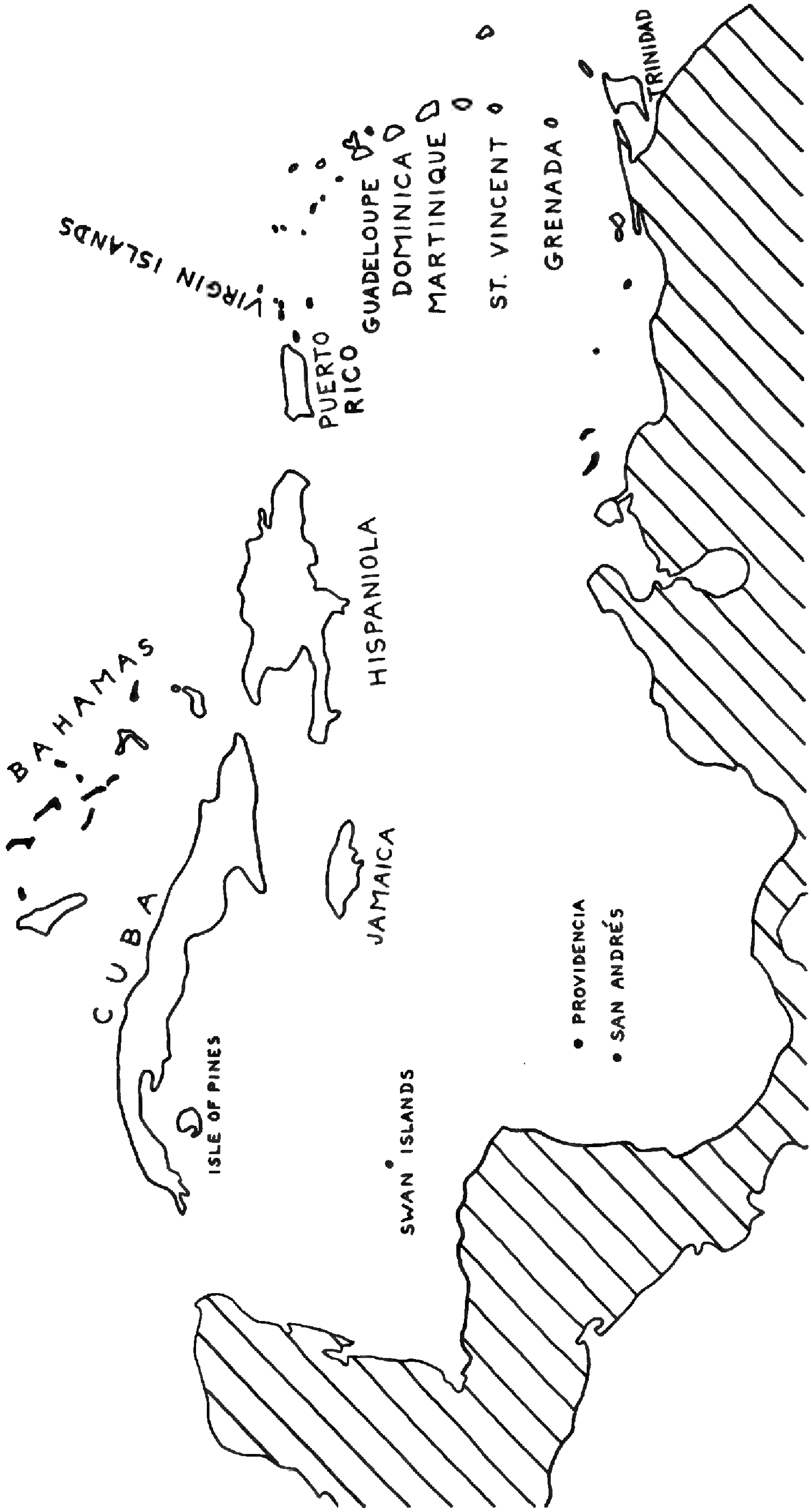

**Fig. 1.** Map of the West Indies.

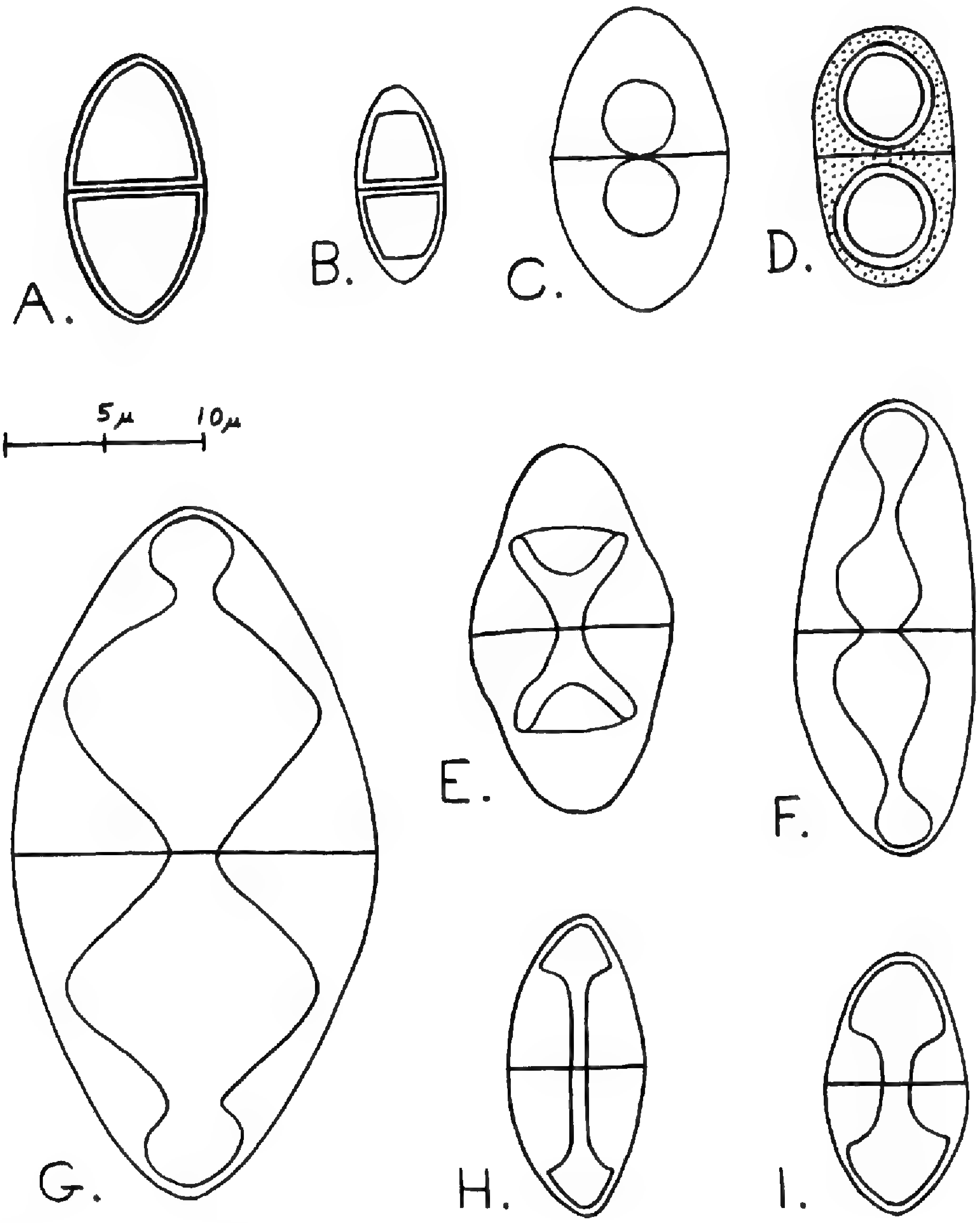

**Fig. 2.** Spore wall thickenings in *Buellia*. **A** — Spore walls and septum thin & uniform, common type; **B** — *B. modesta* (young spore); **C** — *B. dejungens*; **D** — *B. yaucoensis*, holotype; **E** — mischoblastiomorph, *B. posthabita*; **F** — *B. placodiomorphoides*, holotype; **G** — *B. callispora*; **H** — polarilocular, *B. placodiomorpha*; **I** — *B. boergesenii*, holotype.

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# FRESHWATER ALGAE OF ALASKA

## I. SOME DESMIDS FROM THE INTERIOR[1]

HANNAH CROASDALE

### GEOGRAPHY AND GEOLOGY

Alaska forms the northwestern part of North America as a peninsula with an area of about 586,400 square miles. Most of it lies between latitude 60° and 71° N. and longitude 141° and 165° W. About one third of it lies north of the Arctic Circle, but only about one tenth of it, the "Arctic Slope," which slants from the Brooks Range north to the Arctic Ocean, is normally classified botanically as "arctic."

Alaska is of particular interest for scientific study because in spite of its high latitude it suffered less glaciation in the last great ice age than other northern parts of North America. Its glaciation is described by Brooks (1953) as "local rather than continental." This seems to have been due to the scanty precipitation during the coldest period. A broad belt extending from east to west across the middle of Alaska was believed to be practically unglaciated during the Pleistocene (Capps, 1931) while the mountainous regions, including Brooks Range to the north and the higher Alaskan and Coastal Ranges to the south, were deeply ice-covered. The largest glaciers in Alaska today are in the southern part of these highest mountains. Since algae and mosess could presumably survive a period of glaciation, if not themselves covered for too long or scoured away, it seemed interesting to see if relict forms could be found in these unglaciated areas, and if any comparison could be made with the flora of glaciated regions on similar geologic formations.

Of further scientific appeal is the statement by the great Alaskan geologist, Brooks (1953) that "Geologically as geographically Alaska is the meeting point of the Old World and the New. The northwesterly trend of the axis of folding is North American, the southwesterly trend is Asiatic." He also speaks of the deposit of Asiatic rather than American fossils during one of the periods of submergence. Steere (1953), discussing the distribution of arctic bryophytes, points out that Alaska is the region richest in circumpolar arctic species and, together with northwestern Canada is "an area of critical geographical significance, where . . . "bicentric" species might be expected to find a common meeting place." Our

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[1] Field work done under the auspices of the Arctic Institute of North America, with funds provided by the Office of Naval Research.

Later assistance was received in the form of a grant from The National Science Foundation.

region is subarctic rather than arctic, but the extreme richness of my collections, as far as I have examined them, including, apparently, many relict species, points it out as a very important area.

In 1951 two of us, Mrs. E. A. Sherrard, also of Hanover, N. H., and I received a grant from the Arctic Institute of North America which enabled us to spend all of July and August in Alaska, collecting freshwater algae and mosses.

Advised by geologists we chose two focal areas. One was in Mount McKinley National Park at the southern fringe of the central unglaciated band, where we could collect, presumably, in glaciated and unglaciated areas. The algae collected in this area have not yet been studied. A second focal area was chosen at the northern limit of the central unglaciated band, in the Bettles-Wiseman region, in the Koyukuk River valley, a little north of the Arctic Circle. (Plate II).

Alatna (Allakaket) and Bettles are situated on the Koyukuk River, Wiseman is on its Middle Fork, and Nolan lies in the hills to the northwest, on Wiseman Creek (Plate II). According to Maddren (1913) at Alatna, Bettles and Wiseman we were collecting on "Unconsolidated Pleistocene deposits (silts, clays, sands and gravels, comprising terrace deposits, glacial outwash and morainal deposits, and including some undifferentiated Recent deposits.)" At Alatna and Bettles the closest highlands, on both sides of the river, consisted of "Limestone, calcareous sandstones, and arkose, with some igneous rocks." At Wiseman the land not overlaid by the unconsolidated Pleistocene deposits consisted of "Birch Creek Schist (Schists of various types, including some limestones, quartzites, and greenstones). Cut by granitic and dioritic dikes. The gold-bearing formation of the region." Nolan, where gold mining is still being carried on, was on this formation.

From Kellogg and Nygard (1951) we learn that the soils can be classified as follows: Alatna and Bettles — "Half bog, Subarctic Brown Forest and Alluvial soil," Wiseman and Nolan — "Mountain Tundra, Subarctic Brown Forest, Tundra, Half Bog and Bog." The whole area was in the region of "discontinuous permafrost." Permafrost has been reported specifically for the Wiseman-Nolan area.

## GENERAL ECOLOGY

The whole region is broadly classified as "open white spruce — birch forest." The southern slopes of the Brooks Range form the boundary of two broadly defined physiographic provinces: the Arctic, or Northern Mountain system where tundra prevails, and the Central Valley and Plateau region where boreal forests are established. Bettles and Wiseman seem, therefore, to lie in a transitional area where boreal forest and tundra tend to merge. White spruce, birch and poplar, with an undercover principally of *Ledum*, cover most of the land. Along river banks and levees, and sometimes in moist places at higher altitudes, alder and willow grow abundantly, with a dominant undercover of *Equisetum*, *Lycopodium* and *Galium spp.* The exposed land about the riverside villages is covered with various grasses and with several species of the saxifrage and rose families. And everywhere the forest is broken by treeless areas of varying extent locally called tundra, some probably better classified as muskeg.

From Alatna, to Bettles, to Wiseman, to Nolan the transition to more northerly, higher land is evident. Alatna and Bettles are more generally wooded. At Wiseman and Nolan there is more brush tundra, including a wider variety of dwarf and creeping woody plants, as well as many herbaceous plants, typical of arctic-alpine or of tundra areas. *Salix reticulata*, *Betula glandulosa*, *Potentilla fruticosa*, *Shepherdia canadensis*, *Ledum groenlandicum*, *Cassiope tetragona*, *Andromeda polifolia*, *Chamaedaphne calyculata* and other species of the heath family are frequent at Wiseman and less frequent or lacking at Bettles.

Stoeckeler (1949), has summarized from the U. S. Weather Bureau and the U.S. Army and Navy some climatological data for two of our villages which indicates the general nature of the region:

| | Mean Annual Temp. °F. | Days of Annual Freezing Temp. | Mean Annual Precip. (inches) | Mean Annual Snowfall (inches) | Mean Temp. during J-J-Aug. 1946 |
|---|---|---|---|---|---|
| Wiseman | 21.9° | 252 | 8.82 | ? | 54.6° |
| Allakaket | 18.9° | 257 | 12.95 | 77 | 55.8° |

The August of 1951, when we were in this region, happened to be unusually wet and it rained nearly every day. This made algae collecting much less profitable toward the end of the period because the ponds, sloughs, etc. became "drowned out."

## TYPES OF LOCALITIES

An attempt has been made to fit my localities into the scheme used by Strøm (1926). The following symbols are used:

1b Subaerial on damp soil
2a Wet rock
3b On stones, branches, etc. in brooks and rivers
3d On inundated ground
4a On stones at the shores of lakes and ponds
4b From the bottom of lakes and ponds
4c On stones, branches or other substrates in quiet water
5c On submerged parts of plants
5d In grass-bound pools and ditches
5e From mosses (by squeezing)
("T" has been added when the collection was made in a tundra "pothole" or "niggerhead pool.")

Few alpine habitates were encountered. The hills and the one mountain that we climbed were exceedingly dry, with good mosses and lichens but very meagre algae.

Running water habitats were limited to a few small brooks and sloughs. The rivers were in flood condition due to much rain and were heavily loaded with gravel, making collecting difficult and unprofitable.

The tundra pot-holes were innumerable, with very cold water, usually with a neutral reaction. These varied greatly in algal content, being sometimes nearly sterile, sometimes paved with sheets of *Nostoc* and little else, sometimes having a rich desmid flora.

No large lakes with sandy shores occurred in our region. Most so-called lakes were shallow ponds, ringed and paved with moss (most frequently *Drapanocladus exannulatus* (Gumb.) Warnst.), less often with grass, sometimes they were large, sedge-choked marshes. Whenever possible squeezings were taken from moss, from submerged plants other than moss, and from bottom vegetation, using a drag. "Plankton" hauls were made by throwing or dragging a small net. From these shallow but cold ponds and marshes, showing a high pH, came the richest yields, predominantly desmids.

## pH

The pH was determined colorimetrically with a "Lovibond Comparator" which is designed to discount the color natural to the pond water. The indicators used were Chlorphenol Red, pH 4.8–6.4, Bromthymol Blue, pH 6.0–7.6, and Cresol Red, pH 7.2–8.8. These were newly purchased from Eimer and Amend Co. Their readings have been checked against a Beckman pH meter and been declared to be "very close, as close as a visual method can be."

North of the Arctic Circle, which is the region dealt with in this paper, the pH values were consistently high: from 6.4–8.6 with pH 8.0 being the commonest record for ponds, lakes and marshes. Perhaps this is to be accounted for by the underlying formation which in most cases was partly limestone (although the bodies of water always had a heavy growth of vegetation which might be expected to annul the effect). Perhaps the very cold water is an important factor. At any rate I have faith in my records and the localities that *looked* favorable for desmids proved to be so, in spite of the high pH.

It seems possible that I have here the condition that Steinecke (1928) found, if my region is comparable to his "flat moors." While central Alaska is neither truly arctic or alpine there may be enough permafrost and tundra conditions to support a population in non-acid waters similar to the acid *Sphagnum* associations in warmer regions. Cedergren (1928) points out the agreement between the algae of Ca-rich highland regions and lowland algae in well-aerated water, and says "When the ecology of the algae is better known probably most of the arctic-alpine algae will show themselves to be more or less calciphiles, or at least to tolerate Ca, which otherwise is not the rule among desmids."[1]

Everything that I am finding supports these statements in reference to our region. When all my material has been examined the lists of species should be long enough to justify my belief that in these subarctic regions desmids are thriving, at a high pH, under conditions eminently suitable for them.

## SCOPE OF PRESENT PAPER AND PREVIOUS WORK

At the time of writing the material has been studied only from Alatna, Wiseman, Nolan and one station in Bettles, but it has seemed advisable for greater efficiency in the continuation of the investigation to get something into print now for criticism. This paper will (it is hoped) be followed by subsequent ones treating the rest of the desmids and the other greens, bluegreens and heterokonts of the region. Meanwhile study of the rest of the collection will be continued, and then the material, which is rich in diatoms, will be turned over to the experts in that field. It is to be hoped that eventually something of interest may be revealed about the glaciation problem, desmids in localities of high pH, and the relationship of our flora to that of similar situations in Europe and to relict and arctic-alpine flora.

To the best of my knowledge no reports on freshwater algae have been published for the territory where we collected. The complete (?) list of those who have, to date, published on freshwater Alaskan freshwater algae (exclusive of diatoms and flagellates) is: Blum (1953), Collins (1909), Farlow (1885), Harvey (1872), Hasslow (1934), Hooper (1947), Juday et al (1935), Kol (1942), Lowe (1923), Petersen (1932), Prescott (1953), Saunders (1901), Setchell & Gardner (1903), Sjösted (1939), Wailes (1933) (1934) and Whelden (1947). Those within the scope of the present paper are: Saunders on the southern coast, Lowe on the northern coast, Wailes in the extreme southeast and southwest and Kol on glaciers in the southern mountains. It has been possible to locate their stations quite accurately on the map (Pl. I), so they will be entered as "Saunders (A), (B)," etc, and their records will be added to mine, making the list, as far as it goes, complete, to date, for Alaska.

## METHODS

All identifications were made from formalin-preserved material, and the relative abundance indicated by the usual "ccc, cc, c, r, rr" after thorough examination of a number of slides from one sample, using a mechanical stage. This is of course wholly subjective. To me "ccc" means dominant in every slide, "cc" present in nearly every low-power field, "c" many

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[1] "Då algernas ekologi blir bättre känd, komma troligen de flesta av de arktisk-alpina visa sig var mer ell mindre kalkalger err åtminstone tåla kalk, vilket eljes ej är regel bland desmidiacéerna."

specimens seen, "r" only a few specimens seen, and "rr" only one or two specimens seen. When no letter follows, no impression as to abundance was noted.

