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A Comparative Study of the Pollen Morphology of the Solanaceae (Nightshade Family) of Michigan

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A COMPARATIVE STUDY OF THE POLLEN MORPHOLOGY OF THE SOLANACEAE (NIGHTSHADE FAMILY) OF MICHIGAN

by

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A Thesis submitted to the
Faculty of the School of Graduate
Studies in partial fulfillment
of the
Degree of Master of Arts

Western Michigan University
Kalamazoo, Michigan
July 1965

ACKNOWLEDGEMENTS

I wish to express sincere thanks to Dr. Edward G. Voss of the University of Michigan Herbarium for providing some of the pollen samples used in this study.

Special recognition is given to Dr. Richard W. Pippen for the contribution of pollen samples from the Hanes Herbarium at Western Michigan University and also for his assistance during the course of this work.

I also thank Drs. Richard Brewer and Leo C. Vander Beek for their advice and criticism during the preparation of this paper.

Sincere appreciation is given to Sharon Whelan for her kind and patient interest during the preparation of this manuscript.

Ronald A. Kudile

TABLE OF CONTENTS

INTRODUCTION

The importance of pollen morphology has long been recognized and applied by the paleobotanist (Stone 1963). However, the recent use of pollen as a taxonomic character by systematists has stimulated greater interest and research in the area of palynology (Graham 1963).

Several investigators have found pollen to be of significant taxonomic value while others have not. Xavier and Rogers (1963) were able to construct a key to the species of Linum by using characteristics of the pollen alone while Stern (1962) noted interspecific differences in the surface characteristics of pollen grains of all but two species of Dicentra.

This current paper is the result of an investigation of the pollen morphology in the Solanaceae (Nightshade family) that occur in Michigan. No intensive survey of the pollen in this economically important family of plants has been done to date. Erdtman (1952) described the pollen of some species of the Solanaceae, but only a few of them are found in Michigan.

MATERIALS AND METHODS

Pollen grains from a total of eighteen species representing nine genera of Solanaceae were studied. The pollen samples were obtained from herbarium specimens at The University of Michigan Herbarium and the Hanes Herbarium of Western Michigan University, hereafter referred to as MICH and WMU respectively which are the standard designations suggested by Lanjouw and Stafleau (1964).

Pollen grains were mounted on slides using glycerin jelly prepared according to the Brandt formula (Brown 1960) with basic fuchsin stain. Liquefying the glycerin jelly before placing it on the slide was found to be more effective and efficient than melting solid jelly after placing it on the slides since many air bubbles were produced by the latter method. Several specimens were also prepared with lactic acid (ca. 85%), but no significant difference in the pollen was observed.

Before each slide was prepared, a clean piece of paper was placed under the folded packet containing the pollen sample. Dissecting needles and forceps cleaned with a gas flame were used to extract pollen from the anthers and to transfer the sample to a clean slide.

Following transfer of pollen to a slide, two drops of the liquefied fuchsin jelly were placed on the slide with a pipette. A square, number one cover slip was then added. The slides were allowed to set for 24 hours before investigations were made.

A Leitz Ortholux microscope with a 43x objective and a 10x ocular containing an ocular micrometer was used to measure the pollen grains. Care was taken to select only pollen grains which were in equatorial view with an aperture in the top-center position for measuring.

The mean length (P) and breadth (E) was calculated on the basis of 25 pollen grains for each specimen whenever possible. The standard deviation of the length and breadth of each specimen was calculated using the following formula S.D. = $\sqrt{\frac{\Sigma (X-\bar{X})^2}{N}}$ (Mack 1960).

Photomicrographs were made with an Exacta VXII 35mm single lens reflex camera mounted on the above mentioned microscope with a built-in illuminator and blue filter. The exposure, light intensity, diaphragm settings and other data are shown on a table in the appendix.

The taxonomic treatment followed is that appearing in Gleason and Cronquist (1963).

DESCRIPTIONS

In the species of the Solanaceae, the following pollen characters were taken into consideration:

General Shape. The general shape of the pollen ranged from oblate spheroidal (P/E 7/8-8/8), prolate spheroidal (P/E 8/8-8/7), and subprolate (P/E 8/7-8/6) to prolate (P/E 8/6-8/4).

Size. Even though the materials used were subject to relatively uniform storage and preparation, considerable size difference was noted even within single preparations. This was also observed by Stern (1962). Of the pollen studied there was a range from 48.4 x 48.7 microns in Datura stramonium to 10.9 x 11.1 microns in Solanum dulcamara; the other pollen samples were distributed near the mid-point between the above (refer to Table 1).

Apertures. The apertures (weak spots in the pollen wall) were composite and located in the equatorial position. The weak spots through which the pollen tubes pass were composed of long furrows (not zonorate) except in Datura stramonium where they were approximately half the size of all others. A pore which appeared either

circular or lalongate was found in each furrow at the mid-point. Pollen grains with this combination of pores and furrows present in groups of three are referred to as tricolporate.

AMB Types. Observing pollen in polar view indicates both general shape and the location of apertures; by combining the two Erdtman (1952) described, for tricolporate pollen, six basic AMB Types (terms describing both the general shape and the location of the apertures of the pollen when observed in polar view). Wodehouse (1935 p. 543) applied the term limb to describe the same thing. The pollen of the Solanaceae exhibit AMB Types two, three and six or a combination of any two of these Types as illustrated in Erdtman (1952 p. 13). Also refer to figures 19, 20 and 21.

Sexine. The general sexine pattern (sculptine) of the pollen walls varied depending upon the arrangement of pila or clubs on the surface of the wall. The sexines were pilate, reticulate, striate or ornate (Erdtman 1952). Preparation of thin sections will be necessary in order to differentiate the layers of the pollen wall since some are rather thin and others obscure.

Symmetry. All the pollen grains observed were radiosymmetrical.

Polarity. All the pollen grains investigated were

isopolar in which case both halves of each grain are identical.

Detailed descriptions of the pollen of the species studied is presented below. The taxa are arranged alphabetically.

1. Datura stramonium L. - (Fig. 1), oblate spheroidal, 48.4 x 48.7, P/E 8/8.03, AMB Type #3; 3-colporate, short equatorial furrows, ± circular equatorial pores, striate sexine pattern. C. and B. Karne 17, 11 July 1958, Michigan, Jackson Co., Concord, (MICH).

2. Hyoscyamus niger L. - (Fig. 2), oblate spheroidal, 34.9 x 35.6, P/E 8/8.2, AMB Type #2-3; 3-colporate, long equatorial furrows, lalongate-circular equatorial pores, ± reticulate sexine pattern. E. G. Voss 11011, 21 August 1962, Michigan, Cheboygan Co., Mackinaw City, (MICH).

3. Lycium halimifolium Mill. - (Fig. 3), prolate spheroidal, 22.2 x 21.5, P/E 8/7.7, AMB Type #2-3; 3-colporate, long equatorial furrows, ± circular equatorial pores, striate sexine pattern. H. M. Bailey s.n., 28 June 1892, Michigan, Grand Rapids, (MICH). C. K. Dodge s.n., 19 August 1892, Michigan, St. Clair Co., Port Huron, (MICH). C. Hanes s.n.,

1934, Michigan, Kalamazoo Co., Lyons Lake, (WMU).