All drawings were made with an Abbé camera lucida, most of them with the mirror mounted separately, about 12 inches from the miscroscope, a system recommended by Mr. A. M. Scott. The degree of magnification on the plates shows a regrettable lack of uniformity because many of the drawings were made while I was experimenting with the proper position for the mirror, and with the lens combination. Some of the details have been magnified two times my means of a simple desk magnifier, on the camera lucida principle. An illustration is furnished for every plant named, since naked lists from an author as little known as the present one are of little value.

In the following pages certain conventions and abbreviations are used. The dimensions refer to the author's Alaskan material only. "L" = length of cell, "w" = width of cell, "th" = thickness of cell, "isth." = width of isthmus in face view, "pyrenoids" = number of pyrenoids per semicell (Chloroplasts and pyrenoids, often doubtful or distorted in preserved material, are represented on the plates by dotted lines.), "terminal granules" = number of granules in the terminal granule. Specimens found by the author are entered as "Alatna: A5–c" etc. Alatna is the nearest village (Pl. I, II), A5 is the station which will be described in the final installment of this paper, –c indicates the relative abundance. Records of other authors are listed with the author's name followed by a letter (Kol–S) etc, which spots the location on the map of Alaska (Pl. I). Latitude, longitude and altitude were determined with the help of a pocket altimeter, a pedometer and the best maps available (usually flight charts), but should be considered only approximate.

## LIST OF SPECIES

### DESMIDIACEAE

### GONATOZYGON

**Gonatozygon Brébissonii** De Bary (Pl. III, Fig. 2).

L. 220 μ, max. w. 7μ (31 ×), w. at apex 5μ, granules sparse, sharp. Alatna: A2–r.

**Gonatozygon Brébissonii** De Bary var. **tatricum** Raciborski (1885) p. 12 (Pl. III, Fig. 3–5).

L. 75–118 μ, w. 6–8 μ (11–19 ×), pyrenoids 2–6, granules small, sharp. Nolan: N2, N4, Wiseman: W87–r, W88–rr, W95–r.

Probably new for America.

**Gonatozygon Kinahani** (Arch.) Rab. (Pl. III, Fig. 6–7).

L. 271–350 μ, w. 21–25 μ (13–14 ×), pyrenoids 3–6, as isolated cells or short filaments. Alatna: A5–cc, A6–c.

Our plant has cells much wider than the 14 μ limit given by the Wests. It is too short to be the var. *maius* of Taylor (1934), but it approaches the form described by Grönblad (1920), with cells 228–562 μ × 21–23 μ, with chloroplast often spirally twisted.

**Gonatozygon monotaenium** De Bary (Pl. III, Fig. 1).
L. 185–192 μ, w. at middle 9–10 μ (19–20.5 ×), w. at apex 10–11 μ, pyrenoids 5–7, granules rather flat, sometimes indistinct. Wiseman: W23–rr, W68.

### SPIROTAENIA

**Spirotaenia condensata** Bréb. (Pl. III, Fig. 8).
L. 158–173 μ, w. 15–19 μ (9.1–10.5 ×), w. at apex 11–13 μ, Alatna: A5–c.

**Spirotaenia obscura** Ralfs (Pl. III, Fig. 9).
L. 74 μ, w. 14 μ (5.3 ×), w. at apex 6 μ. Wiseman: W90–r.

### MESOTAENIUM

**Mesotaenium Berggrenii** (Wittr.) Lagerh. var. **alaskana** Kol (1942), p. 25.
Reported by Kol (O–S).

**Mesotaenium macrococcum** (Kütz.) Roy & Biss.
Reported by Saunders (D) (as *M. braunii* De Bary).

### ANCYLONEMA

**Ancylonema Nordenskiöldii** Berggren
Reported by Kol (O–S) (as *Ancyclonema Nordenskioldii* Berggren).

### CYLINDROCYSTIS

**Cylindrocystis Brébissonii** Menegh. (Pl. III, Fig. 10).
L. 34.5–51 μ, w. 16–20 μ (2–3 ×), pyrenoid 1. Alatna: A8–c, Bettles: 297–r, Wiseman: W98–r.

**Cylindrocystis Brébissonii** Menegh. forma α (Pl. III, Fig. 11–12).
L. 72–96 μ, w. 24–25 μ (3–3.8 ×), pyrenoids 2. Alatna: A7–r.
Dividing cells?

**Cylindrocystis Brébissonii** Menegh. forma β (Pl. III, Fig. 13).
L. 54 μ, w. 26 μ (2.1 ×), pyrenoid 1. Alatna: A2–r.
A very angular form.

**Cylindrocystis Brébissonii** Menegh. oic forma **cryophila** Kol (1942), p. 26.
Reported by Kol (O–S).

**Cylindrocystis Brébissonii** Menegh. var. **minor** W. & G. S. West (Pl. III, Fig. 15).
L. 32.5 μ, w. 13μ (2.5 ×), pyrenoid 1. Wiseman: W80–c.

**Cylindrocystis Brébissonii** Menegh. var. **turgida** Schmidle. (Pl. III, Fig. 14).
L. 49–52 μ, w. 25–30 μ (1.7–2 ×), pyrenoid 1. Alatna: A2–r, A7–r.

**Cylindrocystis crassa** De Bary
Reported by Lowe (J). "In large gelatinous masses."

**Cylindrocystis crassa** De Bary var. **elliptica** W. & G. S. West (Pl. III, Fig. 16).
L. 28 μ, w. 20 μ (1.4 ×). Alatna: A8–r.

### NETRIUM

**Netrium digitus** (Ehrenb.) Itzigs. & Rothe (Pl. III, Fig. 17).
L. 107–110 μ, w. 33–40 μ (2.7–3.2 ×) (Very common, size not always noted). Alatna: A1–c, A3–cc, A5–cc, A6–cc, A7–r, Bettles: 297–cc, 298–cc, Wiseman: W55, W56–c, W57–c, W70–r, W72–rr. Also reported by Saunders (E) (as *Penium Digitus* (Ehr.) Breb.) and by Wailes (1933, 1934) (N).

**Netrium digitus** (Ehrenb.) Itzigs & Rothe forma α (Pl. III, Fig. 18).
L. 110 μ, w. 40 μ (2.8 ×). Alatna A2–r.
A form approaching var. *curtum* (Borge) Krieger.

**Netrium digitus** (Ehrenb.) Itzigs. & Rothe var. **rhomboideum** Grönbl. (Pl. III, Fig. 19).

Two specimens seen: One (W70) L. 140 μ, w. 55 μ (2.5 ×), w. at apex 20 μ (dimensions very similar to those given to Grönblad); the other (A5) much larger: L. 227 μ, w. 90 μ (2.5 ×), w. at apex 30 μ. Alatna: A5–r, Wiseman: W70–r.

**Netrium digitus** (Ehrenb.) Itzigs. & Rothe var. **lamellosum** (Bréb.) Grönbl. (Pl. III, Fig. 20).

L. 150–154 μ, max. w. 24–39 μ (4–6.2 ×), w. at apex 10–11 μ. Alatna: A2–r, A5–r.

**Netrium digitus** (Ehrenb.) Itzigs. & Rothe var. **lamellosum** (Bréb.) Grönbl. forma α (Pl. III, Fig. 21).

L. 152 μ, max. w. 40–42 μ (3.6–3.8 ×), w. at apex 18 μ. Wiseman: W55, W67. A relatively short form.

**Netrium interruptum** (Bréb.) Lütkem.

Reported by Saunders (C) (as *Penium interruptum* Bréb.)

**Netrium oblongum** (De Bary) Lütkem. (Pl. III, Fig. 22).

L. 107 μ, w. 29 μ (3.7 ×), w. at apex 20 μ. Alatna: A8–c. Also reported by Saunders (E) (as *Penium oblongum* De Bary), and by Wailes (1933, 1934) (N).

**Netrium oblongum** (De Bary) Lütkem. var. **brevius** West (Pl. III, Fig. 23).

L. 78 μ, w. 26 μ (3 ×), w. at apex 13 μ. Alatna: A8–r.

### PENIUM

**Penium cruciferum** (De Bary) Wittr.

Reported by Lowe (H).

**Penium exiguum** West. (Pl. III, Fig. 24–25).

L. 38–60 μ, w. 9–10 μ (4.2–10 ×), w. at apex 8.5–9.5 μ, w. below apex 8–8.5 μ, pyrenoids 2, wall granulate, granules irregularly arranged, smaller and fainter at isthmus, girdle bands not observed, wall colorless in region of isthmus, shading to dark brown at the apices. Alatna: A5–r.

Our plant differs from the species as described by West (1892) in its larger size and colored cell wall. Krieger extends the size range to beyond our limits, does not mention wall color, and describes and figures the wall as "punctate" (as he does all the "granular" Peniums). With its larger size and colored cell wall our plant fits very well into *P. margaritaceum* forma *minor* Cederg. which Krieger includes in *P. exiguum*.

**Penium margaritaceum** (Ehrenb.) Bréb.

Reported by Lowe (H), and by Saunders (B).

**Penium polymorphum** Perty

Reported by Saunders (B).

**Penium silvae-nigrae** Rabanus forma **minor** Bourrelly and Manguin (1952), p. 492. (Pl. III, Fig. 26–27).

L. 33 μ, w. 16–17 μ (2 ×), w. at apex 10 μ, pyrenoid 1, wall colorless, striate, with rather widely-spaced (8 in 10 μ) broken striae, which appear as rows of dashes rather than as punctae. Wiseman: W98–r.

This is closest to Bourrelly and Manguin's form but differs in its shape, with greater taper toward the apex, and in the nature of its striae.

**Penium spirostriolatum** Barker (Pl. III, Fig. 28).

L. 230–275 μ, w. 20.5–30 μ (9.1–11.2 ×), w. at apex 16 μ, transverse sutures very evident, wall yellow, striate, striae 7 in 10 μ, with spiral twist, no punctae visible between the striae. Alatna: A5–c, A6–r. Also reported by Wailes (1933) (M).

**Penium spirostriolatum** Barker forma α (Pl. III, Fig. 29).

L. 334 μ, w. 38 μ (8.8 ×), w. at apex 25 μ, many transverse sutures, wall striate, 4 striae in 10 μ, straight, anastomosing throughout length of cell, clearly punctate between the striae. Alatna: A5.

Bourrelly and Manguin (1946) show a similar form.

## CLOSTERIUM

**Closterium abruptum** West var. **brevius** West & West
Reported by Wailes (1934) (N).

**Closterium acerosum** (Schrank) Ehrenb. (?) (Pl. VII, Fig. 1).
L. 400–475 μ, w. 32–40 μ (10–14.6 ×), w. at apex 8–9 μ, 25° of arc, pyrenoids 6, terminal granules 2, wall yellow-brown, faintly striated, 5–6 striae in 10μ, striae sometimes becoming irregular at apex. Nolan: N6–r, N8–r, Wiseman: W89–rr. Also reported by Saunders (C), and by Wailes (1934) (N).

Possibly a less-curved form of *Cl. Pritchardianum?*

**Cloisterium acerosum** (Schrank) Ehrenb. forma α (Pl. VII, Fig. 2).
L. 387 μ, w. 38 μ (10.2 ×), w. at apex 8 μ, nearly straight, wall striate, 5 striae in 10 μ, broken, spirally arranged, merging into irregularly arranged punctae at apex, girdle bands very evident. Nolan: N8.

Superficially this plant resembles *Cl. acerosum* var. *striatum* Hilse, but in the latter there are flat ribs with striae between.

**Closterium acerosum** (Schrank) Ehrenb. var. **minus** Hantzsch (Pl. VII, Fig. 3).
L. 200–255 μ, w. 18–23 μ (9.7–11.4 ×), w. at apex 4–5 μ, cells nearly straight, ventral wall slightly tumid, pyrenoids 4–6, wall smooth, apices evenly tapered and rounded, not recurved. Alatna: A3–r, A7–rr, Wiseman: W55–rr, W70–rr, W71–rr, W90–r, W91–r, W92–c.

More common than the type.

**Closterium acutum** Bréb. (Pl. VIII, Fig. 13).
L. 100 μ (2 × the longer semicell), w. 4 μ, (25 ×), w. at apex 1 μ, cells straight, wall smooth, colorless. Alatna: A9–rr. Also reported by Saunders (E).

**Closterium angustatum** Kütz. (Pl. IV, Fig. 10).
L. 330–540 μ, w. 22–29 μ (13.7–16.5 ×), w. at apex 13 (19) μ, terminal granules many, 1.5–2.5 costae in 10 μ, wall punctate, brown. Apex sometimes bent back and sometimes swollen. Alatna: A5–r, Bettles: 298–r, Wiseman: W69–c, W70–rr. Also reported by Saunders (D) (as *Cl. angustatum* var. *reticulatum* Wolle), and by Wailes (1933) (M).

**Closterium angustatum** Kütz. forma α (Pl. IV, Fig. 11).
A form about one half as large as the type, wall very rough with punctae. L. 192 μ, w. 9 μ (21.3 ×), w. at apex 7 μ, terminal granule 1, large, 3 costae in 10 μ, sometimes spirally arranged, wall coarsely punctate, yellow. Alatna: A6–r.

**Closterium angustatum** Kütz. var. **gracilius** var. nov. (Pl. IV, Fig. 12).
Varietas tenuissima, membrana inter costas levi, 233–325 μ long., 8.5–10 μ lat. (27.4–32.5 ×), 6.5–7 μ lat. in apice, costae 3 in 10 μ, membrana brunnea.

A very slender variety with the wall smooth between the costae. L. 233–325 μ, w. 8.5–10 μ (27.4–32.5 ×), w. at apex 6.5–7 μ, 3 costae in 10 μ, wall brown. Rosa (1939) describes a forma *tenuis*, but his is much larger and relatively broader. Alatna: A5, Bettles: 298–r.

**Closterium Archerianum** Cleve (Pl. IV, Fig. 7).
L. 205–240 μ, w. 21.5–22 μ (9–11 ×), w. at apex 4–5 μ, 120°–130° of arc, pyrenoids 8, striae 6–7 in 10 μ. Alatna: A1–c, Wiseman: W21–r, W22.

**Closterium Archerianum** Cleve forma α (Pl. IV, Fig. 8).
A form with twice as many striae as the type. L. 223 μ, w. 20 μ (11 ×), apex 4 μ, 125° of arc, pyrenoids 5, 10 striae in 10 μ, wall yellow. Alatna: A2.

**Closterium arcuarium** Hughes (1952), p. 272. (Pl. V, Fig. 18).
L. 225 μ, w. 21 μ (10.7 ×), w. at apex 4.5 μ, 95° of arc, pyrenoids 5, wall smooth, yellowish. Alatna: A5–rr.

A little larger and somewhat less tumid than Hughes' plant but otherwise very similar.

**Closterium Baillyanum** Bréb. (Pl. IV, Fig. 9).

L. 560 μ, w. 55 μ (10 ×), w. at apex 26 μ, 25° of arc, terminal granules many, wall punctate, pale brown, darker at apex. Alatna: A5–c.

**Closterium cornu** Ehrenb. (Pl. VII, Fig. 13).

L. 141 μ, w. 6 μ (23.5 ×), w. at apex 3 μ, about 20° of arc, wall smooth, older semicell brown. Alatna: A6. Also reported by Lowe (H) "Very common . . . the majority were more curved than the type form."

With us it appeared as a rather slender, straight form.

**Closterium cornu** Ehrenb. forma α (Pl. VII, Fig. 14–15).

L. 160–200 μ, w. 7.2–11 μ (16.3–22 ×), w. at apex 2 μ, cells straight, evenly tapered to the truncate apices, pyrenoids 3–4, terminal granules (seen once) 3, wall colorless, smooth. Wiseman: W17, W78–r, W89–rr.

**Closterium costatum** Corda (Pl. IV, Fig. 13).

L. 360 μ, w. 40 μ (9 ×), w. at apex 14 μ, 70° of arc, 2 costae in 10 μ, wall yellow, smooth between the costae. Wiseman: W55, W59–r.

**Closterium cuspidatum** Bail. (Pl. VI, Fig. 18).

L. 153 μ, w. 51 μ (3 ×), w. at apex 14 μ, 195° of arc, pyrenoids 4–5, scattered, terminal granules many, wall smooth, colorless, apex with dorsal hump, terminal spine 9 μ long. Alatna: A5–r.

**Closterium cynthia** De Not. (Pl. IV, Fig. 6).

L. 100–165 μ, w. 12–20 μ (7.4–11 ×), w. at apex 3.5–4 μ, 135°–165° of arc, pyrenoids 3–5, striae 7–10 in 10 μ, terminal granules (rarely seen) 3–4, wall pale brown. Alatna: A5, A6, Wiseman: W55–r, W90–r.

**Closterium cynthia** De Not. forma α (Pl. IV, Fig. 4).

A form about twice as large as the type. L. 245 μ, w. 32 μ (7.6 ×), w. at apex 5 μ, 135° of arc, striae 6 in 10 μ, wall colorless. Only empty cell observed. Alatna: A6–c.

**Closterium cynthia** De Not. forma β (Pl. IV, Fig. 5).

A form with thickened area in wall at apex. L. 140–182 μ, w. 14–20 μ (8–10 ×), w. at apex 3–4 μ, 120°–150° of arc, pyrenoids 4, terminal granules (rarely seen) 5, striae 9–11 in 10 μ, wall colorless to pale brown. Alatna: A9–rr, Wiseman: W78–r, W92.

**Closterium dianae** Ehrenb. (Pl. V, Fig. 1–6).

L. 145–220 μ, w. 14–21 μ (9–14.7 ×), w. at apex 2–4 μ, 85°–135° of arc, pyrenoids 3–6, terminal granules 1–3, wall smooth, colorless, rarely yellow. Granular thickening in wall at apex ("end pore" of some authors) not always present, but apices usually obliquely truncate. Alatna: A5–cc, A6, A10–rr, Bettles: 297–cc, 298–cc, Wiseman: W20–r, W21–cc, W25–r, W28–r, W29–cc, W71–rr, W83, W84–c, W85, W96–rr. Also reported by Saunders (E) "Only one specimen seen."

A very common and variable species, grading into its varieties and into *Cl. venus*, *Cl. parvulum*, *Cl. tumidulum* and *Cl. Leibleinii*. The minimum length given by West & West of 270 μ is evidently meant to be 170 μ.

**Closterium dianae** Ehrenb. forma α (Pl. V, Fig. 11–12).

A form more sharply bent near the extremities, approaching var. *compressum* Klebs. L. 78–90 μ, w. 13–16 μ (5.6–6 ×), w. at apex 3 μ, 145°–175° of arc, pyrenoids 2, terminal granule 1, wall smooth, colorless, no granular thickening at apex. Nolan: N6–rr, Wiseman: W101–cc.

**Closterium dianae** Ehrenb. var. **arcuatum** (Bréb.) Rabenh. (Pl. V, Fig. 7).

L. 127–280 μ, w. 14–37 μ (8–9.1 ×), w. at apex 2–4 μ, 150°–152° of arc, pyrenoids 3–4, terminal granules 5, wall smooth, pale yellow, granular thickening at apex sometimes present. Alatna: A5–c, Wiseman: W72. Also reported by Wailes (1933) (M).

**Closterium dianae** Ehrenb. var. **brevius** (Wittr.) Petkoff (Pl. V. Fig. 10).

L. 90–139 μ, w. 14–20 μ (6.4–7 ×), w. at apex 2–4 μ, 130°–150° of arc, inner margin slightly swollen, pyrenoids 3–5, terminal granules 3, wall smooth, colorless or pale yellow, granular thickening at apex rarely present. Nolan: N8, Wiseman: W1–c, W78–r, W101–c.

This seems to grade into *Cl. Leibleinii* var. *minimum* on the thick side and into varieties of *Cl. venus* and *Cl. incurvum* on the small side.