4. Lycopersicon esculentum Mill. - (Fig. 4), prolate spheroidal, 19.6 x 18.6, P/E 8/7.6, AMB Type #2-3; 3-colporate, long equatorial furrows, lalongate equatorial pores, ± reticulate sexine pattern. C. K. Dodge s.n., 14 September 1892, Michigan, St. Clair Co., Port Huron, (MICH).

5. Nicandra physalodes (L.) Gaertn. - (Fig. 5), oblate-prolate spheroidal, 29.1 x 29.8, P/E 8/8.1, AMB Type #2-3; 3-colporate, long equatorial furrows, lalongate-circular pores, ± reticulate sexine pattern. E. C. Almendinger s.n., 10 August 1867, Michigan, Ann Arbor, (MICH). C. E. J. Hermann 6451, 5 October 1934, Michigan, Washtenaw Co., (MICH).

6. Nicotiana rustica L. - (Fig. 6), prolate spheroidal, 26.9 x 28.0, P/E 8/7.1, AMB Type #2; 3-colporate, long equatorial furrows, lalongate-circular pores, ± ornate sexine pattern. G. B. Sudworth s.n., 2 August 1884, Michigan, Salem, (MICH).

7. Nicotiana tabacum L. - (Fig. 7), subprolate, 32.0 x 25.8, P/E 8/6.5, AMB Type #2; 3-colporate, long equatorial furrows, ± circular pores, ± ornate sexine pattern. C. K. Dodge s.n., 7 September 1906,

Michigan, St. Clair Co., Port Huron, (MICH).

8. Petunia hybrida Vilm. - (Fig. 8), oblate spheroidal, 25.5 x 28.7, P/E 8/8.54, AMB Type #2, 3-colporate, long equatorial furrows, ± circular pores, ± striate sexine pattern. C. K. Dodge s.n., 1 September 1892, Michigan, St. Clair Co., Port Huron, [name on specimen Petunia violacea Lindl.], (MICH).

9. Physalis grandiflora Hook. - (Fig. 9), prolate spheroidal, 26.2 x 23.9, P/E 8/7.4, AMB Type #3 and #6; 3-colporate, long equatorial furrows, lalongate equatorial pores, ± reticulate sexine pattern. H. A. Baggley s.n., 20 July 1941, Michigan, Kewenaw Co., Isle Royale, [name on specimen is Chamaesaracha grandiflora (Hook.) Fern.], (MICH). C. K. Dodge s.n., 26 June 1915, Michigan, Naubinway, (MICH). C. K. Dodge s.n., 23 June 1907, Michigan, Alpena Co., North Point, (MICH). A. S. Pease s.n., 14 July 1935, Michigan, Mackinac Co., Cedarville, (MICH). H. Sharpensteen s.n., 27 July 1933, Michigan, Menominee Co., (MICH).

10. Physalis heterophylla Nees. - (Fig. 10), prolate spheroidal-subprolate, 23.3 x 20.0, P/E 8/7.3 - 8/6.0, AMB Type #2 and #6; 3-colporate, long equ-

atorial furrows, lalongate equatorial pores, ± pilate-reticulate sexine pattern. H. W. B. s.n., 20 September 1893, Michigan, Grand Rapids, (MICH). J. H. Ehlers 5600, 14 July 1934, Michigan, Emmet Co., Brutus, (MICH). C. Hanes s.n., 1937, Michigan, Sugar Loaf Lake, (WMU). C. D. Richardson 3865, 30 July 1950, Michigan, Dollar Bay, (MICH). E. G. Voss 4583, 10 July 1957, Michigan, Alcoma Co., (MICH).

11. Physalis ixocarpa Brot. - (Fig. 11), prolate, 26.2 x 18.6, P/E 8/5.7, AMB Type #2; 3-colporate, long equatorial furrows, lalongate equatorial pores, reticulate sexine pattern. E. C. Almendinger s.n., 27 August 1861, Michigan, Leuawee Co., Tecumseh, (MICH).

12. Physalis longifolia Nutt. - (Fig. 12), prolate, 26.2 x 19.3, P/E 8/5.6, AMB Type #6; 3-colporate, long equatorial furrows, lalongate equatorial pores, pilate sexine pattern. E. Halfruit s.n., 20 July 1935, Michigan, Cass Co., Silver Creek Twp., [name on specimen Physalis subglabrata Cronq.], (MICH).

13. Physalis virginiana Mill. - (Fig. 13), prolate, 25.3 x 18.8, P/E 8/6.1, AMB Type #6; 3-colporate, long equatorial furrows, lalongate equatorial pores, ± pilate-reticulate sexine pattern. C. K. Dodge

s.n., 21 June 1901, Michigan, St. Clair Co., Port Huron, (MICH). Houghton and Bull s.n., 22 August 1839, Michigan, Green Bay, (MICH). R. R. W. 7207, 28 June 1931, Michigan, Loon Lake, [name on specimen Physalis lanceolata Waterfall], (MICH).

14. Solanum carolinense L. - (Fig. 14), prolate spheroidal, 23.3 x 22.6, P/E 8/7.7, AMB Type #2; 3-colporate, long equatorial furrows, lalongate equatorial pores, pilate sexine pattern. C. Hanes s.n., 1933, Michigan, Schoolcraft, (WMU). E. G. Voss 7450, 15 July 1958, Michigan, Hillsdale Co., (MICH).

15. Solanum dulcamara L. - (Fig. 15), oblate spheroidal, 10.9 x 11.1, P/E 8/8 - 8/8.2, AMB Type #2; 3-colporate, long equatorial furrows, lalongate equatorial pores, pilate sexine pattern. E. G. Voss 4658, 28 July 1957, Michigan, Ogemaw Co., (MICH). E. G. Voss 7315, 8 July 1958, Michigan, Saniac Co., (MICH).

16. Solanum melongena L. - (Fig. 16), subprolate, 28.4 x 22.2, P/E 8/6.3, AMB Type #6; 3-colporate, long equatorial furrows, lalongate equatorial pores, pilate sexine pattern. C. K. Dodge s.n., 15 September 1902, Michigan, St. Clair Co., Port Huron, (MICH).

17. Solanum nigrum L. (Fig. 17), subprolate, 20.6 x 17.2 P/E 8/6.2, AMB Type #6; 3-colporate, long equatorial furrows, lalongate equatorial pores, pilate sexine pattern. J. V. Dieterle s.n., 17 August 1954, Michigan, Grand Traverse Co., [name on specimen Solanum americanum Mill.], (MICH). C. Hanes s.n., 1933, Michigan, Kalamazoo Co., (WMU). C. Hanes s.n., 1951, Michigan, Kalamazoo Co., Schoolcraft, [name on specimen Solanum americanum Mill.], (WMU). E. G. Voss 7977, 12 September 1958, Michigan, Hillsdale Co., (MICH).

18. Solanum rostratum Dunal. - (Fig. 18), prolate spheroidal, 24.2 x 19.8, P/E 8/7.3, AMB Type #2; 3-colporate, long equatorial furrows, lalongate equatorial pores, pilate sexine pattern. C. Hanes s.n., 1933, Michigan, Kalamazoo Co., (WMU). J. W. Sutton s.n., 30 September 1917, Michigan, Ann Arbor, (MICH).