**Closterium dianae** Ehrenb. var. **minus** (Wille) Schröder (Pl. V, Fig. 8–9).

L. 125–140 μ, w. 10.5–18 μ (8–12 ×), w. at apex 2–3 μ, 100°–125° of arc, pyrenoids 3, terminal granule 1, wall smooth and colorless, granular thickening at apex sometimes present. Alatna: A3, Nolan: N8.

This seems to be an entirely artificial variety including all small forms with concave ventral surface which might be *Cl. dianae.* It grades into *Cl. parvulum* and *Cl. calosporum* (which requires the spore for identification).

**Closterium Ehrenbergii** Menegh. (Pl. VI, Fig. 20).

L. 395 μ, w. 88 μ (4.4 ×), w. at apex 10 μ, 120° of arc, wall smooth, colorless. Wiseman: W15–rr.

Only one empty cell was seen, but species is unmistakable from its size and shape.

**Closterium exile** West & West var. **unicrystallatum** Kol (1942), p. 26.

Reported by Kol (S).

**Closterium gracile** Bréb. (Pl. VIII, Fig. 4, 6).

L. 90–276 μ, w. 4.5–6 μ (18–46 ×), w. at apex 1.8–3 μ, cells straight, incurved toward the apices, pyrenoids 4–7, terminal granules 1–4, wall smooth, colorless to yellow. Alatna: A5–cc, A6, Bettles: 298–r, Wiseman: W69, W70. Also reported by Wailes (1934) (M).

**Closterium gracile** Bréb. forma **sigmoideum** fa. nov. (Pl. VIII, Fig. 5).

Forma sigmoidea.

L. 185 μ, w. 53 μ (34 ×), w. at apex 3 μ, pyrenoids 7–8, wall smooth, colorless. Alatna: A5–r.

This has probably been seen and figured before, but it is not in the list of sigmoid species in North America given by Irénée-Marie (1954).

**Closterium gracile** Bréb. var. **tenue** (Lemm.) West & West. (Pl. VIII, Fig. 7).

L. 80 μ, w. 4 μ (20 ×), w. at apex 1.5 μ, 35° of arc, pyrenoids 2 (?), wall smooth, colorless. Alatna: A6–rr.

A rather stout form.

**Closterium idiosporum** West & West (?) (Pl. VIII, Fig. 9).

L. 240 μ, w. 12 μ (20 ×), w. at apex 2.5 μ, 10° of arc, pyrenoids 5, wall smooth, colorless. Wiseman: W90.

No spore was seen, but the Wests do not seem to consider this essential for identification.

**Closterium incurvum** Bréb. (Pl. VI, Fig. 5–8).

L. 37–70 μ, w. 7–12 μ (4.2–6.9 ×), w. at apex 1.5–2.5 μ, 175°–200° of arc, pyrenoids 1–3 (usually 2), terminal granule 1, wall smooth, colorless. Alatna: A3–r, A5–r, A6–cc, A7–r, Bettles: 297–cc, 298–cc, Wiseman: W78–rr, W84, W96–r, W99.

This species which was very common and constant in character, with much greater curvature and relatively stouter than *Cl. venus*, seems better kept as a separate species, as is the practice of Grönblad, Irénée-Marie and others.

**Closterium incurvum** Bréb. forma *a* (Pl. VI, Fig. 9–10).

A larger and more slender form. L. 82–90 μ, w. 10–12.5 μ (7–8.2 ×), w. at apex 1.8–2.2 μ, 175°–180° of arc, pyrenoids 2–3, terminal granules 2, wall smooth and colorless. Wiseman: W52–c, W78, W85–cc.

Since one specimen shows a granular thickening of the wall at the apex, perhaps this may be a small form of *Cl. dianae* var. *compressum.*

**Closterium Jenneri** Ralfs (Pl. VI, Fig. 1).

L. 82–90 μ, w. 9–10 μ (9–10 ×), w. at apex 3–4 μ, 120°–150° of arc (difficult to measure), pyrenoids 4, terminal granule 1, wall smooth, even with oil immersion, pale yellow or brown. Alatna: A5, A6, Bettles: 297.

This plant with its smooth (or very finely striated) wall, its blunter apices, and typical curvature, seems better maintained as a separate species rather than a variety of *Cl. cynthia*. This practice is also followed by Grönblad, Irénée-Marie and others.

**Closterium Jenneri** Ralfs forma α (Pl. VI, Fig. 2).

A small, less-curved form. L. 84 μ, w. 10 μ, (8.4 ×), 110° of arc, pyrenoids 2, terminal granule 1, wall smooth, pale brown. Alatna: A6. Perhaps this is the plant reported by Lowe (H) ". . . a form with apices less curved than type."

**Closterium Jenneri** Ralfs var. **tenue** var. nov. (Pl. VI, Fig. 3–4).

Varietas tenuis, minus curvata quam planta typica, forma, autem typica, parte media recta, apicibus incurvatis, relative obtusis, 117–143 μ long., 9.5–11 μ lat. (10.6–13.4 ×), 2.5–3 μ in apice, 90°–115° arcus (mensura difficilis), pyrenoidea 2–4, granula terminalia 2, membrana levis, sine colore, raro dilute brunnea.

A slender variety, less curved than the type but with the typical straight middle portion and incurved apical region. Apices also relatively blunt and without a thickened area or pore in the wall. L. 117–143 μ, w. 9.5–11 μ (10.6–13.4 ×), w. at apex 2.5–3 μ, 90°–115° of arc (difficult to measure), pyrenoids 2–4, terminal granules 2, wall smooth, colorless, in one case pale brown. Alatna: A1, A2, Wiseman: W56, W70–r.

**Closterium juncidum** Ralfs

Reported by Saunders (C).

**Closterium juncidum** Ralfs var. **brevior** Roy (Pl. IV, Fig. 15).

L. 175 μ, w. 12 μ (14.6 ×), w. at apex 6.5 μ, 35° of arc, 1 large terminal granule, 13 striae in 10 μ. Alatna: A10–r.

**Closterium juncidum** Ralfs var. **elongatum** Roy & Biss. (Pl. IV, Fig. 16).

L. 350 μ, w. 8.2 μ (42.7 ×), w. at apex 6 μ, 10 striae in 10 μ, wall colorless. Alatna: A9–rr.

**Closterium Kuetzingii** Bréb. (Pl. IX, Fig. 1).

L. 470 μ, w. 22 μ (21 ×), w. at apex 3 μ, wall striate, 11 striae in 10 μ. Bettles: 297–r, 298–r, Wiseman: W84. Also reported by Wailes (1934) (N).

**Closterium Kuetzingii** Bréb. var. **laeve** (Racib.) Krieger (Pl. IX, Fig. 2).

L. 420–480 μ, w. 18 μ (23.4–26.7 ×), w. at apex 1.5–2 μ, wall colorless, smooth. Alatna: A3, A9, Wiseman: W83.

**Closterium Kuetzingii** Bréb. var. **laeve** (Racib.) Krieger forma α (Pl. IX, Fig. 3).

L. 400 μ, w. 21 μ (19 ×), w. at apex 3 μ, wall smooth. Wiseman: W84.

In shape tending toward *Cl. rostratum*.

**Closterium Leibleinii** Kütz.

Reported by Wailes (1934) (M).

**Closterium Leibleinii** Kütz. var. **minimum** Schmidle (Pl. VI, Fig. 19).

L. 76–92 μ, w. 15–20 μ (4.7–5.8 ×), w. at apex 2.5–3.5 μ, 141°–155° of arc, pyrenoids 2–3, wall smooth, colorless. Nolan: N8, Wiseman: W1. W80–c.

Krieger absorbs this variety into the species, but makes no allowance in his dimensions for the small size and relative shortness of Schmidle's variety. All of our forms seem closer to Schmidle's description (1893) for var. *minimum* than to the description Krieger gives for *Cl. Leibleinii*.

**Closterium libellula** Focke

Reported by Saunders (A) (as *Penium closterioides* Ralfs).

**Closterium libellula** Focke var. **intermedium** (Roy & Bissett) G. S. West (Pl. IV, Fig. 1).

L. 84 μ, w. 15.5 μ (5.4 ×), w. at apex 6 μ, pyrenoids 3. Alatna: A9–r.

**Closterium lineatum** Ehrenb. (Pl. VIII, Fig. 12).

L. 460–590 μ, w. 20–22 μ (22–28 ×), w. at apex 6–7 μ, cells straight in median portion, slightly incurved toward the apices, pyrenoids 10, terminal granule 1, wall yellow to dark yellow-brown, striate, 6–9 striae in 10 μ, punctate at apex, in one case punctae observed between the striae. Wiseman: W17–r, W29–c, W72–rr, W94–r.

**Closterium lineatum** Ehrenb. var. **elongatum** Rosa (1951), p. 200 (Pl. VIII, Fig. 11).

L. 570–665 μ, w. 15–21.5 μ (31–38 ×), w. at apex 6.5–7 μ, cells nearly straight, pyrenoids 14, terminal granule 1, 6–9 striae in 10 μ, striae becoming broken at apex but maintaining straight lines, no punctae. Wall of apex with thickened area. Alatna: A9–rr.

Probably the first record for America.

**Closterium lunula** (Müll.) Nitzsch. (Pl. VII, Fig. 4).

L. 500–600 μ, w. 66–80 μ (6.7–7.6 ×), w. at apex 20–27 μ, 33°–45° of arc, pyrenoids many, scattered, wall smooth, colorless, apices slightly recurved. Alatna: A5, Wiseman: W87–r, W88–r, W90–r, W92–cc, W94–cc. Also reported by Saunders (B) "Occasional."

**Closterium lunula** (Müll.) Nitzsch. forma **gracilis** Messik. (1935), p. 119. (Pl. VII, Fig. 5).

L. 610 μ, w. 95 μ (6.4 ×), w. at apex 28 μ, 35° of arc, pyrenoids many, scattered, terminal granules many, small, wall smooth, colorless, chloroplast with longitudinal plates (6 visible in surface view) notched in the manner of *Netrium digitus*. Bettles: 298–rr.

Our plant differs from Messikommer's in its slightly tumid ventral surface, making it more nearly symmetrical, and in its larger dimensions. However, the chloroplast plates with notched edges, the less recurved apices and smooth wall seem to fit most closely into his form. An end vacuole with many small granules is very evident in our plant. Very similar is *Cl. lunula* var. *carinthiacum* Beck-Mannagetta (1931), p. 266, figured by Irénée-Marie (1954), which, however, lacks the terminal vacuole (or "Endblase" (?)) which is so conspicuous in our plant and in Messikommer's. Similar also is *Cl. lunula* var. *Massartii* (de Wild.) Krieger, which is, however, more nearly symmetrical, somewhat larger, and has less dissected chloroplast plates. Perhaps these three could be combined as one variety of *Cl. lunula.*

**Closterium macilentum** Bréb.

Reported by Saunders (D) (as *Cl. Brébissonii* Delp.).

**Closterium moniliferum** (Bory) Ehrenb. (Pl. VI, Fig. 21).

L. 220–305 μ, w. 30–41 μ (6.3–7.6 ×), w. at apex 7–8 μ, 70°–100° of arc, pyrenoids 4–8, terminal granules many, wall smooth, colorless. Wiseman: W74–r, W80–r, W89–c, W91–cc, W92–cc, W94–c. Also reported by Lowe (H).

**Closterium moniliferum** (Bory) Ehrenb. var. **concavum** Klebs. (Pl. VI, Fig. 22).

L. 238–250 μ, w. 37–43 μ (6.4–6.8 ×), w. at apex 7–8 μ, 115°–120° of arc, pyrenoids 5–6, terminal granules 4, wall smooth, pinkish brown. Wiseman: W78–r.

**Closterium navicula** (Bréb.) Lütkem. (Pl. IV, Fig. 2–3).

L. 47–86 μ, w. 12–17.5 μ (3.9–4.9 ×), w. at apex 5–6.5 μ, pyrenoid 1. Alatna: A1, A3–r, A5–cc, A6–c, Wiseman: W55–r, W90.

**Closterium parvulum** Näg. (Pl. V, Fig. 13–17).

L. 92–140 μ, w. 10.5–18 μ (7–11 ×), w. at apex 2–3 μ, 120°–165° of arc, pyrenoids 2–5, terminal granules 1–5, wall smooth, colorless, rarely pale brown. Alatna: A2, A3, A5–cc, A9–rr, Bettles: 297–r, Wiseman: W21–cc, W28–r, W42, W49–cc, W55–r, W56, W59–c, W70, W76, W78. Also reported by Lowe (H,K), and by Saunders (C) "very abundant."

Another very common and variable species, grading into varieties of *Cl. dianae* and *Cl. venus*. Separation in this paper has been made mainly on the basis of *Cl. parvulum* having a greater curvature and sharper apices than *Cl. dianae*, and a lesser curvature and larger size than *Cl. venus.* The presence of a granular thickening in the wall at the apex is as variable in *Cl. parvulum* as in *Cl. dianae*, but in general *Cl. parvulum* has an evenly tapered apex while the apex of *Cl. dianae* is obliquely truncated.

**Closterium praelongum** Bréb. (Pl. VII, Fig. 9).

L. 515 μ, w. 19.5 μ (26.3 ×), w. at apex 6 μ, cell nearly straight, incurved near the apices, with tips recurved, pyrenoids 7, wall very pale brown, striate, 10 striae in 10 μ. Wiseman: W90–rr, W92–rr.

**Closterium praelongum** Bréb. var. **brevius** West (Pl. VII, Fig. 16).

L. 205–360 μ, w. 17–20 μ (12–18 ×), w. at apex 3.5–5 μ, 25°–35° of arc, apices more or less recurved, pyrenoids 5–11, terminal granules 1–2, wall brownish, finely striated, 11–13 striae in 10 μ. Wiseman: W87–c, W94.

**Closterium Pritchardianum** Arch. (Pl. VII, Fig. 8).

L. 410 μ, w. 30 μ (13.7 ×), w. at apex 8 μ, 35° of arc, ventral side also concave, wall striate, 6 striae in 10 μ. Alatna: A10.

**Closterium Pritchardianum** Arch. forma **laeve** Hughes (1952), p. 284 (Pl. VII, Fig. 7).

L. 330–525 μ, w. 30 μ (11–17.5 ×), w. at apex 8–9 μ, 20°–35° of arc, apices abruptly tapered, somewhat recurved, pyrenoids 6–7, wall smooth, colorless. Alatna: A10, Wiseman: W78–r.

Compare *Cl. acerosum*. In my material there is a considerable overlapping of characters between these two species and their varieties.

**Closterium pronum** Bréb. (Pl. VIII, Fig. 8).

L. 255 μ, w. 11 μ (26.8 ×), w. at apex 2 μ, cells nearly straight, pyrenoids 12, terminal granules 9–10, wall smooth, colorless. Wiseman: W72.

A relatively short form.

**Closterium pseudolunula** Borge (Pl. VII, Fig. 6).

L. 295–310 μ, w. 38.5–44 μ (7–7.6 ×), w. at apex 8 μ, 65° of arc, pyrenoids 4, in median row, terminal granules 6–8, wall smooth, yellow. Wiseman: W21–c.

**Closterium Ralfsii** Bréb. var. **hybridum** Rabenh. (Pl. VIII, Fig. 10).

L. 465 μ, w. 38 μ (12 ×), w. at apex 8 μ, 38° of arc, 10 striae in 10 μ, wall brown. Wiseman: W83–rr. Also reported by Wailes (1934) (N).

**Closterium rostratum** Ehrenb. (Pl. IX, Fig. 4–5).

L. 360–440 μ, w. 20–40 μ (9.3–19.3 ×), w. at apex 2–2.5 μ, apex sometimes swollen, wall brown, striate, 7–12 striae in 10 μ, wall sometimes thickened at apex. Alatna: A3, A10–r, Nolan: N8–r, Wiseman: W21–r, W29–rr, W72–rr, W78–r, W85–rr. Also reported by Wailes (1933) (M) (as *Cl. rostratum* var. *brevirostratum* West).

This was by far the commonest of the beaked Closteriums and showed considerable variation.

**Closterium setaceum** Ehrenb. (Pl. IX, Fig. 6).

L. 330–480 μ, w. 11–18 μ (26.7–33 ×), w. at apex 2.5 μ, wall delicately striate, 13 striae in 10 μ. Alatna: A2–rr, A5–cc, A6–r. Also reported by Lowe (H), and by Wailes (1934) (N).

**Closterium strigosum** Bréb. var. **elegans** (G. S. West) Krieger (Pl. VIII, Fig. 3).

L. 195 μ, w. 7.5 μ (26 ×), w. at apex 2 μ, wall smooth, colorless. Alatna: A2–rr.

This is more slender than the 11–21 μ allowed in the dimensions given by Krieger, but he includes in this variety *Cl. strigosum* forma of Schmidle (1902) which has the breadth of only 5 μ.

**Closterium striolatum** Ehrenb. (Pl. IV, Fig. 14).

L. 250–260 μ, w. 23–24 μ (11 ×), w. at apex 9–10 μ, 60° of arc, pyrenoids 4–7, wall striate, 5–7 striae in 10 μ, pale brown. Alatna: A3–r, A6–r, Wiseman: W29. Also reported by Lowe (H), by Saunders (B), and by Wailes (1933), (M).

**Closterium toxon** W. West (Pl. VIII, Fig. 1–2).

L. 200–205 μ, w. 14–15 μ (13.7–14.3 ×), w. at apex 7 μ, 20°–35° of arc, pyrenoids 3, terminal granule 1, wall smooth, colorless to yellow, apices slightly incurved, in one case a little swollen. Alatna: A1, Bettles: 297.

**Closterium tumidulum** Gay (Pl. V, Fig. 19–20).

L. 102–132 μ, w. 15–18 μ (6.5–7.3 ×), w. at apex 2–3 μ, 130°–150° of arc, pyrenoids 2–7, 1 large or many small terminal granules, wall smooth, colorless. Wiseman: W80, W92.

Our plants are less tumid, with less attenuated apices than those figured by Krieger, but Borge (1901) shows a form rather like ours.

**Closterium tumidum** Johnson (Pl. VII, Fig. 11–12).

L. 162–165 μ, w. 19 μ (8.5–8.7 ×), w. at apex 4–5 μ, 20°–30° of arc, pyrenoids 2–3, wall smooth, colorless. Alatna: A1.

**Closterium tumidum** Johnson forma α (Pl. VII, Fig. 10).

L. 180 μ, w. 19 μ (9.5 ×), w. at apex 3 μ, straight, pyrenoids 5, terminal granule 1. Alatna: A3.

A form longer than the type, cells straight and more tapered.

**Closterium venus** Kütz. (Pl. VI, Fig. 11).

L. 56–85 μ, w. 8–10 μ (7–9.4 ×), w. at apex 1.2–1.9 μ, 150° of arc, pyrenoids 2, terminal granules 2 (rarely observed), wall smooth, colorless, rarely yellowish. Wiseman: W28, W72–c, W78–c. Also reported by Lowe (H) "Fairly common," and by Saunders (C).

Much rarer than *Cl. incurvum* or *Cl. venus* var. *crassum.*

**Closterium venus** Kütz. forma α (Pl. VI, Fig. 17).

L. 78–80 μ, w. 10–11 μ (7.3–7.8 ×), w. at apex 1.8–2 μ, 170° of arc, pyrenoids 2, terminal granules 2, wall smooth, colorless. Wiseman: W52, W87–r.

A form between *Cl. venus* and the large form of *Cl. incurvum.*

**Closterium venus** Kütz. forma **maior** Strøm (Pl. VI, Fig. 15–16).

L. 100–125 μ, w. 15–20 μ (6.3–6.7 ×), w. at apex 3–4 μ, 150°–160° of arc, pyrenoids 3–4, terminal granules 3 (?) (seen only once), wall smooth, colorless. Wiseman: W21, W57–r.