TABLE 1. Comparative size data on some solanaceae

Species	P.°		E.°	
	Mean	S.D.	Mean	S.D.
Datura stramonium+	48.36		48.72	
Hyoscyamus niger+	34.90	± 6.14	35.64	± 7.27
Lycium halimifolium*	22.18	± 5.11	21.45	± 4.14
Lycopersicon esculentum*	19.64	± 5.52	18.55	± 3.16
Nicandra physalodes*	29.09	± 1.92	29.82	± 4.40
Nicotiana rustica*	26.91	±13.67	28.00	±14.00
Nicotiana tabacum*	32.00	± 6.83	25.82	± 6.25
Petunia hybrida+	25.45	± 6.03	28.73	± 4.94
Physalis grandiflora*	26.21	± 3.24	23.91	± 4.40
Physalis heterophylla*	23.27	± 3.68	20.00	± 3.33
Physalis ixocarpa*	26.18	± 9.09	18.55	± 3.85
Physalis longifolia*	26.18	± 5.20	19.27	± 6.25
Physalis virginiana*	25.33	± 5.92	18.79	± 3.97
Solanum carolinense*	22.72	± 3.65	19.45	± 4.27
Solanum dulcamara*	10.91	± 1.11	11.09	± 1.47
Solanum melongena*	28.36	± 6.29	22.18	± 3.01
Solanum nigrum*	20.63	± 4.07	17.18	± 3.72
Solanum rostratum*	24.18	± 3.65	19.82	± 4.62

*Sample of 25 grains/specimen
+Sample of 15 grains/specimen
°Measurements in microns

TABLE 2. Summary of pollen characters

Species	Sexine Pattern	Pore Shape	Size (P/E) (in microns)	General Shape	AMB Type
Datura stramonium	striate	circular	48.4/48.7	O.S.	3
Hyoscyamus niger	reticulate	circular	34.9/35.6	O.S.	2-3
Lycium halimifolium	striate	circular	22.2/21.5	P.S.	2-3
Lycopersicon esculentum	reticulate	lalongate	19.6/18.6	P.S.	2-3
Nicandra physalodes	reticulate	lalongate -circular	29.1/29.8	O.S.	2-3
Nicotiana rustica	ornate	lalongate -circular	26.9/28.0	P.S.	2
Nicotiana tabacum	ornate	circular	32.0/25.8	S.P.	2
Petunia hybrida	striate	circular	25.5/28.7	O.S.	2
Physalis grandiflora	reticulate	lalongate	26.2/23.9	P.S.	3&6
Physalis heterophylla	pilate-reticulate	lalongate	23.3/20.0	P.S.	2&6
Physalis ixocarpa	reticulate	lalongate	26.2/18.6	P.	2
Physalis longifolia	pilate	lalongate	26.2/19.3	P.	6

TABLE 2. Continued

Physalis virginiana	pilate-reticulate	lalongate	25.3/18.8	P.	6
Solanum carolinense	pilate	lalongate	22.7/19.5	P.S.	2
Solanum dulcamara	pilate	lalongate	10.9/11.1	O.S.	2
Solanum melongena	pilate	lalongate	28.4/22.2	S.P.	6
Solanum nigrum	pilate	lalongate	20.6/17.2	S.P.	6
Solanum rostratum	pilate	lalongate	24.2/19.8	P.	2

O.S. = oblate spheroidal
P. = prolate
P.S. = prolate spheroidal
S.P. = subprolate

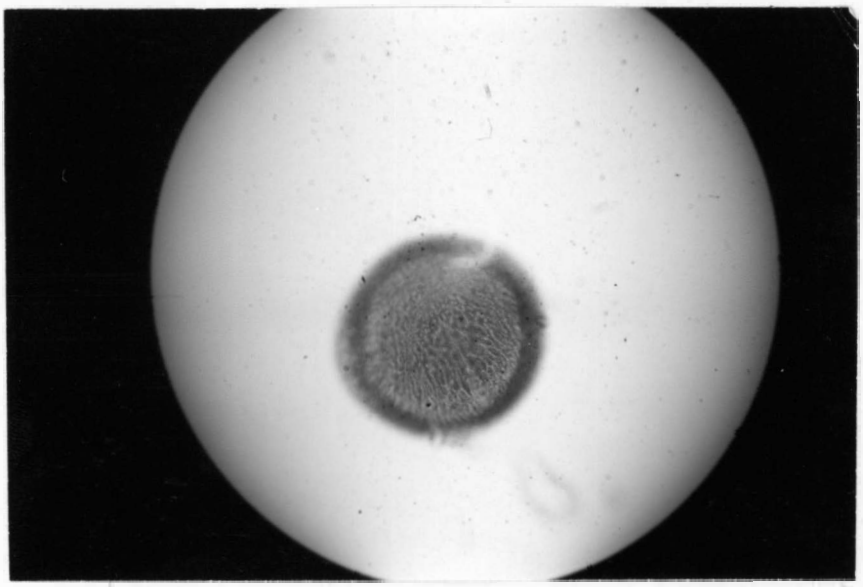

Fig. 1 Datura stramonium (1,000x)

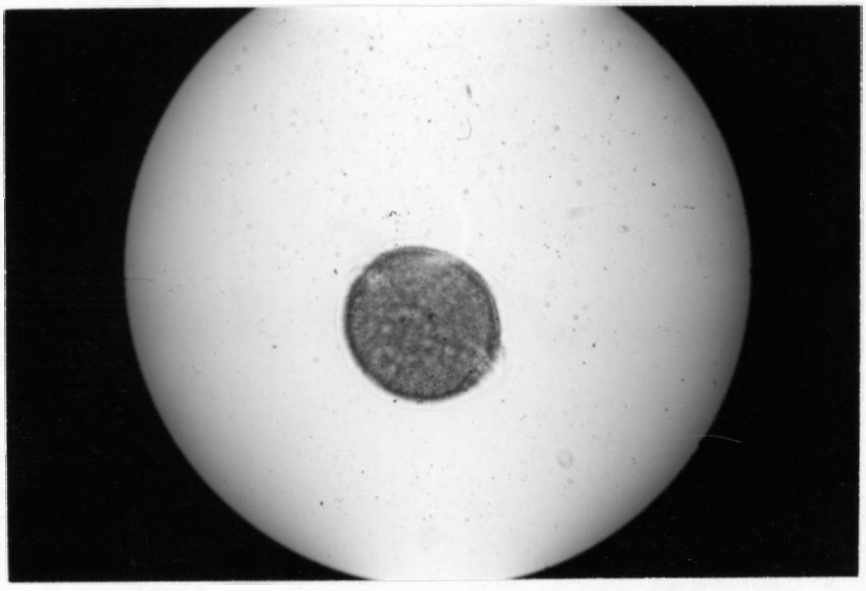

Fig. 2 Hyoscyamus niger (1,000x)