Krieger absorbs Strøm's form into *Cl. parvulum,* which is not unreasonable considering his figure which shows a curvature of only about 120° of arc. However, our specimens fit Strøm's description and have a curvature of 150°–160° of arc, which is better for *Cl. venus* than for *Cl. parvulum,* so it seems more appropriate to include them in Strøm's form.

**Closterium venus** Kütz. var. **crassum** var. nov. (Pl. VI, Fig. 12–14).

Varietas crassior, magis curvata, 76–92 μ long., 13–15.5 μ lat. (5–6.4 ×), 2–3 μ lat. in apice, 140°–170° arcus, pyrenoidea 1–5 (plerumque 2), granula terminalia 1–4, membrana levis, sine colore.

L. 76–92 μ, w. 13–15.5 μ (5–6.4 ×), w. at apex 2–3 μ, 140°–170° of arc, pyrenoids 1–5 (commonly 2), terminal granules 1–4, wall smooth, colorless. Alatna: A1, A2–cc, A3–cc, A4–r, Nolan: N6–r, N8, Wiseman: W21–c, W28–r, W76–c, W78.

A much stouter, more strongly curved variety. This was a very common form, occurring in abundance in many of the collections. Grönblad, 1952, Mem. Soc. Fauna Flora Fenn. 28:51, figures a somewhat similar form.

## PLEUROTAENIUM

**Pleurotaenium coronatum** (Bréb.) Rabenh.

Reported by Wailes (1933) (M).

**Pleurotaenium Ehrenbergii** (Bréb.) De Bary (Pl. X, Fig. 1).

L. 380–500 μ, w. at basal swelling 26–35 μ (16.3–17 ×), w. at apex 18–21 μ, 3–5 (6) tubercles visible across the apex, wall colorless, punctate. Alatna: A2–c, A9–r, A10, Bettles: 298–r, Wiseman: W17, W25–r, W28–c, W52–r, W55–c, W57, W70–r, W72–c, W74, W78–r, W85c. Also reported by Wailes (1933) (M), and (1934), (N).

**Pleurotaenium Ehrenbergii** (Bréb.) De Bary forma α (Pl. X, Fig. 2).

L. 356–420 μ, w. at basal swelling 27–29 μ, max. w. 29–31 μ (11.7–13.5 ×), w. at apex 19–22 μ, 4 tubercles visible across apex, semicell slightly swollen in mid-region, wall colorless, punctate, pores irregular, faint, *elongate*. Wiseman: W84–c.

This relatively short form with swollen semicells is closest to var. *tumidum* Turner which Krieger includes in the species. The elongate pores seem unique.

**Pleurotaenium Ehrenbergii** (Bréb.) De Bary var. **curtum** Krieger (Pl. X, Fig. 3).

L. 210–320 μ (2 × the longer semicell), w. at basal swelling 30–31 μ (10.7 ×), w. at apex 18 μ, 5 tubercles visible across apex, wall colorless, apparently smooth. Wiseman: W85–c.

**Pleurotaenium Ehrenbergii** (Bréb.) De Bary var. **elongatum** West (Pl. X, Fig. 4).

L. 640 μ, w. at basal swelling 26 μ (24.6 ×), w. at apex 19–20 μ, 5 prominent tubercles visible across apex, wall colorless, sparsely punctate. Wiseman: W59.

**Pleurotaenium eugeneum** (Turn.) West & West (Pl. IX, Fig. 7).

L. 890 μ, w. at basal swelling 40 μ (22.3 ×), w. at apex 33 μ, basal swelling prominent, lateral margin undulate throughout length, nearly parallel, apex not swollen, with 11 visible tubercles, wall apparently smooth. Only one specimen seen. Bettles: 298–rr.

Our plant, with its definite undulate margins, approaches var. *undulatum* (Borge) Krieger, but its relative narrowness and few apical tubercles make it fit better into the species, which, according to the Wests, has "slightly sinuate" margins.

**Pleurotaenium minutum** (Ralfs) Delp. (Pl. X, Fig. 10).

L. 145 μ, w. at basal swelling 13 μ (11.1 ×), w. at apex 9 μ, semicell evenly tapered from basal swelling to rounded apex, wall apparently smooth. Alatna: A1–c. Also reported by Saunders (E) (as *Docidium minutum* Ralfs).

**Pleurotaenium minutum** (Ralfs) Delp. var. **elongatum** (West & West) Cedergren (Pl. X, Fig. 11).

L. 260 μ, w. at basal swelling 9.5 μ (27 ×), w. at apex 7 μ, basal swelling very slight, semicell evenly tapered to rounded apex, chloroplast axial (?), with a single row of 8 pyrenoids, wall apparently smooth. Alatna: A5–cc.

**Pleurotaenium minutum** (Ralfs) Delp. var. **gracile** (Wille) Krieger (Pl. X, Fig. 12).

L. 172–250 μ, w. at basal swelling 11–13 μ (14.3–21.1 ×), w. at apex 7–8 μ, basal swelling very slight, semicell evenly tapered to apex which is truncate with rounded corners, chloroplast axial with a single row of 3–6 pyrenoids. Alatna: A1, A2–r, A3–c, A5–cc.

**Pleurotaenium nodosum** (Bail.) Lund.

Reported by Saunders (A) "Common."

**Pleurotaenium trabecula** (Ehrenb.) Näg. (Pl. X, Fig. 5).

L. 320–590 μ, w. at basal swelling 21–36 μ (10.6–16.4 ×), w. at apex 15–25 μ, slight inflation above basal swelling, sometimes tumid in middle, wall punctate. Alatna: A1, A3–rr, A5–cc, A6–cc, A7–r, Bettles: 298–r, Wiseman: W25–c, W55, W59–c, W70–c, W85–cc, W92–rr. Also reported by Lowe (L) "Three individuals." (as *Pl. trabecula* fa. *clavata* (Kütz.) West.)

**Pleurotaenium trabecula** (Ehrenb.) Näg. var. **crassum** Wittr. (Pl. X, Fig. 6).

L. 246–450 μ, w. at basal swelling 26–53 μ, max. w. 29–53 μ (6.4–8.5 ×), w. at apex 16–25 μ, undulation above basal swelling very slight, or more often absent, semicells usually gradually inflated, reaching maximum width about ⅓ to ½ way from isthmus to apex. Apex without tubercles, rounded. Wall punctate, colorless, in the smallest plant pinkish. Alatna: A3–rr, Nolan: N6, N8, Wiseman: W78–rr, W83–r, W85–c, W92.

**Pleurotaenium trabecula** (Ehrenb.) Näg. var. **elongatum** Cedergren forma **scrobiculatum** forma nova (Pl. X, Fig. 7).

Forma membrana scrobiculata. Cellula 760 μ long., 38 μ lat. in inflatione basali, 27 μ lat. in apice rotundato-truncato. Membrana sine colore, scrobiculata, quoque poro intra areolam circularem elavatamque sito.

L. 760 μ, w. at basal swelling 38 μ (20 ×), max. w. above basal swelling 35 μ, w. at apex 27 μ, apex rounded-truncate, cell wall colorless, scrobiculate. Only one specimen seen. Wiseman: W59–rr.

The wall structure is very striking, presenting an appearance unlike anything I have seen in *Pleurotaenium*. The pores are irregularly and rather widely spaced, each pore lying within a circular raised area.

**Pleurotaenium trabecula** (Ehrenb.) Näg. var. **hirsutum** (Bail.) Krieger (Pl. X, Fig. 8).

L. 394 μ, w. at basal swelling 34 μ, max. w. above basal swelling 35 μ (11.3 ×), w. at apex 20 μ, apex rounded, wall colorless, punctate, with definite extrusions through the pores, giving a spiny appearance. Alatna: A1.

**Pleurotaenium trabecula** (Ehrenb.) Näg. var. **rectum** (Delp.) West & West (Pl. X, Fig. 9).

L. 264–380 μ, w. at basal swelling 17–22 μ (14.7–17.5 ×), w. at apex 12–14 μ, no undulation above basal swelling, wall apparently smooth. Alatna: A3–c, A5–cc, Wiseman: W59–r.

**Pleurotaenium truncatum** (Bréb.) Näg. (Pl. IX, Fig. 8).

L. 400 μ, w. at base 47 μ, max. w. 50 μ (8 ×), w. at apex 29 μ, 7 visible flattened tubercles, wall irregularly punctate. Wiseman: 84–rr, 85–rr. Also reported by Lowe (H), and by Saunders (C).

**Pleurotaenium truncatum** (Bréb.) Näg. var. **crassum** Boldt (Pl. IX, Fig. 9–10).

Only two plants were seen, which were very different but seem to fit here better than anywhere. One (Fig. 9) L. 370 μ, w. at base 75 μ, max. w. 80 μ (4.6 ×), w. at apex 32 μ, had no basal swelling, 4 plainly visible apical tubercles, and an apparently smooth wall. The other (Fig. 10) L. 260 μ, w. at base 35 μ, max. w. 45 μ (5.7 ×), w. at apex 17 μ, had a slight basal swelling, 3 barely visible apical tubercles, and a punctate wall. Wiseman: W78–rr (Fig. 9), W85–r (Fig. 10).

This seems to be a flexible variety. Boldt's original description (1885) does not allow for apical tubercles, the Wests deny them, Krieger illustrates them, Irénée-Marie (1939) says that they may be present or not, more often not, and points out an interesting association of the presence of tubercles on less swollen specimens as an instance of reversion to type.

### TRIPLOCERAS

**Triploceras gracile** Bail.

Reported by Saunders (E) "Common."

### TETMEMORUS

**Tetmemorus Brébissonii** (Menegh.) Ralfs

Reported by Saunders (E) "Frequent."

**Tetmemorus Brébissonii** (Menegh.) Ralfs var. **minor** De Bary

Reported by Wailes (1934) (N).

**Tetmemorus laevis** (Kütz.) Ralfs (Pl. X, Fig. 13).

L. 85–110 μ, w. at base 28–29 μ (3–3.8 ×), w. at apex 15μ, punctate with widely and irregularly spaced pores. Alatna: A8–cc. Also reported by Saunders (E, F), and by Wailes (1934) (N).

### EUASTRUM

**Euastrum abruptum** Nordst. forma **minor** West & West

Reported by Wailes (1933) (M).

**Euastrum affine** Ralfs

Reported by Saunders (G).

**Euastrum ansatum** Ralfs (Pl. XI, Fig. 4).

L. 70–75 μ, w. 34–41 μ, isth. 12–15 μ, w. at apex 16–17 μ, th. 23 μ. Lateral facial protuberances very low, wall coarsely punctate. Alatna: A8–c, A10–r. Also reported by Lowe (H), and by Saunders (F).

**Euastrum ansatum** Ralfs forma α (Pl. XI, Fig. 5).

A form with large slits in wall on face of semicell. L. 70 μ, w. 40 μ, isth. 14 μ, w. at apex 17 μ, th. 23 μ. Wall with slit in middle of semicell, triangular on one face, linear on other. Punctae less prominent, not in vertical rows. Alatna: A5–rr.

This is apparently Schaarschmidt's var. *valleculatum* which Krieger puts under the species.

**Euastrum ansatum** Ralfs var. **dideltiforme** Ducellier (Pl. XI, Fig. 6).

L. 84–90 μ, w. 44–45 μ, isthmus 12–15 μ, w. at apex 20–22 μ, th. 28 μ. Wall with crease from apical notch to central scrobiculation, punctae only slightly vertical in arrangement. Alatna: A5–r, A6.

**Euastrum bidentatum** Näg. (Pl. XII, Fig. 12, 13).

L. 50–56 μ, w. 30–37 μ, isth. 9.5–11 μ. th. 21–24 μ, wall smooth or punctate. Alatna: A5–c, A7–r, A8–c, A10–r, Wiseman: W65–r, W67, W78–r, W83–r, W84–r, W85–r. Also reported by Lowe (H, L) "the most common species of the genus."

This occurred sparsely in many stations, and showed considerable variation in facial decoration.

**Euastrum bidentatum** Näg. forma α (Pl. XII, Fig. 14).

A large rounded form with lobes much reduced. L. 60–76 μ, w. 37–40 μ, isth. 13–15 μ, th. 27 μ. Central granules a double row of three, lateral granules somewhat radial in arrangement, wall strongly punctate. Wiseman: W52–r, W53, W56–r.

Closest to *forma* of Skuja (1934), which Krieger absorbs in the species.

**Euastrum bidentatum** Näg. var. **oculatum** (Istv.) Krieger forma α (Pl. XII, Fig. 15).

L. 61–70 μ, w. 37–41 μ, isth. 8–10 μ, th. 26 μ. Wiseman: W67, W70–r.

Our form had the lateral depressions of forma *glabrum* of Scott and Prescott (1952), but did not have the smooth central protuberance characterizing that form.

**Euastrum binale** (Turp.) Ehrenb.

Reported by Lowe (H, I).

**Euastrum binale** (Turp.) Ehrenb. var. **Grönbladii** Messik. (Pl. XIII, Fig. 7).

L. 13–15 μ, w. 12–13 μ, isth. 4 μ, th. 8 μ. Alatna: A5–c.

Our plant resembles Grönblad's smaller form, without the 4 apical granules.

**Euastrum binale** (Turp.) Ehrenb. var. **Gutwinskii** Schmidle (Pl. XIII, Fig. 8–9).

L. 24–27 μ, w. 18–19 μ, isth. 5–7 μ, th. 11–12 μ. Alatna: A1, A2–r, Wiseman: W69–r, W70–c. Also reported by Lowe (H).

**Euastrum binale** (Turp.) Ehrenb. var. **tumoriferum** Kossinsk. (Pl. XIII, Fig. 10).

L. 23 μ, w. 20 μ, isth. 8 μ, th. 16 μ. Alatna: A8–r.

**Euastrum Ciastonii** Racib. (Pl. XIII, Fig. 2–4).

L. 47–49 μ, w. 25–28 μ, isth. 6–9 μ, th. 17 μ. Facial ornamentation somewhat variable. Alatna: A5–c, A6–r.

**Euastrum crassicolle** Lund. (Pl. XIII, Fig. 14).

L. 26 μ, w. 16 μ, isth. 7 μ, th. 8 μ. Alatna: A8–r. Apex very square in lateral view.

**Euastrum crassicolle** Lund. var. **dentiferum** Nordst. (Pl. XIII, Fig. 15).

L. 26 μ, w. 16 μ, isth. 7 μ, th. 8 μ. Alatna: A8–rr.

Very similar to species but with apex more rounded in face view and provided with teeth. Probably new for North America.

**Euastrum denticulatum** (Kirchn.) Gay. (Pl. XIII, Fig. 11–12).

L. 20–32 μ, w. 18–26 μ, isth. 11–13 μ, th. 5–9 μ. Alatna: A5–c, Bettles: 298–r, Wiseman: W56–r, W71–r. Also reported by Lowe (H).

Our smallest form (fig. 12) has a large, flat granule inside the pair of marginal granules in each lobe, and 3 granules on the central protuberance. This is very close to the plant shown by Prescott & Scott (1945).

**Euastrum didelta** (Turp.) Ralfs

Reported by Saunders (B), and Wailes (1933, 1934) (N).

**Euastrum dubium** Näg.

Reported by Lowe (L) "Approaching var. *Snowdoniense* West & West."

**Euastrum dubium** Näg. forma α (Pl. XII, Fig. 6).

L. 32–36 μ, w. 23–26 μ, isth. 5.5–7 μ, th. 14–18 μ. Small granules within lobes inconspicuous or lacking, one large smooth central protuberance; apical and lower lateral angles usually furnished with a small tooth. Wiseman: W25–c, W27–c, W28–cc, W55–r, W57–r, W59–r, W69–c, W72–c, W87–rr.

**Euastrum dubium** Näg. forma β (Pl. XII, Fig. 7).

L. 25 μ, w. 18 μ, isth. 5.5 μ. A smaller form, approaching var. *ornatum*, with 1 definite granule within each lobe and 1 large, smooth central protuberance. Alatna: A3.

**Euastrum dubium** Näg. var. **ornatum** Wolosz. (Pl. XII, Fig. 8).

L. 29–31 μ, w. 21.5–22 μ, isth. 6–7.5 μ, th. 14.5 μ. Our plant lacks the granules within the apical lobes. Wiseman: W70–c, W85–c.

**Euastrum dubium** Näg. var. **ornatum** Wolosz. forma α (Pl. XII, Fig. 9, 10).

A form with simpler ornamentation. L. 28 μ, w. 19–20 μ, isth. 6 μ, th. 12 μ. Bettles: 297–c, 298–c, Wiseman: W78–rr.

**Euastrum dubium** Näg. var. **poriferum** Prescott & Scott (1945), p. 237. (Pl. XII, Fig. 11).

L. 34 μ, w. 25 μ, isth. 8 μ, th. 18 μ. Lower lateral lobes more produced, otherwise very similar, with centrally located mucilege pore and coarse punctations over whole cell. Wiseman: W68.

**Euastrum elegans** (Bréb.) Kütz. (Pl. XIII, Fig. 5–6).

L. 27–34 μ, w. 18–24 μ, isth. 5–7 μ, th. 13.5–14 μ. Alatna: A5–c, A6–r, Bettles: 297–c, 298–c, Wiseman: W55, W59, W67, W68–cc, W69–c, W70–c. Also reported by Lowe (H) "Several ponds," and by Saunders (A, E, F) "Common in freshwater." A very common species.

**Euastrum erosum** Lund. var. **granulosum** Cedercreutz (Pl. XIII, Fig. 1).

L. 46 μ, w. 25 μ, isth. 9 μ, th. 18 μ. Alatna: A8–r.

**Euastrum evolutum** (Nordst.) West & West var. **integrius** West & West forma **turgidum** Scott & Prescott (1952), p. 381 (Pl. XII, Fig. 3).

L. 54–60 μ, w. 33–35 μ, isth. 9–12 μ, th. 20–22 μ. Wall punctate. Alatna: A3–r, A7–c.

Except for the distinctly punctate wall and pair of scrobiculations above the central protuberance, this closely resembles *E. quebecense* of Irénée-Marie (1939).

**Euastrum gemmatum** Bréb.

Reported by Saunders (C), and by Wailes (1933) (M).

**Euastrum insulare** (Wittr.) Roy var. **silesiacum** Grönbl. (Pl. XIII, Fig. 13).

L. 20–22 μ, w. 15–17 μ, isth. 4–6.5 μ, th. 10 μ. Small, relatively short, rounded, upper angles of lateral lobe extending beyond lower angles, slight median inflation. Alatna: A1, A2–c, Bettles: 298–c.

Commoner than the above entries indicate. Since at first, distinction was not made between the species and this variety the records lacking figures are omitted.

**Euastrum lapponicum** Schmidle (Pl. XII, Fig. 4).

L. 37–40 μ, w. 23–26 μ, isth. 8–9 μ, th. 15–20 μ. The smaller granules on apical and basal lobes usually lacking. Alatna: A5–r, A6–r, Bettles: 297–r, 298–r.

**Euastrum lapponicum** Schmidle forma α (Pl. XII, Fig. 5).

A depressed form. L. 32 μ, w. 24 μ, w. of apex 7 μ, th. 16 μ. Alatna: A5–r.

**Euastrum obesum** Josh.

Reported by Wailes (1934) (N).

**Euastrum obesum** Josh. var. **crassum** Prescott & Scott (1945), p. 282. (Pl. XI, Fig. 7).

L. 104–120 μ, w. 53–61 μ, isth. 17–20 μ, th. 38–? μ. All lobes much rounded, wall coarsely punctate. Alatna: A5–c, A6–r, Bettles: 298–r.