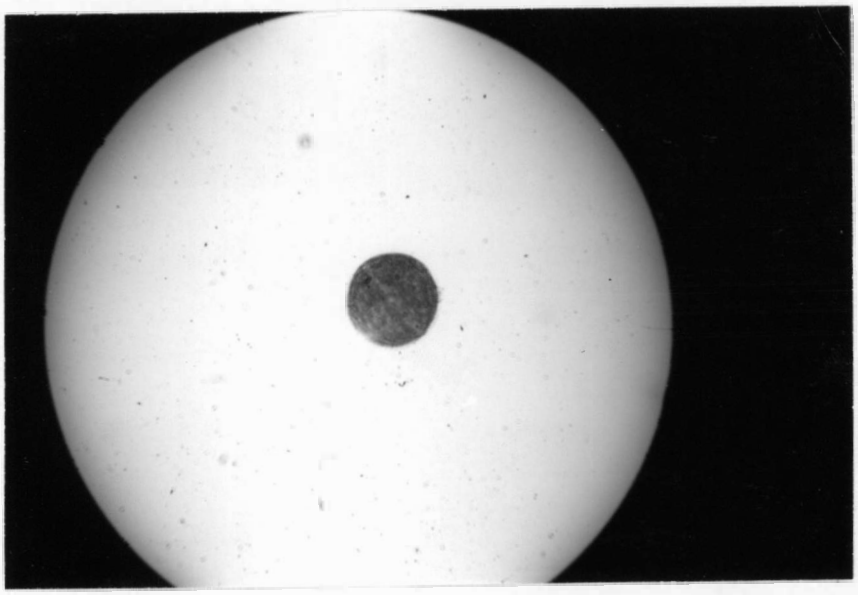

Fig. 3 Lycium halimifolium (1,000x)

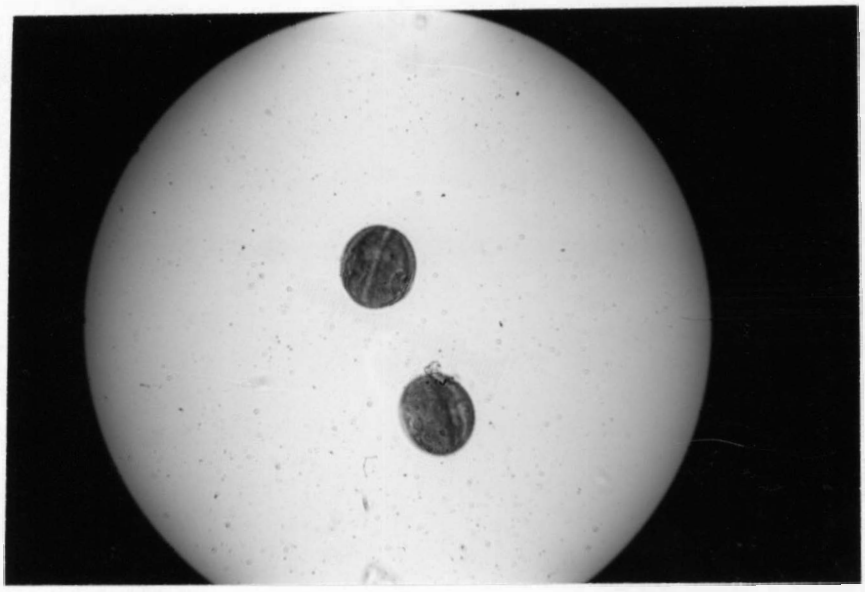

Fig. 4 Lycopersicon esculentum (1,000x)

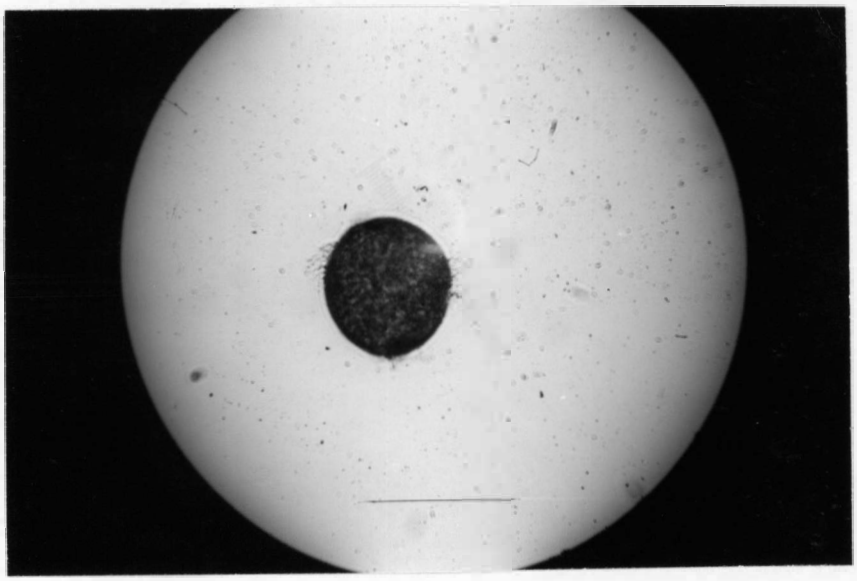

Fig. 5 Nicandra physalodes (1,000x)

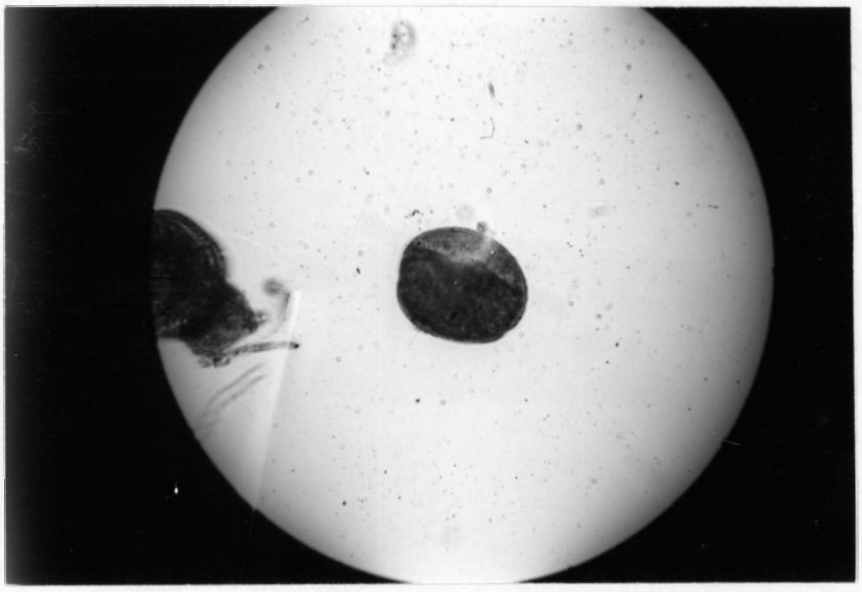

Fig. 6 Nicotiana rustica (1,000x)