**Euastrum oblongum** (Grev.) Ralfs. (Pl. XI, Fig. 1).

L. 148–164 μ, w. 6.8–8.5 μ, isth. 18–27 μ, th. 32 μ. With or without central scrobiculation, incision between upper lateral lobes and apical lobes sometimes open, sometimes closed, wall widely punctate. Alatna: A5–r, A6–r, Bettles: 298–r, Wiseman: W53–r, W55–r. Also reported by Lowe (H), Saunders (E), and Wailes (1933) (M).

**Euastrum oblongum** (Grev.) Ralfs forma α (Pl. XI, Fig. 2).

Wall very coarsely punctate (or scrobiculate?). L. 152–170 μ, w. 74–85 μ, isth. 22–25 μ, central scrobiculations 0–3. Alatna: A5, Bettles: 298–r, Wiseman: W70–r, W90–r.

A very striking form. This extra-heavy pitting of the wall occurs in several different species, and perhaps characterizes subarctic forms.

**Euastrum pectinatum** Bréb. var. **brachylobum** Wittr. (Pl. XI, Fig. 8).

L. 62–79 μ, w. 44–49 μ, isth. 13–15 μ, th. 24–32 μ. Rather variable. Wall usually rather coarsely punctate, with radial pattern on apical lobe in apical view. Alatna: A5–r, Wiseman: W13, W14.

**Euastrum pectinatum** Bréb. var. **rostratum** Taylor. (Pl. XI, Fig. 9).

L. 65–71 μ, w. 46–52 μ, isth. 11–13 μ, th. 30–31 μ. Wall evenly, coarsely punctate with larger punctae at apex. Wiseman: W55–r, W59–r, W67, W70–r, W78.

Variable, grading into var. *brachylobum.*

**Euastrum pulchellum** Bréb.

Reported by Wailes (1933, 1934) (M, N).

**Euastrum sinuosum** Lenorm. var. **scrobiculatum** Nordst. (Pl. XI, Fig. 3).

L. 80–86 μ, w. 46–47 μ, isth. 13–14 μ, th. 28–33 μ. Each facial protuberance pierced by scrobiculation, also 3 scrobiculations between them. Alatna: A5–c.

Krieger does not figure scrobiculations in facial protuberances, but he notes this as a characteristic of the species.

**Euastrum tetralobum** Nordst. (Pl. XI, Fig. 10).

L. 86–87 μ, w. 62–63 μ, isth. 20 μ. Alatna: A8–r. Less deeply dissected than the type.

This is usually considered to be a "truly arctic species."

**Euastrum Turneri** West (Pl. XII, Fig. 1, 2).

L. 37–40 μ, w. 27–29 μ, isth. 8–9 μ, th. 17–18 μ. Alatna: A5, A6, Bettles: 298–r. No two are alike in facial markings.

**Euastrum validum** West & West forma α (Pl. XIII, Fig. 16).

With two small protuberances, 1 above and 1 below the central scrobiculation. L. 25–28 μ, w. 18–20 μ, isth. 5 μ, th. 9.5–11 μ. Alatna: A5–c, A6–c, Bettles: 298–r.

**Euastrum verrucosum** Ehrenb. (Pl. XI, Fig. 11).

L. 88–89 μ, w. 72–76 μ, isth. 19–23 μ, th. 48 μ. Lobes rather extended, sinus closed for less than one half its length, then widely open. Wiseman: W29–r, W72–r. Also reported by Saunders (A).

Our form approaches var. *alatum* Wolle but the basal angles do not bend back toward the middle to cause "hooked appearance."

**Euastrum verrucosum** var. **reductum** Norst.

Reported by Wailes (1933, 1934) (M, N).

**Euastrum verrucosum** Ehrenb. 2 unnamed varieties.

Reported by Wailes (1933, 1934) (M, N).

**Euastrum** sp.? (Pl. XIII, Fig. 17).

L. 52 μ, w. 31 μ, isth. 10 μ, th. 21 μ. Cells medium-sized, about 1.7 × longer than broad, deeply constricted, sinus closed, semicell pyramidate, basal angles subrectangular, apex strongly convex, with deep narrow median incision. Semicell with 5 large, smooth protuberances, one within each apical lobe, one within lower angle of each basal lobe and one in the middle below a pair of mucilege pores. Small tooth at each angle of basal lobe. Wall smooth. Alatna: A7–rr.

This seems quite new, but since only 1 specimen was seen I hesitate to describe a new species.

**Euastrum** sp.? (Pl. XIII, Fig. 18).

L. 62 μ, w. 42 μ, isth. 15 μ, th. 26 μ. Semicell divided by narrow incisions into 4 not quite equal lobes. Isthmus deep and narrow. One smooth, squarish, central protuberance. Wall smooth. Nolan: N2–rr. (Only one specimen seen.)

This is also *Micrasterias*-like. Possibly it is teratological.

## LIST OF SPECIES — ECOLOGICAL

Collected by the author between the 3rd and 17th of August, 1951

| | North Latitude | Altitude in feet | pH | Type of Locality |
|---|---|---|---|---|
| Gonatozygon Brébissonii | 66° 34′ | 400 | 8.0 | 5b |
| G. — var. tatricum | 67° 25′–28′ | 2110–2210 | 7.0–8.6 | 4c, 5c, cT |
| G. Kinahani | 66° 33′ | 400 | 8.0 | 5c, e |
| G. monotaenium | 67° 27′–28′ | 2050 | 8.0 | 3b, 5c |
| Spirotaenia condensata | 66° 33′ | 400 | 8.0 | 5e |
| S. obscura | 67° 27′ | 2110 | 7.7 | 4c, 5c |
| Cylindrocystis Brébissonii | 66° 33′–67° 24′ | 400–4500 | 7.0 | 2a, 3d, 5c |
| C. — forma α | 66° 33′ | 400 | 8.0 | 5c |
| C. — forma β | 66° 34′ | 400 | 8.0 | 5b |
| C. — var. minor | 67° 27′ | 2110 | 7.2 | 3b |
| C. — var. turgida | 66° 33′–34′ | 400 | 8.0 | 5b, c |
| C. crassa var. elliptica | 66° 33′ | 400 | — | 3d |
| Netrium digitus | 66° 33′–67° 27′ | 400–2050 | 6.9–8.0 | 5b, c, e |
| N. — forma α | 66° 34′ | 400 | 8.0 | 5b |
| N. — var. lamellosum | 66° 33′–34′ | 400 | 8.0 | 5b, e |
| N. — var. — forma α | 67° 25′–27′ | 2000–2050 | 6.9–8.0 | 5c, e |
| N. — var. rhomboideum | 66° 33′–67° 27′ | 400–2050 | 8.0 | 5e |
| N. oblongum | 66° 33′ | 400 | — | 3d |
| N. — var. brevius | 66° 33′ | 400 | — | 3d |
| Penium exiguum | 66° 33′ | 400 | 8.0 | 5e |
| P. silvae-nigrae f. minor | 67° 24′ | 4500 | — | 2a |
| P. spirostriolatum | 66° 33′ | 400 | 8.0 | 5c, e |
| P. — forma α | 66° 33′ | 400 | 8.0 | 5e |
| Closterium acerosum (?) | 67° 27′–28′ | 2110–2200 | 7.0–7.7 | 4c, 5c, cT, dT |
| Cl. — forma α | 67° 28′ | c. 2200 | — | 5dT |
| Cl. — var. minus | 66° 33′–67° 27′ | 400–2110 | 6.9–8.0 | 4c, 5b, c, e |
| Cl. acutum | 66° 33′ | 400 | 8.0 | 5b |
| Cl. angustatum | 66° 33′–67° 27′ | 400–2050 | 7.0–8.0 | 5c, e |
| Cl. — forma α | 66° 33′ | 400 | 8.0 | 5c |
| Cl. — var. gracilius | 66° 33′–55′ | 400–665 | 7.0–8.0 | 5c, e |
| Cl. Archerianum | 66° 34′–67° 28′ | 400–2050 | 8.0 | 3b, 5e |
| Cl. — forma α | 66° 34′ | 400 | 8.0 | 5b |
| Cl. arcuarium | 66° 33′ | 400 | 8.0 | 5e |
| Cl. Baillyanum | 66° 33′ | 400 | 8.0 | 5e |
| Cl. cornu | 66° 33′ | 400 | 8.0 | 5c |
| Cl. — forma α | 67° 27′–28′ | 2030–2110 | 7.7–8.1 | 4c, 5b, c, e |
| Cl. costatum | 67° 25′ | 2000 | 6.9 | 5c, e |
| Cl. cuspidatum | 66° 33′ | 400 | 8.0 | 5e |
| Cl. cynthia | 66° 33′–67° 27′ | 400–2110 | 6.9–8.0 | 5c, e |
| Cl. — forma α | 66° 33′ | 400 | 8.0 | 5c |
| Cl. — forma β | 66° 33′–67° 27′ | 400–2110 | 7.7–8.0 | 4c, 5a, b, c, e |
| Cl. dianae | 66° 33′–67° 28′ | 400–2210 | 7.0–8.2 | 3b, 4c, 5c, cT, e, eT |
| Cl. — forma α | 67° 25′–28′ | 2020–2200 | — | 5cT |
| Cl. — var. arcuatum | 66° 33′–67° 27′ | 400–2050 | 8.0 | 5c, e |
| Cl. — var. brevius | 67° 25′–28′ | 2000–2200 | 8.0 | 3d, 5cT, dT, e |
| Cl. — var. minus | 66° 34′–67° 28′ | 400–2200 | 8.0 | 5b, dT |
| Cl. Ehrenbergii | 67° 28′ | 2050 | 8.1 | 5e |
| Cl. gracile | 66° 33′–67° 27′ | 400–2050 | 7.0–8.0 | 5c, e |

| | North Latitude | Altitude in feet | pH | Type of Locality |
|---|---|---|---|---|
| Cl. — forma sigmoideum | 66° 33′ | 400 | 8.0 | 5e |
| Cl. — var. tenue | 66° 33′ | 400 | 8.0 | 5c |
| Cl. idiosporum (?) | 67° 27′ | 2110 | 7.7 | 4c, 5c |
| Cl. incurvum | 66° 34′–67° 27′ | 400–2210 | 7.0–8.0 | 5b, c, cT, e, eT |
| Cl. — forma α | 67° 24′–27′ | 2000–2110 | 7.4–8.0 | 5c, e, eT |
| Cl. Jenneri | 66° 33′–55′ | 400–665 | 7.0–8.0 | 5c, e |
| Cl. — forma α | 66° 33′ | 400 | 8.0 | 5c |
| Cl. — var. tenue | 66° 34′–67° 27′ | 400–2050 | 6.9–8.0 | 5b, e |
| Cl. juncidum v. brevior | 66° 33′ | 400 | — | 4c |
| Cl. — var. elongatum | 66° 33′ | 400 | 8.0 | 5b |
| Cl. Kuetzingii | 66° 55′–67° 27′ | 665–2110 | 7.0 | 5c, eT |
| Cl. — var. laeve | 66° 33′–67° 27′ | 400–2110 | 7.0–8.0 | 5b, eT |
| Cl. — var. — forma α | 67° 27′ | 2110 | 7.0 | 5eT |
| Cl. Leibleinii v. minimum | 67° 25′–28′ | 2000–2200 | 7.2–8.0 | 3b, d, 5dT |
| Cl. libellula v. intermedium | 66° 33′ | 400 | 8.0 | 5b |
| Cl. lineatum | 67° 27′–28′ | 2050–2110 | 7.1–8.1 | 4c, 5b, c |
| Cl. — var. elongatum | 66° 33′ | 4000 | 8.0 | 5b |
| Cl. lunula | 66° 33′–67° 27′ | 400–2110 | 7.0–8.0 | 4c, 5c, e |
| Cl. — forma gracilis | 66° 55′ | 665 | 7.0 | 5c |
| Cl. moniliferum | 67° 27′ | 2040–2110 | 7.2–7.7 | 3b, 4c, 5c, e |
| Cl. — var. concavum | 67° 27′ | 2030 | 8.0 | 5e |
| Cl. navicula | 66° 33′–67° 27′ | 400–2110 | 6.9–8.0 | 4c, 5b, c, e |
| Cl. parvulum | 66° 33′–67° 28′ | 400–2050 | 6.4–8.2 | 3b, 5b, c, e, eT |
| Cl. praelongum | 67° 27′ | 2110 | 7.7 | 4c, 5c |
| Cl. — var. brevius | 67° 27′ | 2110 | 7.7 | 4c, 5c |
| Cl. Pritchardianum | 66° 33′ | 400 | 8.0 | 4c |
| Cl. — forma laeve | 66° 33′–67° 27′ | 400–2030 | 8.0 | 4c, 5e |
| Cl. pronum | 67° 27′ | 2050 | 8.0 | 5c |
| Cl. pseudolunula | 67° 28′ | 2050 | — | 3b |
| Cl. Ralfsii var. hybridum | 67° 27′ | 2110 | 7.0 | 5eT |
| Cl. rostratum | 66° 33′–67° 28′ | 400–2110 | 7.0–8.0 | 3b, 4c, 5b, c, dT, e, eT |
| Cl. setaceum | 66° 33′–34′ | 400 | 8.0 | 5b, c, e |
| Cl. strigosum v. elegans | 66° 34′ | 400 | 8.0 | 5b |
| Cl. striolatum | 66° 33′–67° 27′ | 400–2050 | 7.1–8.0 | 5b, c, e |
| Cl. toxon | 66° 34′–55′ | 400–665 | 7.0–8.0 | 5c, e |
| Cl. tumidulum | 67° 27′ | 2110 | 7.2–7.7 | 3b, 4c, 5c |
| Cl. tumidum | 66 ° 34′ | 400 | 8.0 | 5e |
| Cl. — forma α | 66 ° 34′ | 400 | 8.0 | 5b |
| Cl. venus | 67° 27′ | 2030–2050 | 8.0–8.2 | 5c, e |
| Cl. — forma | 67° 24′–27′ | 2000–2110 | 7.4–7.7 | 4c, 5c |
| Cl. — forma maior | 67° 25′–28′ | 2000–2050 | 6.9 | 3b, 5b |
| Cl. — var. crassum | 66° 34′–67° 28′ | 400–2200 | 7.0–8.2 | 3b, d, 5b, c, cT, d, dT, e |
| Pleurotaenium Ehrenbergii | 66° 33′–67° 28′ | 400–2110 | 6.9–8.2 | 4c, 5b, c, e, eT |
| Pl. — forma α | 67° 27′ | 2110 | 7.0 | 5eT |
| Pl. — var. curtum | 67° 27′ | 2110 | 7.0 | 5eT |
| P.l — var. elongatum | 67° 25′ | 2000 | 6.9 | 5c |
| Pl. eugeneum | 66° 55′ | 665 | 7.0 | 5c |
| Pl. minutum | 66° 34′ | 400 | 8.0 | 5e |

| | North Latitude | Altitude in feet | pH | Type of Locality |
|---|---|---|---|---|
| Pl. — var. elongatum | 66° 33′ | 400 | 8.0 | 5e |
| Pl. — var. gracile | 66° 33′–34′ | 400 | 8.0 | 5b, e |
| Pl. trabecula | 66° 33′–67° 28′ | 400–2110 | 6.9–8.2 | 4c, 5b, c, e, eT |
| Pl. — var. crassum | 66° 34′–67° 28′ | 400–2110 | 7.0–8.0 | 4c, 5b, c, cT, dT, e, eT |
| Pl. — var. elongatum forma scrobiculatum | 67° 25′ | 2000 | 6.9 | 5c |
| Pl. — var. hirsutum | 66° 34′ | 400 | 8.0 | 5e |
| Pl. — var. rectum | 66° 33′–67° 25′ | 400–2000 | 6.9–8.0 | 5b, c, e |
| Pl. truncatum | 67° 27′ | 2110 | 7.0 | 5eT |
| Pl. — var. crassum | 67° 27′ | 2030–2110 | 7.0–8.0 | 5e, eT |
| Tetmemorus laevis | 66° 33′ | 400 | — | 3d |
| Euastrum ansatum | 66° 33′ | 400 | — | 3d, 4c |
| E. — forma α | 66° 33′ | 400 | 8.0 | 5e |
| E. — var. dideltiforme | 66° 33′ | 400 | 8.0 | 5c, e |
| E. bidentatum | 66° 33′–67° 27′ | 400–2110 | 7.0–8.0 | 3d, 4c, 5c, e, eT |
| E. — forma α | 67° 24′–25′ | 2000 | 6.9–7.4 | 5c, e |
| E. — var. oculatum | 67° 27′ | 2050 | 8.0 | 5c, e |
| E. binale var. Grönbladii | 66° 33′ | 400 | 8.0 | 5e |
| E. — var. Gutwinskii | 66° 34′–67° 27′ | 400–2050 | 8.0 | 5b, c, e |
| E .— var. tumoriferum | 66° 33′ | 400 | — | 3d |
| E. Ciastonii | 66° 33′ | 400 | 8.0 | 5c, e |
| E. crassicolle | 66° 33′ | 400 | — | 3d |
| E. — var. dentiferum | 66° 33′ | 400 | — | 3d |
| E. denticulatum | 66° 33′–67° 27′ | 400–2050 | 6.9–8.0 | 5c, e |
| E. dubium forma α | 67° 25′–28′ | 2000–2110 | 6.9–8.2 | 4c, 5b, c, e |
| E. — forma β | 66° 34′ | 400 | 8.0 | 5b |
| E. — var. ornatum | 67° 27′ | 2050–2110 | 7.0–8.0 | 5e, eT |
| E. — var. — forma α | 66° 55′–67° 27′ | 665–2030 | 7.0–8.0 | 5c, e |
| E. — var. poriferum | 67° 27′ | 2050 | 8.0 | 5c |
| E. elegans | 66° 33′–67° 27′ | 400–2050 | 6.9–8.0 | 5e, c |
| E. erosum var. granulosum | 66° 33′ | 400 | — | 3d |
| E. evolutum v. integrius forma turgidum | 66° 33′–34′ | 400 | 8.0 | 5b, c |
| E. insulare v. silesiacum | 66° 34′–55′ | 400–665 | 7.0–8.0 | 5b, c, e |
| E. lapponicum | 66° 33′–55′ | 400–665 | 7.0–8.0 | 5c, e |
| E. — forma α | 66° 33′ | 400 | 8.0 | 5e |
| E. obesum var. crassum | 66° 33′–55′ | 400–665 | 7.0–8.0 | 5c, e |
| E. oblongum | 66° 33′–67° 25′ | 400–2000 | 6.9–8.0 | 4b, 5c, e |
| E. — forma α | 66° 33′–67° 27′ | 400–2110 | 7.0–8.0 | 4c, 5c, e |
| E. pectinatum v. brachylobum | 66° 33′–67° 28′ | 400–2050 | 8.0–8.1 | 4b, 5c, e |
| E. — var. rostratum | 67° 25′–27′ | 2000–2050 | 6.9–8.0 | 5c, e |
| E. sinuosum v. scrobiculatum | 66° 33′ | 400 | 8.0 | 5e |
| E. tetralobum | 66° 33′ | 400 | — | 3d |
| E. Turneri | 66° 33′–55′ | 400–665 | 7.0–8.0 | 5c, e |
| E. validum forma α | 66° 33′–55′ | 400–665 | 7.0–8.0 | 5c, e |
| E. verrucosum | 67° 27′ | 2050 | 7.1–8.0 | 5c |
| E. sp. (1) | 66° 33′ | 400 | 8.0 | 5c |
| E. sp. (2) | 67° 28′ | c. 2200 | 8.6 | 5c |

## ACKNOWLEDGEMENTS

The author owes much to many people. First to Dr. P. F. Scholander, of Woods Hole Oceanographic Institute, who started me off, and kept pushing until I got there. Then to the Arctic Institute of North America which gave us the grant enabling us to work where we wished in Alaska. Everyone we met in Alaska was generous to us, special thanks being due to Dr. L. Irving and his staff at the Public Health Service, who gave us a "Base Station," to Dr. Adolph Murie, then Biological Director at McKinley Park, and to the James Crouders at Bettles who gave us a home north of the Arctic Circle.