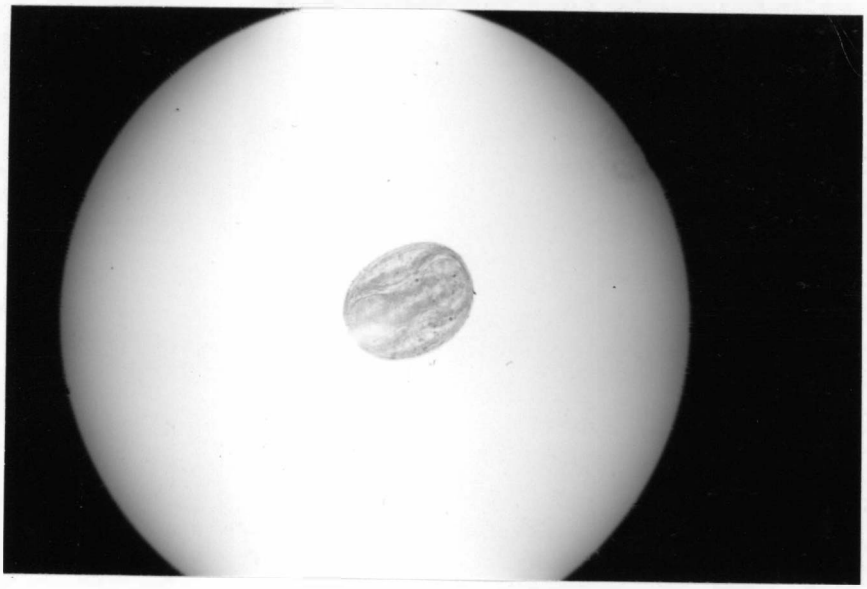

Fig. 7 Nicotiana tabacum (1,000x)

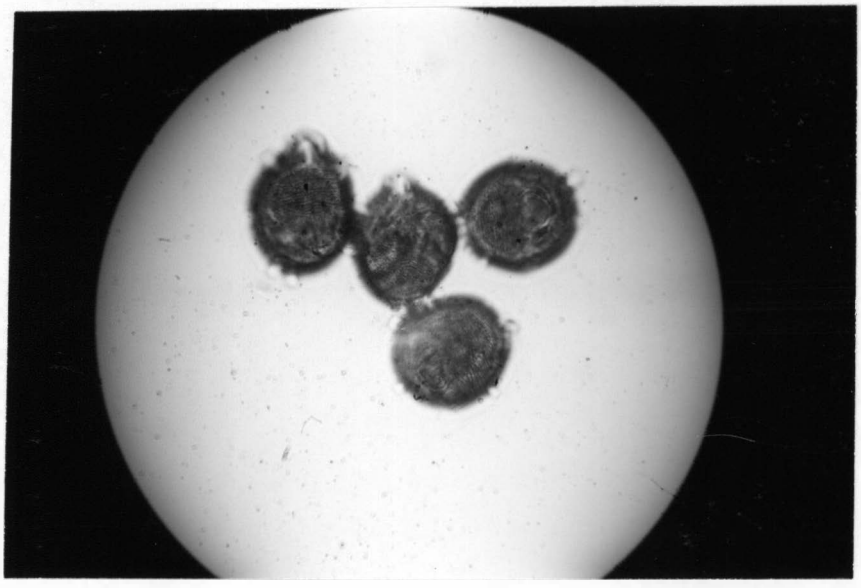

Fig. 8 Petunia hybrida (1,000x)

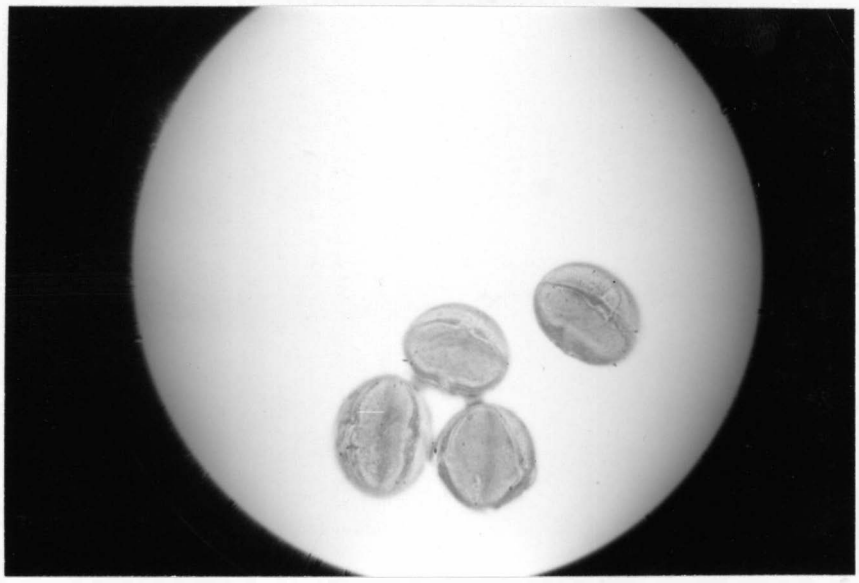

Fig. 9 Physalis grandiflora (1,000x)

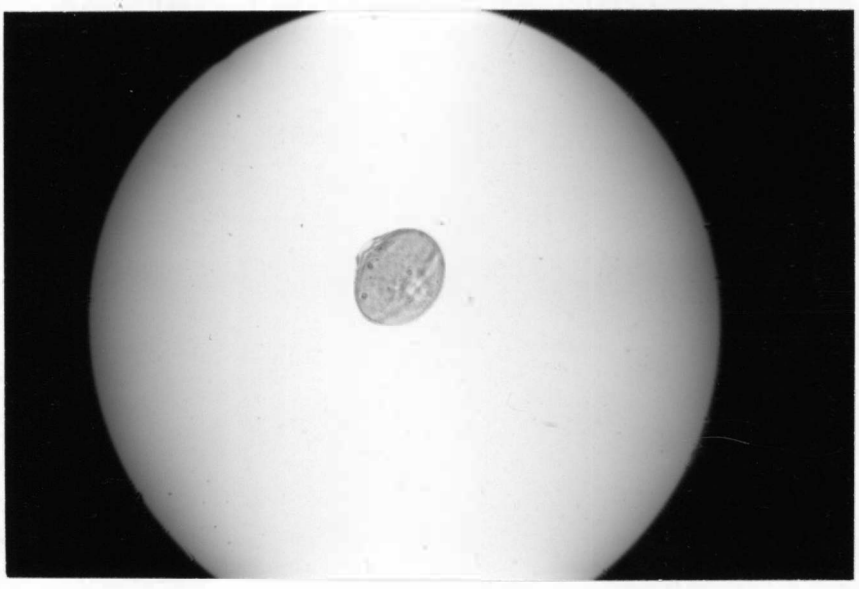

Fig. 10 Physalis heterophylla (1,000x)