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Dartmouth College
Hanover, N. H.

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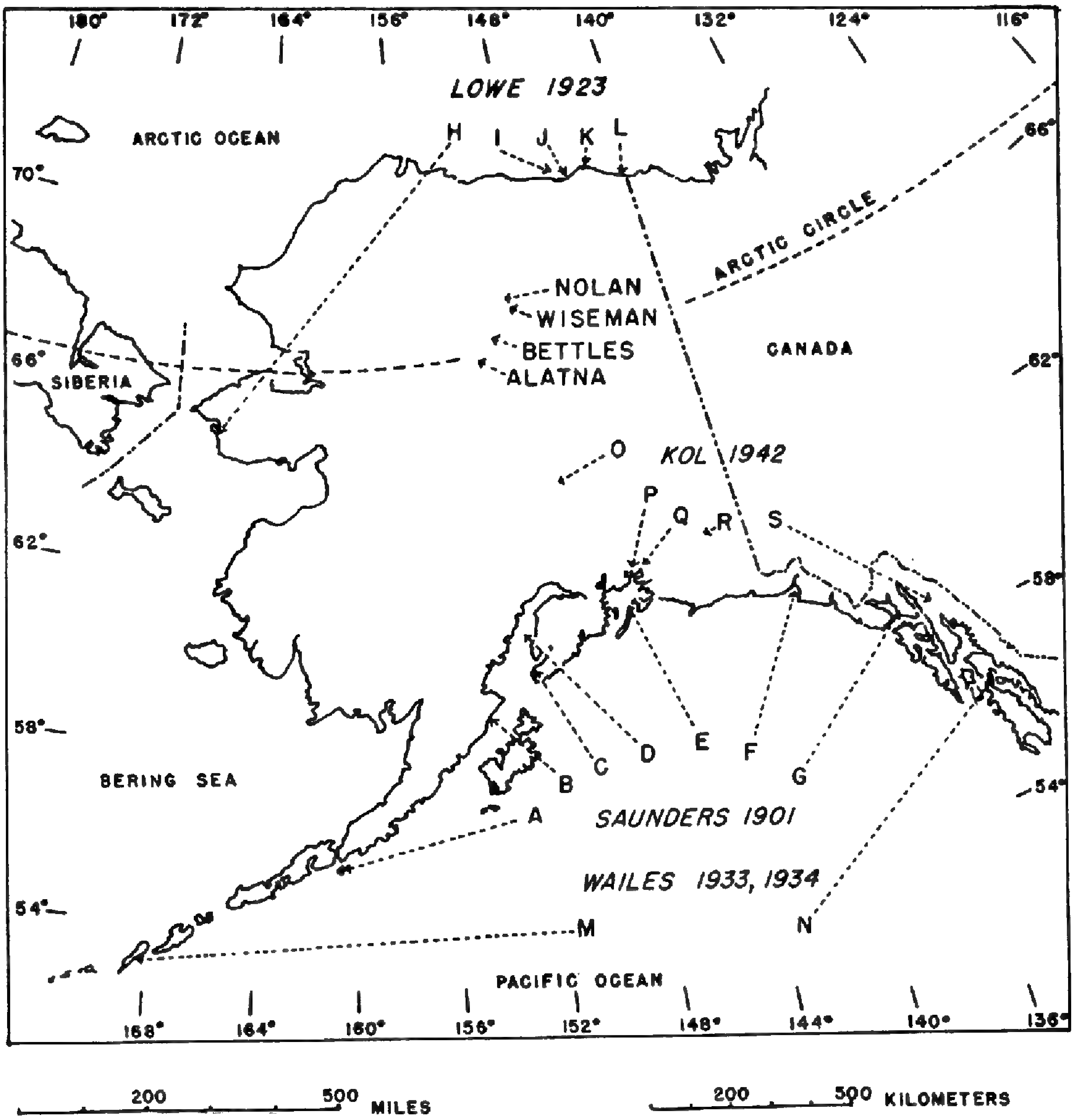
PLATE I

ALASKA



LOCALITIES WHERE ALGAE HAVE BEEN COLLECTED
(WITHIN SCOPE OF THIS PAPER)

SAUNDERS, 1901

A - POPOF ISLAND (c.160°W., 55°N.)
B - KUKAK BAY (c.154°W., 58° 30'N.)
C - SELDOVIA (c.153°40'W., 59°22' N.)
D - COOK INLET (c.152°-154°W., 60°-61°N.)
E - PRINCE WILLIAM SOUND (c.146°-148°W., 60°-61°N.)
F - YAKUTAT BAY (c.139°40'W., 59° 30')
G - GLACIER BAY (c.136°W., 58°30'N.)

LOWE, 1923

H - TELLER (c.166° 20'W., 65°15'N.)
I - CAMDEN BAY (c.143-145°W., 70°N.)
J - COLLINSON POINT (144°49'W., 69°59'N.)
K - MARTIN POINT (143°W, 70°08'N.)
L - DEMARCATION POINT (141°12'W., 69°41'N.)

WAILES, 1933, 1934

M - UMNAK ISLAND (c.168°W., 53°N.)
N - PETERSBERG (133°W., 56°50'N.)

KOL, 1942

O - TEKLANIKA GLACIER (c.149° 30'W., 63°25'N.)
P - COLUMBIA GLACIER (c.147°W., 61°N.)
Q - WORTHINGTON GLACIER (c.145°45'W., 61° 10'N.)
Q - VALDEZ GLACIER (c.146°15'W., 61°15'N.)
R - KENNICOTT GLACIER (c.143 W., 61° 30'N.)
S - MENDENHALL GLACIER (c.134° 33'W., 58°26'N.)

THIS PAPER

ALATNA (c.152°40'W., 66°33'-34'N.)
BETTLES (c.151° 30'W., 66° 55'N.)
WISEMAN (c.150° 03'-15'W., 67°24'-28'N.)
NOLAN (c.150°15'W., 67°28'N.)

## PLATE II

## BEETLES — WISEMAN REGION

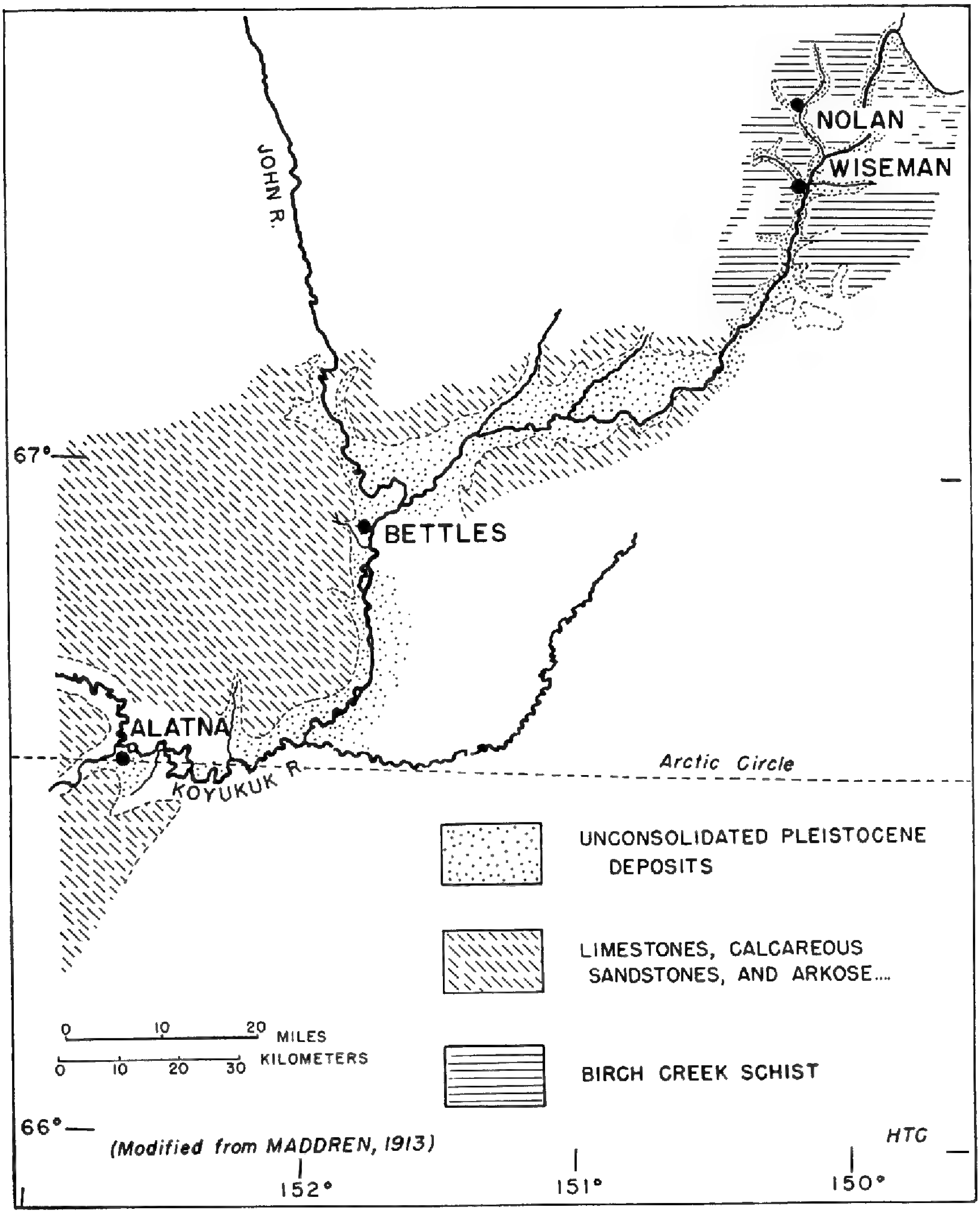
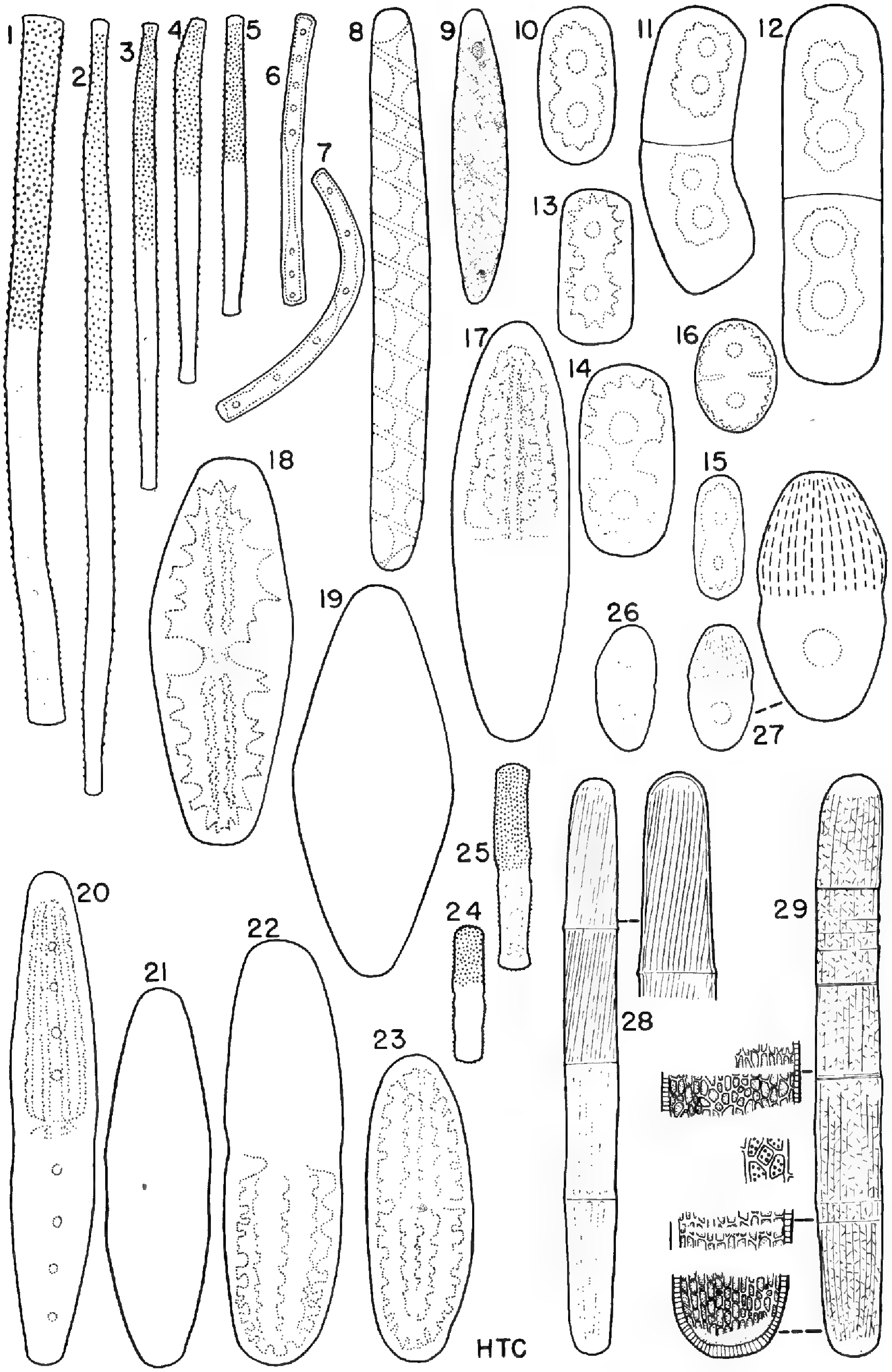

JOHN R.
NOLAN
WISEMAN
BETTLES
ALATNA
KOYUKUK R.
Arctic Circle
67°
66°
UNCONSOLIDATED PLEISTOCENE DEPOSITS
LIMESTONES, CALCAREOUS SANDSTONES, AND ARKOSE....
BIRCH CREEK SCHIST
0 10 20 MILES
0 10 20 30 KILOMETERS
(Modified from MADDREN, 1913)
152°
151°
150°
HTC

PLATE II

## PLATE III

1. Gonatozygon monotaenium, × 475
2. G. Brébissonii, × 450
3–5. G. Brébissonii v. tatricum, × 500
6–7. G. Kinahani, × 100
8. Spirotaenia condensata, × 450
9. S. obscura, × 500
10. Cylindrocystis Brébissonii, × 500
11–12. C. Brébissonii f. α, × 500
13. C. Brébissonii f. β, × 375
14. C. Brébissonii v. turgida, × 500
15. C. Brébissonii v. minor, × 475
16. C. crassa v. elliptica, × 500
17. Netrium digitus, × 450
18. N. digitus f. α, × 450
19. N. digitus v. rhomboideum, × 200
20. N. digitus v. lamellosum, × 450
21. N. digitus v. lamellosum f. α, × 325
22. N. oblongum, × 500
23. N. oblongum v. brevius, × 500
24–25. Penium exiguum, × 450
26–27. P. silvae-nigrae f. minor, 26 × 500, 27 × 500, × 1000
28. P. spirostriolatum, × 200, × 325
29. P. spirostriolatum f. α, × 200, × 325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HTC

PLATE III

## PLATE IV

1. Closterium libellula v. intermedium, × 375
2–3. C. navicula, 2 × 350, 3 × 375
4. C. cynthia f. α, × 325
5. C. cynthia f. β, × 375, × 750
6. C. cynthia, × 375, × 750
7. C. Archerianum, × 225, × 350
8. C. Archerianum f. α, × 150, × 325
9. C. Baillyanum, × 150
10. C. angustatum, × 225, × 350
11. C. angustatum f. α, × 325, × 650
12. C. angustatum v. gracilius, × 325, × 625
13. C. costatum, × 225, × 350
14. C. striolatum, × 325
15. C. juncidum v. brevior, × 375
16. C. juncidum v. elongatum, × 375

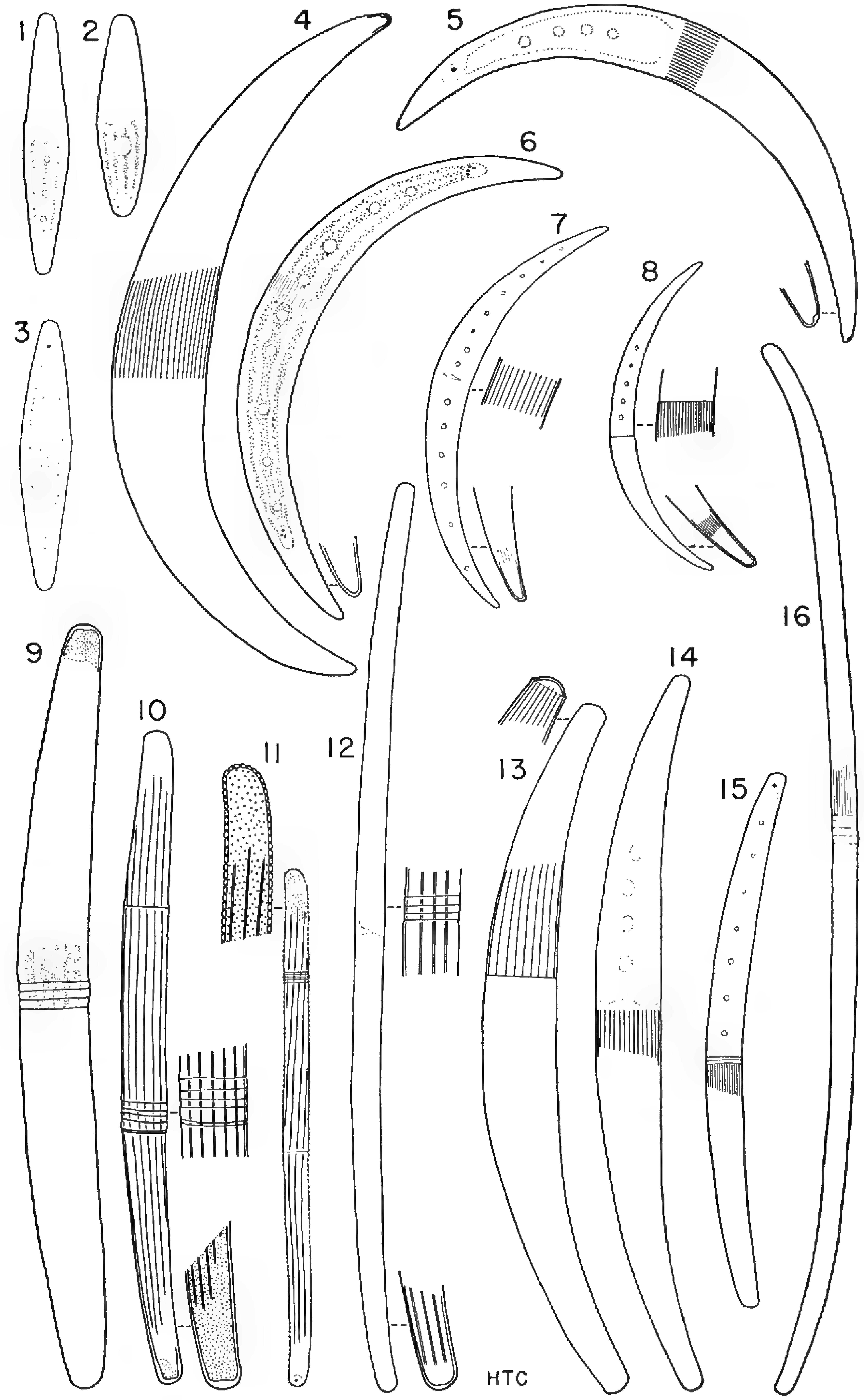

PLATE IV

## PLATE V

1–6. Closterium dianae, 1,3,6 × 325, × 650, 2 × 325, × 475, 4,5 × 325, × 500
7. C. dianae v. arcuatum, × 200, × 425
8–9. C. dianae v. minus, × 450, × 900
10. C. dianae v. brevius, × 475, × 950
11–12. C. dianae f. α, 11 × 500, × 1000, 12 × 325, × 650
13–17. C. parvulum, 13–15 × 475, × 950, 16 × 325, × 650, 17 × 450, × 900
18. C. arcuarium, × 450, × 900
19–20. C. tumidulum, × 525, × 1050

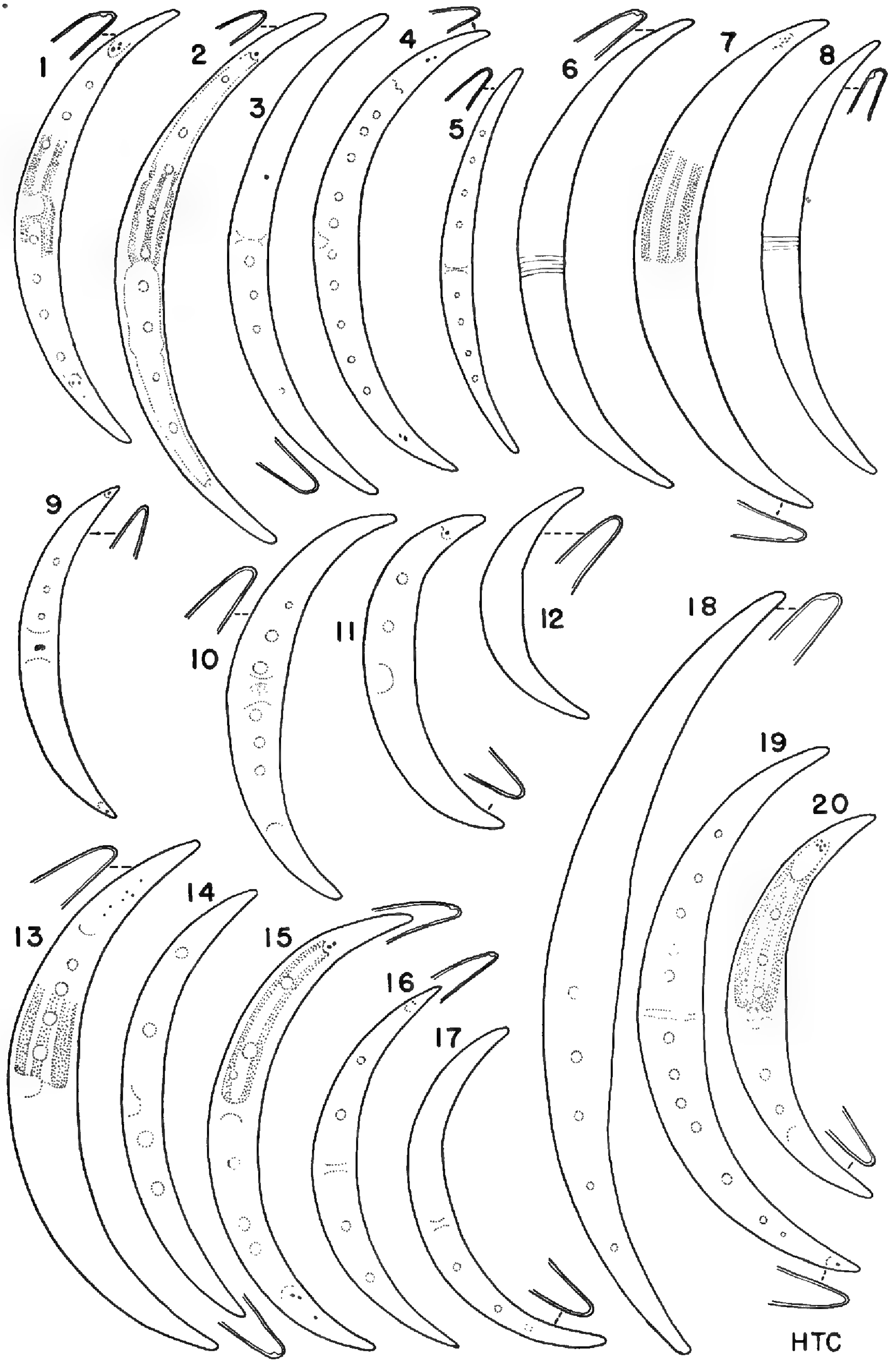

PLATE V

## PLATE VI

1. Closterium Jenneri, × 425
2. C. Jenneri f. α, × 425
3–4. C. Jenneri v. tenue, × 475
5–8. C. incurvum, 5,7 × 500, 6 × 450, 8 × 475
9–10. C. incurvum f. α, × 475
11. C. venus, × 475
12–14. C. venus v. crassum, 12,13 × 475, 14 × 450
15–16. C. venus v. maior, 15 × 475, 16 × 325
17. C. venus f. α, × 475
18. C. cuspidatum, × 450
19. C. Leibleinii v. minimum, × 475
20. C. Ehrenbergii, × 100
21. C. moniliferum, × 325
22. C. moniliferum v. concavum, × 325

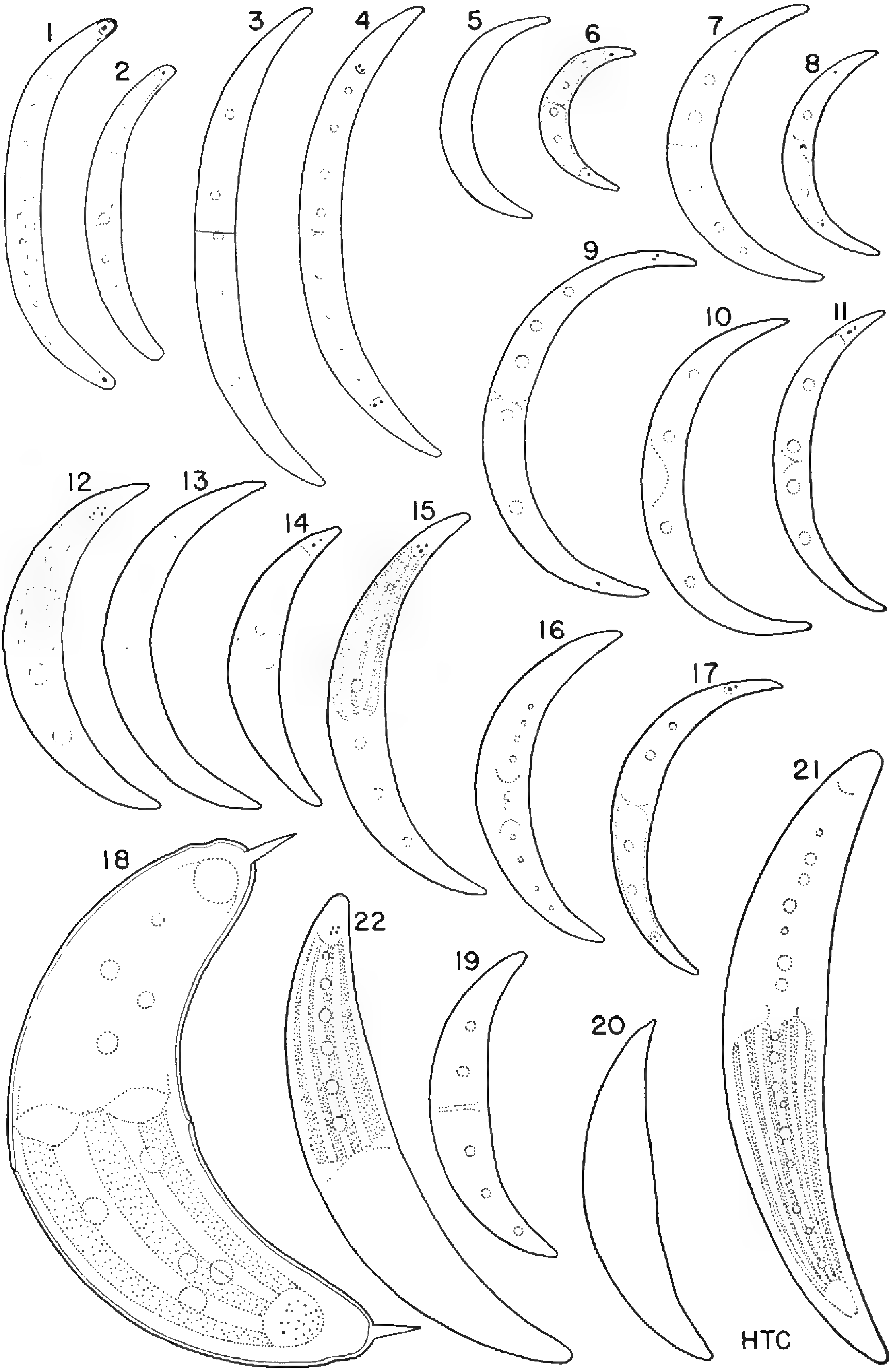

PLATE VI

## PLATE VII

1. Closterium acerosum, × 200
2. C. acerosum f. α, × 325
3. C. acerosum v. minus, × 475
4. C. lunula, × 100
5. C. lunula f. gracilis, × 100
6. C. pseudolunula, × 325
7. C. Pritchardianum f. laeve, × 325
8. C. Pritchardianum, × 325
9. C. praelongum, × 325, × 500
10. C. tumidum f. α, × 450

11–12. C. tumidum, × 325

13. C. cornu, × 425

14–15. C. cornu f. α, × 475

16. C. praelongum v. brevius, × 325, × 475

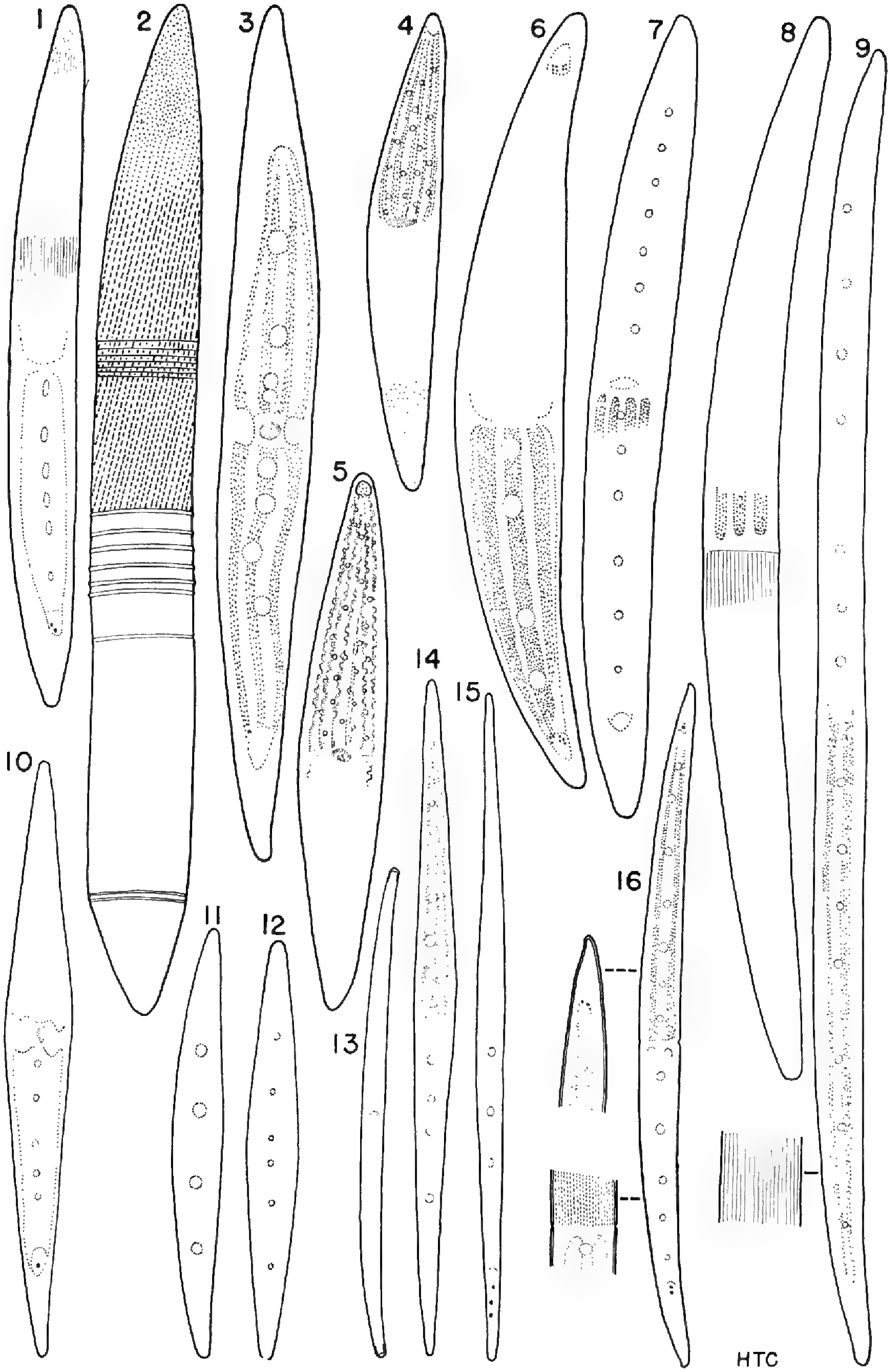

PLATE VII

## PLATE VIII

1–2. Closterium toxon, × 375
3. C. strigosum v. elegans, × 525
4. C. gracile, × 525
5. C. gracile f. sigmoideum, × 525
6. C. gracile, × 525
7. C. gracile v. tenue, × 525
8. C. pronum, × 375
9. C. idiosporum (?), × 375
10. C. Ralfsii v. hybridum, × 250, × 550
11. C. lineatum v. elongatum, × 125, × 600
12. C. lineatum, × 100, × 600
13. C. acutum, × 600

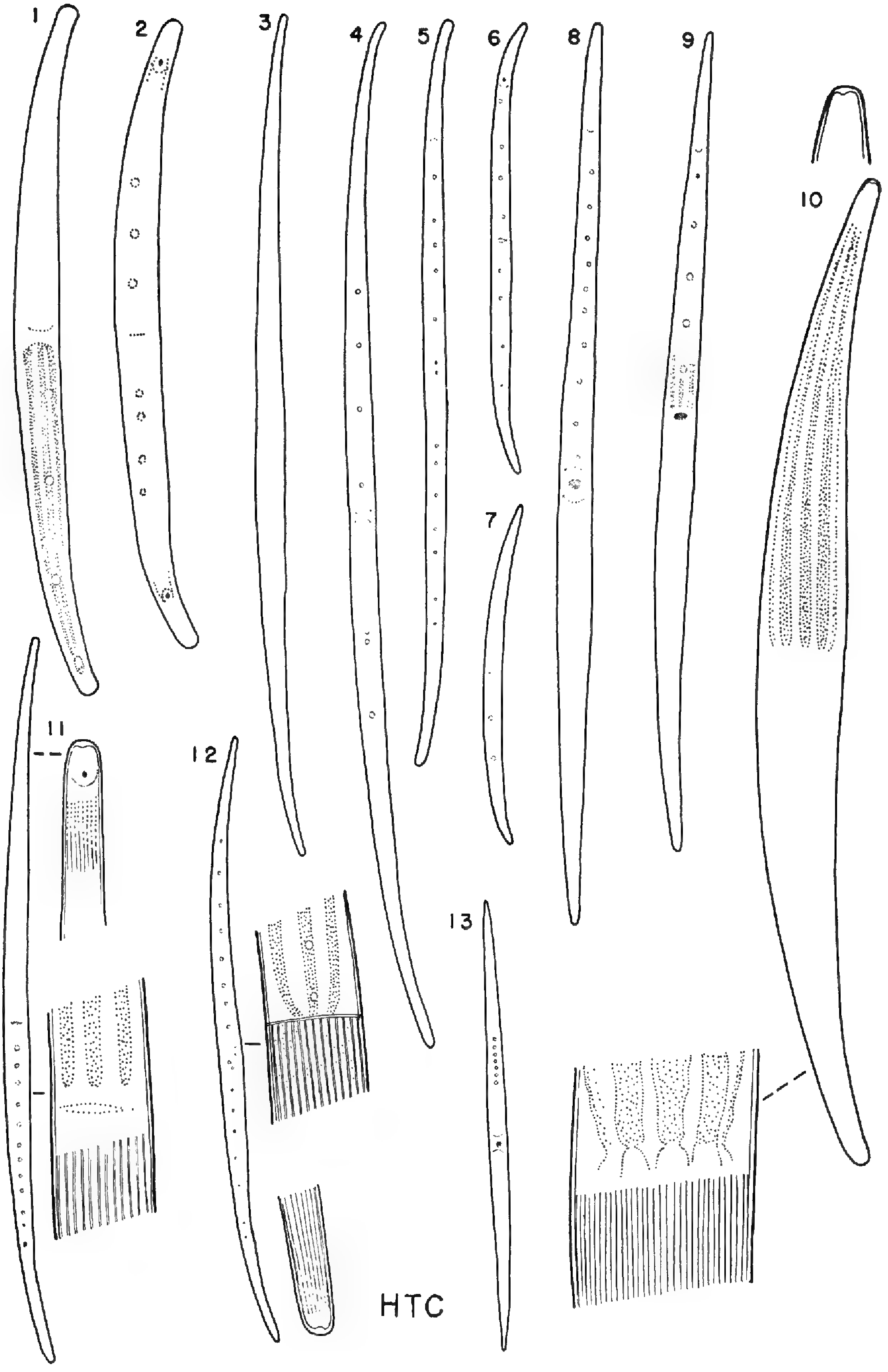

PLATE VIII

## PLATE IX

1. Closterium Kuetzingii, × 250, × 550
2. C. Kuetzingii v. laeve, × 250
3. C. Kuetzingii v. laeve f. α, × 250

4–5. C. rostratum, 4 × 375, 5 × 250, × 375

6. C. setaceum, × 375, detail from larger plant × 425
7. Pleurotaenium eugeneum, × 125, × 375
8. P. truncatum, × 375, × 550