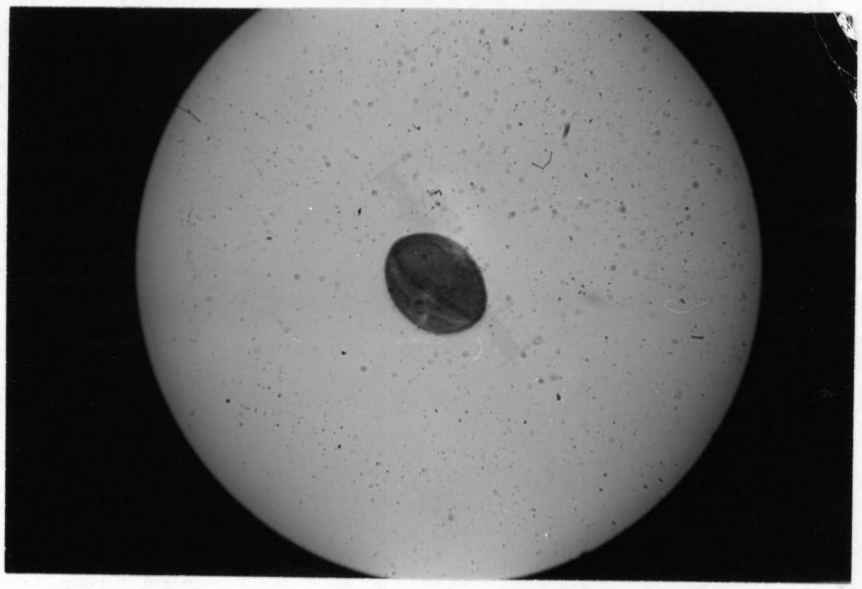

Fig. 11 Physalis ixocarpa (1,000x)

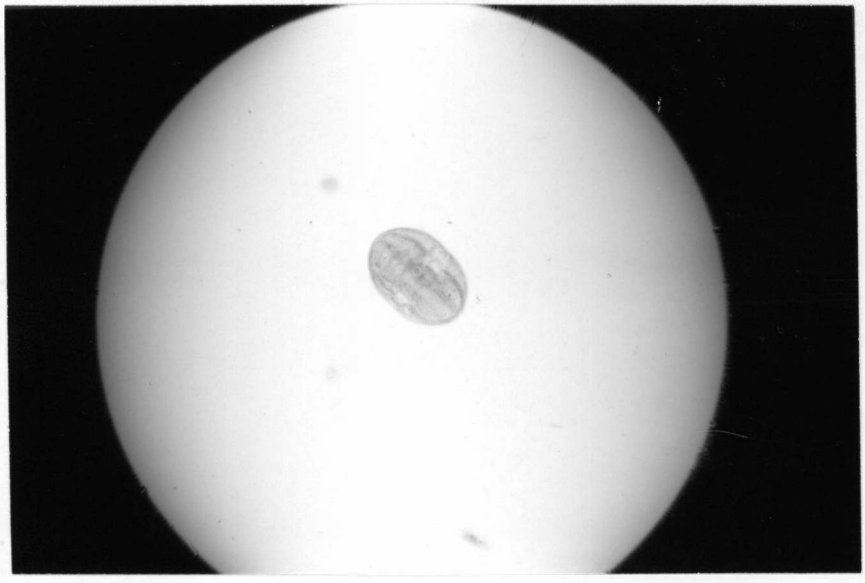

Fig. 12 Physalis longifolia (1,000x)

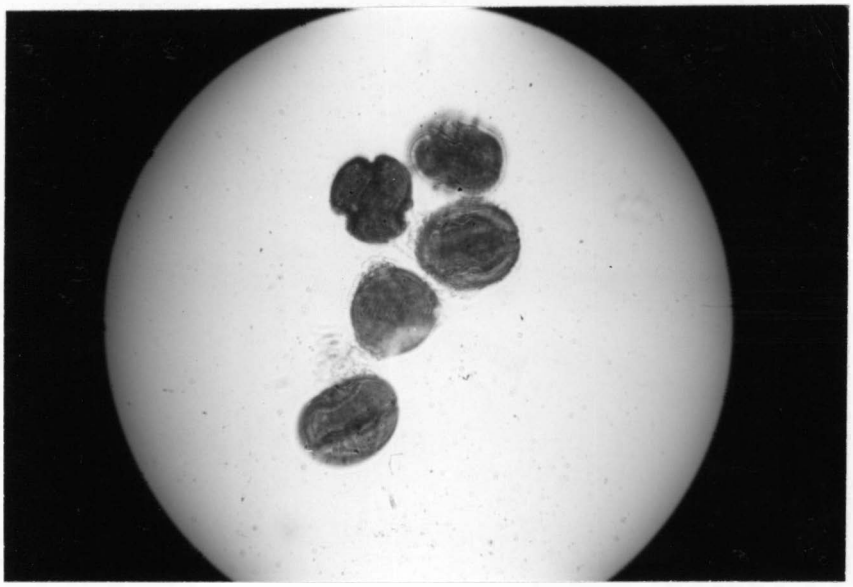

Fig. 13 Physalis virginiana (1,000x)

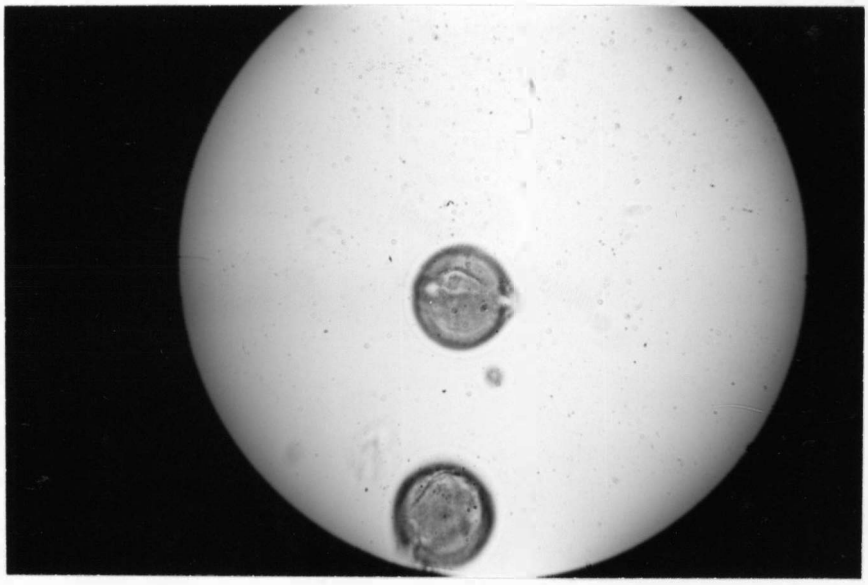

Fig. 14 Solanum carolinense (1,000x)

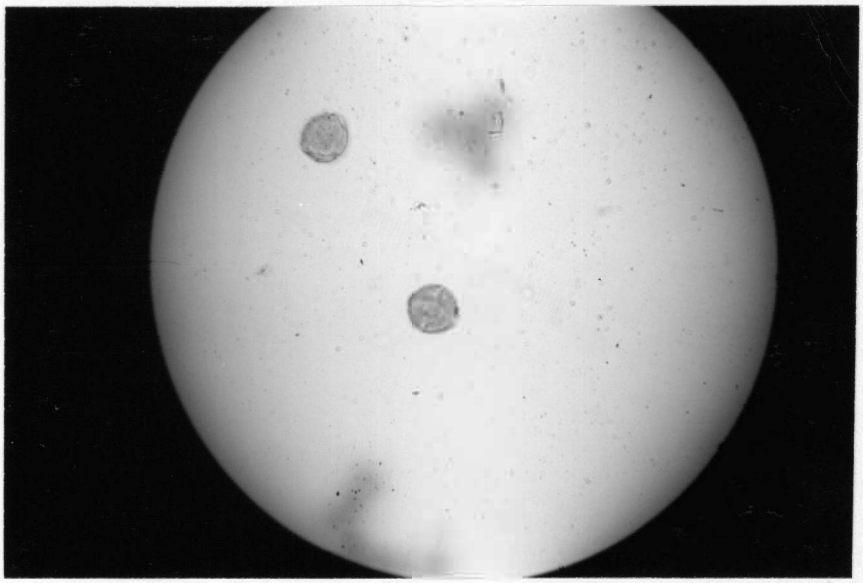

Fig. 15 Solanum dulcamara (1,000x)