9–10. P. truncatum v. crassum, × 375

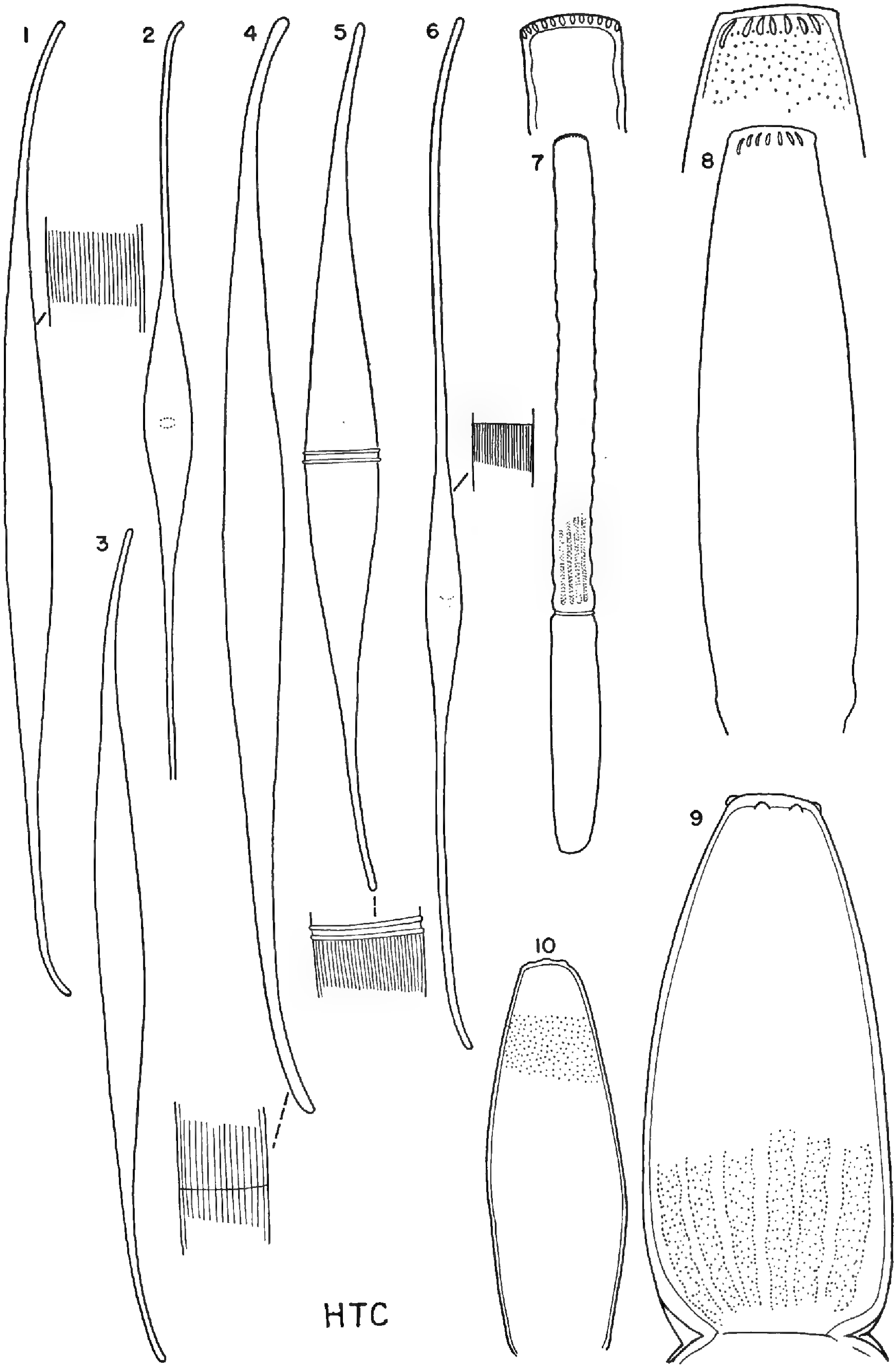

Plate IX

## PLATE X

1. Pleurotaenium Ehrenbergii, × 325, × 475
2. P. Ehrenbergii f. α, × 475
3. P. Ehrenbergii v. curtum, × 325, × 475
4. P. Ehrenbergii v. elongatum, × 325, × 475
5. P. trabecula, × 375
6. P. trabecula v. crassum, × 325
7. P. trabecula v. elongatum f. scrobiculatum, × 325, × 475
8. P. trabecula v. hirsutum, × 325
9. P. trabecula v. rectum, × 450
10. P. minutum, × 325
11. P. minutum v. elongatum, × 450
12. P. minutum v. gracile, × 450
13. Tetmemorus laevis, × 500

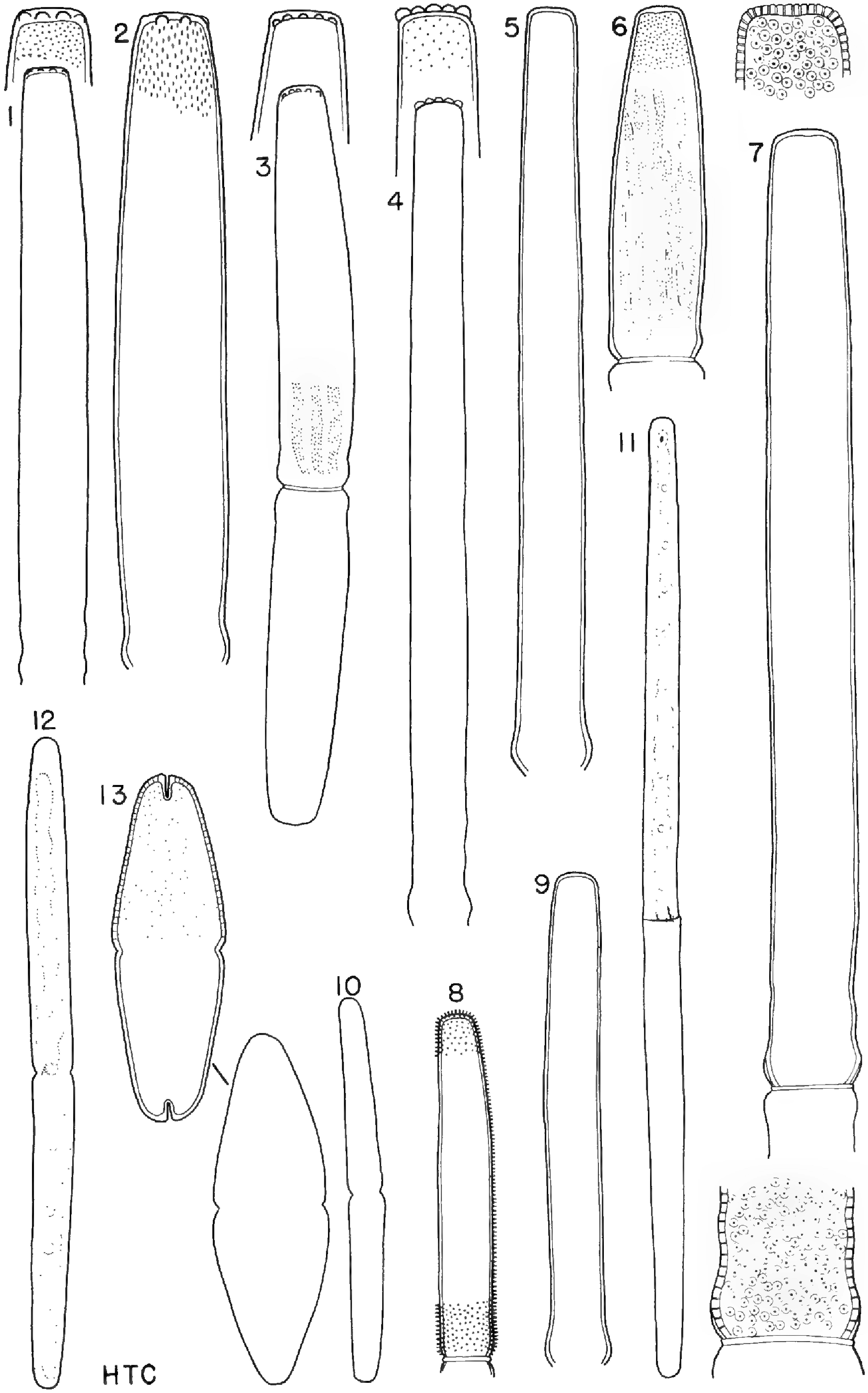

PLATE X

## PLATE XI

1. Euastrum oblongum, × 450
2. E. oblongum f. $a$, × 450
3. E. sinuosum v. scrobiculatum, × 450
4. E. ansatum, × 500
5. E. ansatum f. $a$, × 450
6. E. ansatum v. dideltiforme, × 450
7. E. obesum v. crassum, × 450
8. E. pectinatum v. brachylobum, × 450
9. E. pectinatum v. rostratum, × 500
10. E. tetralobum, × 500
11. E. verrucosum, × 475

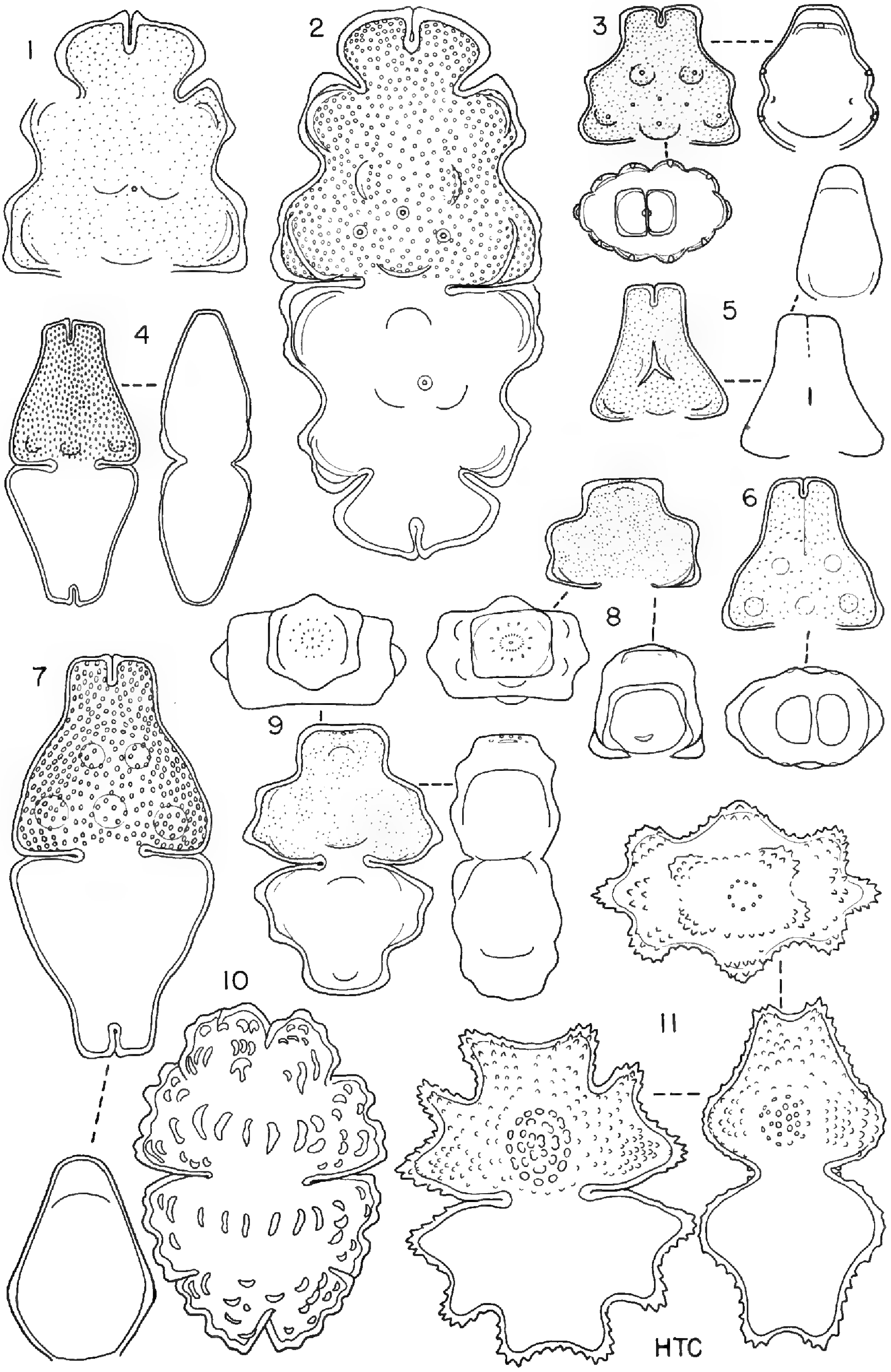

PLATE XI

## PLATE XII

1 2. Euastrum Turneri, 1 × 675, 2 × 750
3. E. evolutum v. integrius, × 700
4. E. lapponicum, × 675
5. E. lapponicum f. α, × 700
6. E. dubium f. α, × 750
7. E. dubium f. β, × 700
8. E. dubium v. ornatum, × 750
9–10. E. dubium v. ornatum f. α, × 750
11. E. dubium v. poriferum, × 750
12–13. E. bidentatum, 12 × 800, 13 × 750
14. E. bidentatum f. α, × 750
15. E. bidentatum v. oculatum f. α, × 750

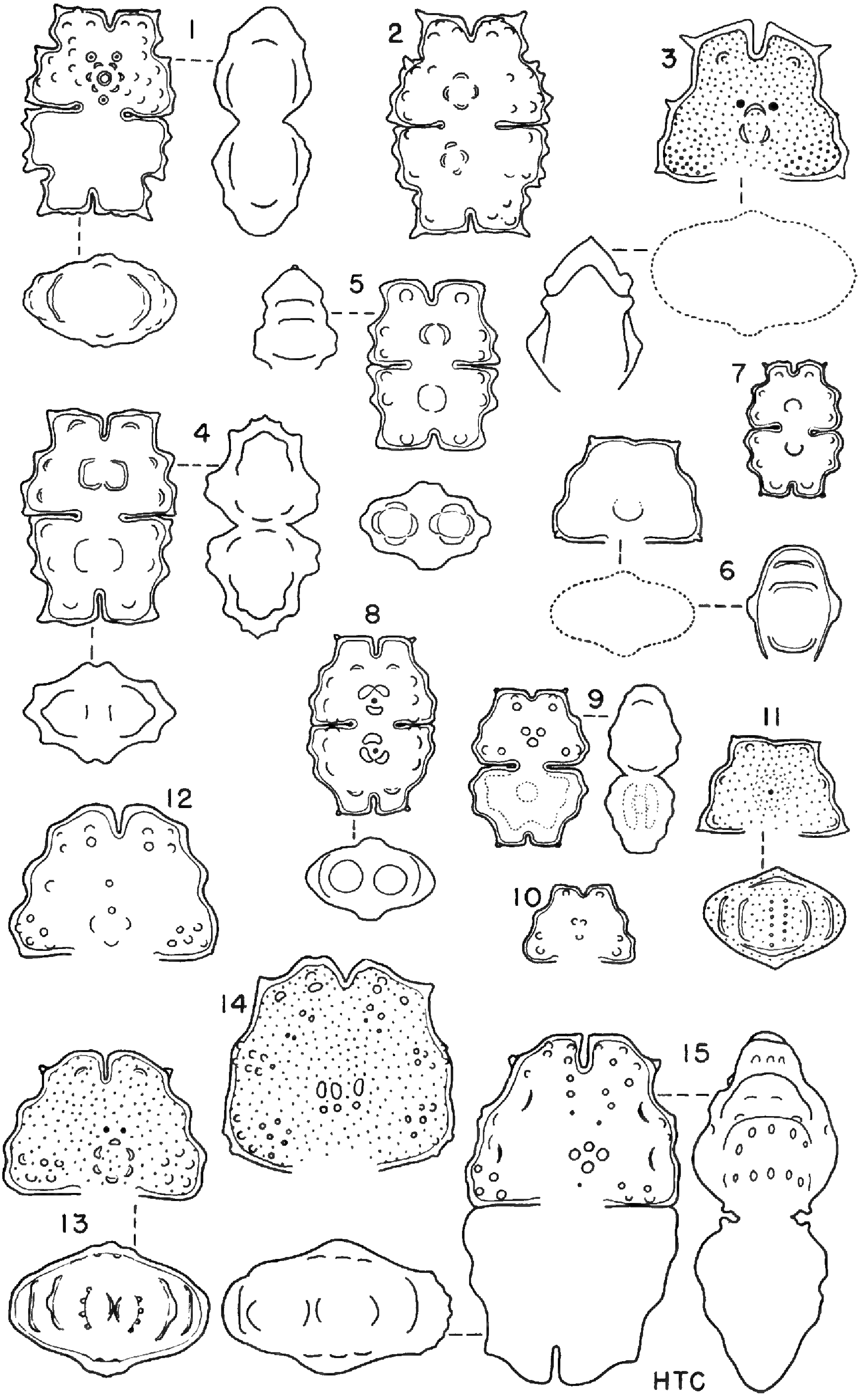

PLATE XII

## PLATE XIII

1. Euastrum erosum v. granulosum, × 800
2–4. E. Ciastonii, × 700
5–6. E. elegans, 5 × 750, 6 × 700
7. E. binale v. Grönbladii, × 700
8–9. E. binale v. Gutwinskii, × 750
10. E. binale v. tumoriferum, × 800
11–12. E. denticulatum, 11 × 750, 12 × 700
13. E. insulare v. silesiacum, × 750
14. E. crassicolle, × 800
15. E. crassicolle v. dentiferum, × 1375
16. E. validum, × 700
17. E. sp., × 800
18. E. sp., × 500

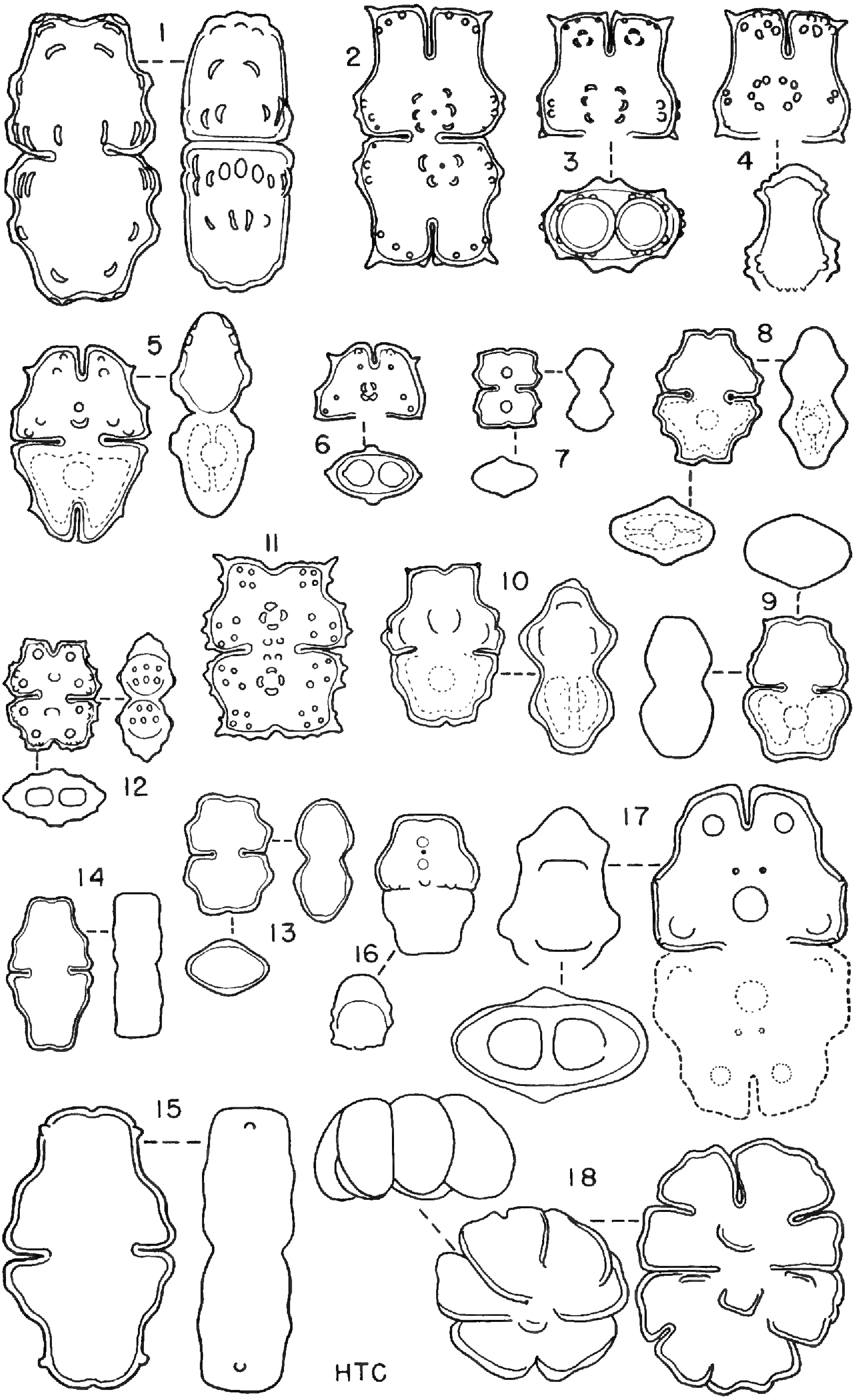

PLATE XIII

# INDEX TO VOLUME 4

## Index to Authors and Titles

# INDEX TO GENERA AND SPECIES

New names are in **bold face type.**

*Note*: Refer to the following lists not repeated here —