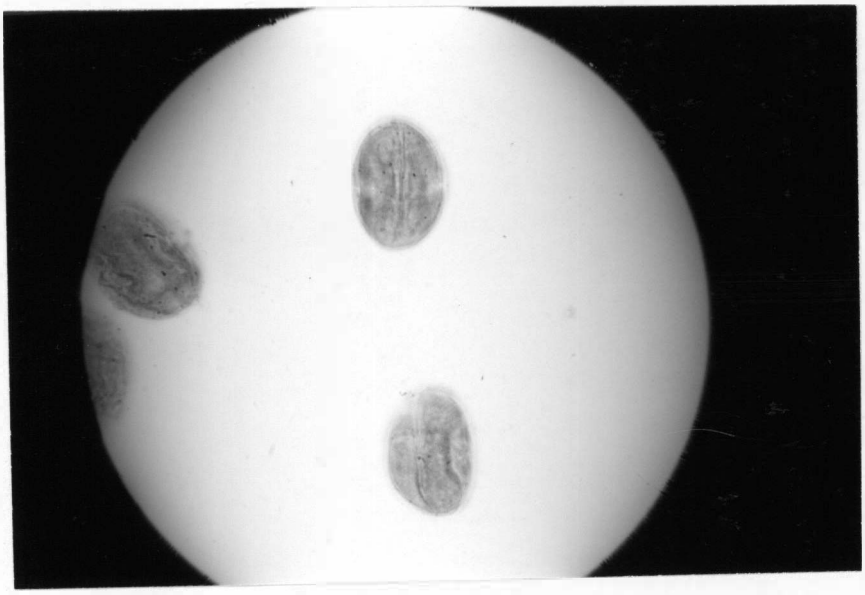

Fig. 16 Solanum melongena (1,000x)

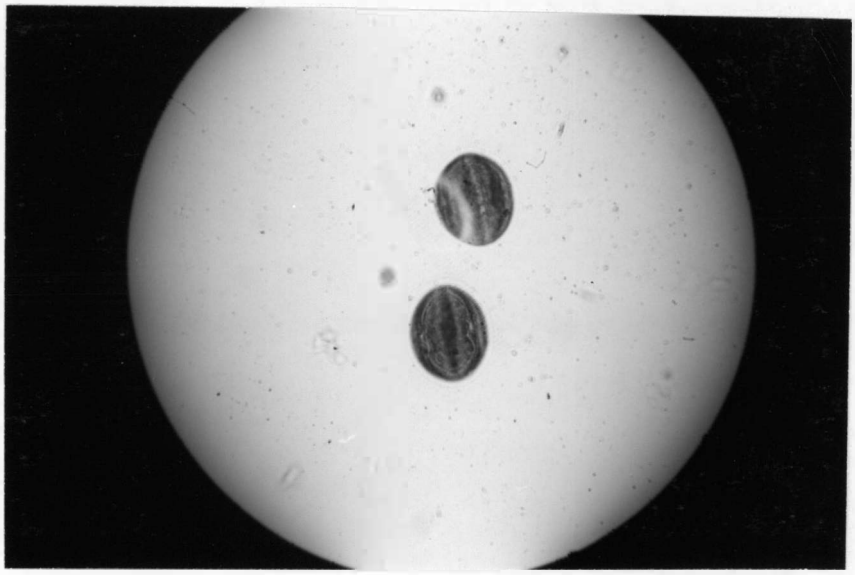

Fig. 17 Solanum nigrum (1,000x)

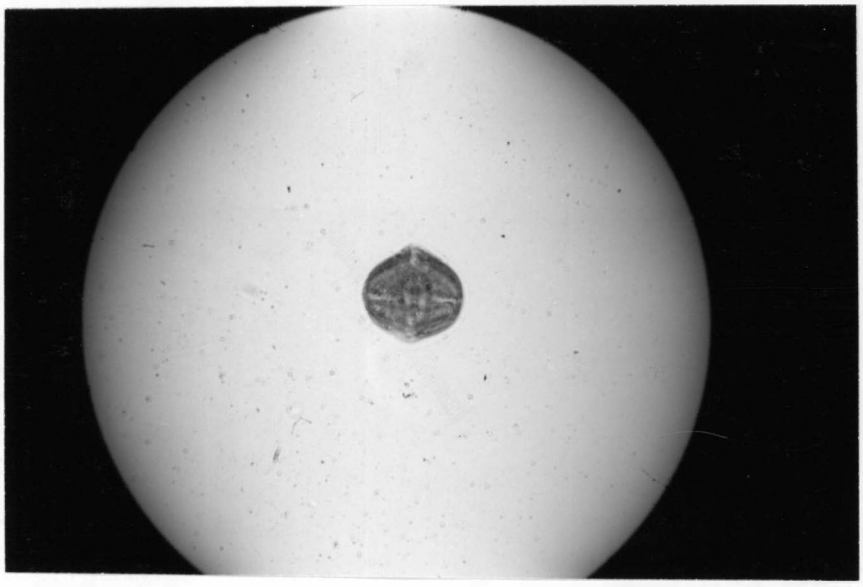

Fig. 18 Solanum rostratum (1,000x)

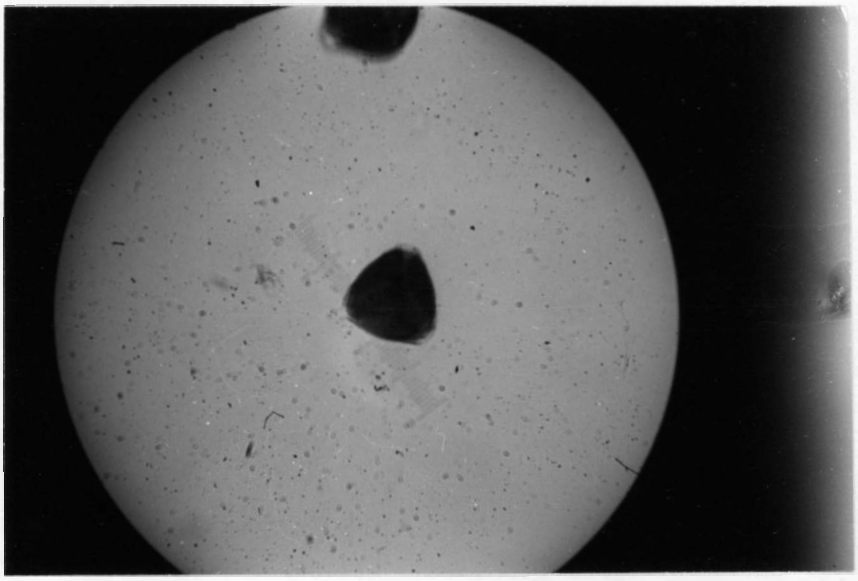

Fig. 19 Solanum rostratum AMB #2 (1,000x)

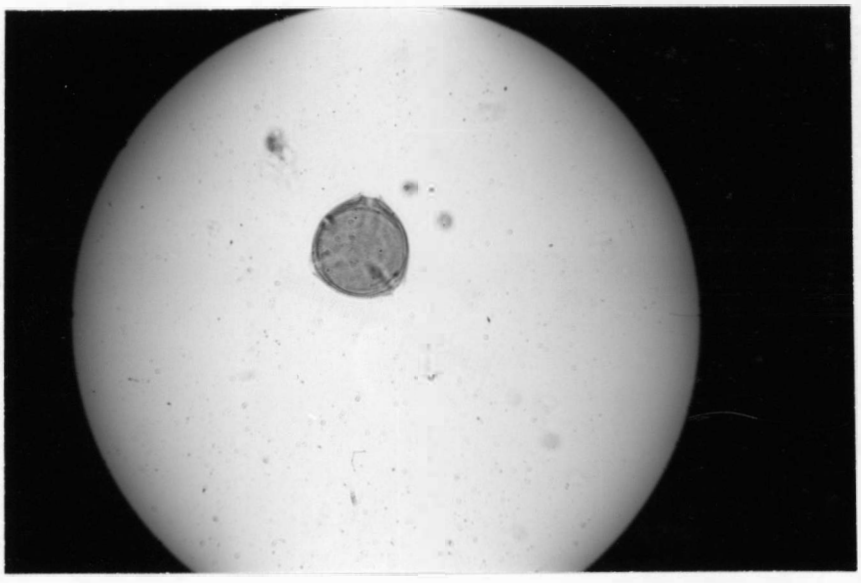

Fig. 20 Solanum carolinense AMB #2 (1,000x)

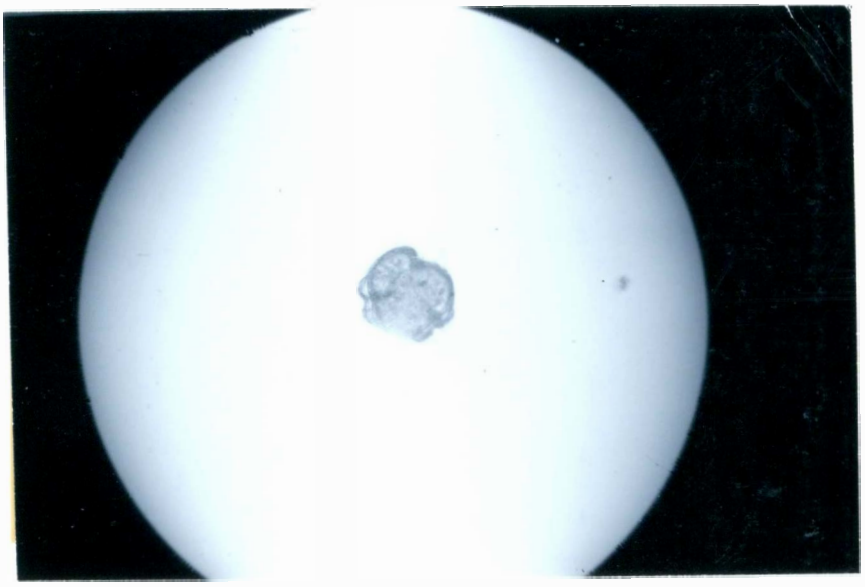

Fig. 21 Solanum melongena AMB #6 (1,000x)

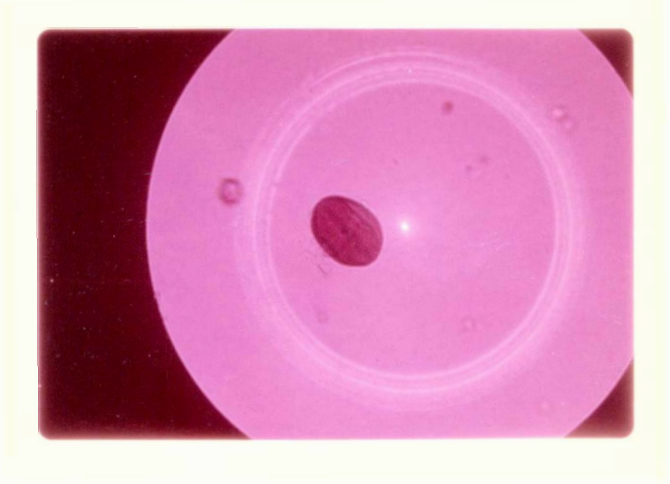

Fig. 22 Physalis longifolia (1,000x)

DISCUSSION

The results indicate, in general, that the structure of the pollen is similar in all the species of Solanaceae studied. However, some morphological differences can be observed between the pollen of certain genera (see TABLE 2.).

The sexine proved to be very useful in distinguishing some genera. The genus Nicotiana, for example, is the only genus having an ornate sexine. All the species of Solanum observed have a pilate sexine whereas the species of Physalis exhibited a reticulate or reticulate-pilate sexine. A reticulate sexine was also observed in the genera Hyoscyamus, Lycopersicon and Nicandra. Datura, Petunia and Lycium have striate sexine patterns.

On the basis of pore (aperture) shape, the genera studied may be roughly divided into two groups: (1) Those with lalongate pores which include Physalis, Solanum and Lycopersicon. (2) Those with circular pores which include Datura, Lycium, Petunia and Nicotiana. The other genera have intermediate pore shapes.

The size of the pollen was essentially the same in

all of the species with the exceptions of Datura which has large pollen (ca. 48 microns long as compared to the general range of 19 to 35 microns long for the majority of the others) and Solanum dulcamara which has unusually small pollen (ca. 11 microns long). Refer to figures 1, Datura stramonium, and figure 15, Solanum dulcamara.

No correlations were noted as to the general shapes and AMB Types because of the extreme amount of variation in the pollen of all species (see figures 19, 20 and 21).

Certain other similarities between genera may be readily observed. Datura, Lycium and Petunia have striate sexine patterns and circular pores. On the other hand, Solanum, Physalis and Lycopersicon are similar in that they all have lalongate pores and are about the same size; however, they do exhibit different sexine patterns.

SUMMARY

Pollen samples of eighteen species from nine genera in the Solanaceae were obtained from herbarium specimens for a morphological study. It is concluded that although variation exists, the pollen of this family are essentially similar. However, certain generic alignments may be noted on the basis of pollen characters.

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APPENDIX

TABLE 1. Photographic data

Film	Time	Light Intensity	Upper Diaphragm	Lower Diaphragm	Magnification
Kodak Panatomic X ASA 32 (black and white)	1/5 sec.	6.0	2	11	1,000x (oil)
Kodak Kodachrome II* ASA 25 (color)	1/5 sec.	6.0	2	11	1,000x (oil)

*Physalis longifolia (Fig. 22)