CHAPTER - THREE

POLLEN MORPHOLOGY OF

GLORIOSAL

I GENERAL INFORMATION

The present study of pollen morphology of the genus Gloriosa deals with various cytotypes (2x, 4x and 8x) and two hybrid groups (4 hybrids and their parents), covering 6 species.

The pollen grains of the genus Gloriosa are fundamentally 1-colpate; colpus proceeds slightly to the proximal face; and colpi lips are not well differentiated. Exine thickness is on an average 1.50-1.75 \( \mu \text{m} \) in aceto-lysed grains, and 1.25-1.50 \( \mu \text{m} \) in unaceto-lysed grains. The fundamental exine surface pattern is striate, the elements of which are constituted of the ridges (striae) and channels (lirae). In a typical morphotype, the striae and lirae alternate with each other in long uninterrupted, parallel rows (Text figs.7-8). The characters that have been taken into account with regard to the exine surface are as follows:
A. **SURFACE SECTORS** (Text fig. 1 & 4)

   a) Distal sector: zone of colpate area
   b) Proximal sector: zone of noncolpate area
   c) Intersector: zone connecting the proximal and distal sectors characterised by the twisting of striae

B. **STRIAE** (Text figs. 7-8)

   a) Height: high or low (relative)
   b) Roofs: even or uneven
   c) Striae gaps: striae depressions
   d) Striae bridges: the horizontal bridge connecting two adjacent striae dividing the lirae into smaller lumina
   e) Nature: straight or curved, broken or unbroken

C. **LIRAE** (Text fig. 7)

   a) Floor: shallow or deep
   b) Nature: straight or curved, interrupted or uninterrupted
   c) Margin: even or uneven
D. GENERAL FEATURES

a) Orientation of the striae and lirae: oriented along the length of the colpus (equatorial), perpendicular to the colpus (polar) or at an angle (angular) or concentric (concentric)
b) Secondary patterns on striae and lirae (Text figs. 9-10): The striae and/or lirae are punctate, beset with circular pits, or non-punctate
c) Exine strata (Text fig. 6): consists of usual stratified layers namely the endoexine, ectoexine comprised of the columella, infra-tegillum (formed by the fusion of the columella heads) and suprategillum
d) Other data: The lirae when divided by striae bridges produce striato-reticulate, striato-foveolate, striato-fossulate patterns

II MORPHOLOGICAL DATA

In presenting the pollen morphological data, the various materials of Gloriosa investigated have been categorized into hybrid groups followed by octoploid species
which are not involved in the formation of hybrids. The data with regard to the size and shape of the pollen grains of the various materials are summarised in Tables V-VIII.

1. HYBRID GROUP I: (Diploid) $2n = 22$

The hybrid group I includes two diploid species namely *G. superba* and *G. lutea*, and their hybrid *G. superba* X *G. lutea*.

(i) *G. superba* L. (Female parent)

2n = 22

(a) **Supra surface morphology** (SEM); (Plate-I
Figs. 1-2): Grains 1-colpate. Exine surface striato-reticulate; striato reticulum matted; striae single tiered, criss-cross at places (Fig.2, arrow), adjacent once connected sporadically resulting in the division of lirae into small, reticulate luminar areas (striato-reticulate); striae at places closer or connate dividing the lumina into elongate, fossulate areas (fossulo-striate; Fig.1, arrow), often uneven on its surface, being provided with triangular elevations.
(b) **Sub-surface morphology (LM);** (Plate - I Figs. 3-4; Text figs. 14-16): Striae mounts circular to ellipsoidal, close and connected; striae gaps sparse; striae orientation polar on distal face, slightly angular on proximal face, concentric towards the edges.

(c) **Shape types:** 3 shape types (Us);

(ref. Table-V and Text fig. 22)

- Spheroidal grains - 22.0%
- Ellipsoidal grains - 75.5%
- Spindle shaped grains - 2.5%

(d) **Size measurements:** E diameter -(Us:Ac)/EAc.

- Spheroidal grains - 23.8 : 26.3 \( \mu m \)/+ 10.2%
- Ellipsoidal grains - 28.4 : 37.0 \( \mu m \)/+ 30.2%
- Spindle grains - 25.4 : 32.2 \( \mu m \)/+ 27.0%

(For other details refer Table-VI and Text figs.23-24).

(e) **Marker features:** Striato-reticulate exine ornamentation; single tiered striae; parallely arranged, elongated lumina separated by horizontal striae bridges; closely placed striae mounts with few striae gaps. 3 shape types with dominance of ellipsoidal grains (75.5%) (E diameter of ellipsoidal grains 28.4:37.0\( \mu m \) (Us:Ac), and EAc + 30.2%).
(11) *G. lutea* Hort. (Male parent)

2n = 22

(a) **Supra surface Morphology (SEM)**; (Plate-II Figs. 5-6): Grains 1-colpate. Exine surface striato-undulate punctate (corrugate), formed by the fusion of adjacent striae of the basic striato-reticulate form; striae single tiered, beset with low mounts and interspersed with fissures. Puncta large sized.

(b) **Sub surface morphology (LM)**; (Plate-II Figs. 7-8; Text figs. 17a-b): Exine surface punctate; puncta large in size and surrounded by variously shaped and oriented striae mounts; striae almost fused without any definite striae formation; striae gaps less on the distal face.

(c) **Shape types**: 3 shape types (Uo);

(ref. Table-V and Text fig.22)

Spheroidal grains - 14.5%

Ellipsoidal grains - 80.0%

Spindle shaped grains - 5.5%

(d) **Size measurements**: E diameter-(Uc/Ac)/EAc

Spheroidal grains - 25.0 : 38.2 µm/+ 52.8%

Ellipsoidal grains - 30.1 : 45.2 µm/+ 50.3%
Spindle shaped grains - 26.7 : 37.2 /μm/+ 39.0%  
(For other details refer Table-VI and Text figs. 23-24).

(e) **Marker features:** Striato undulate punctate exine, (corrugate); striae single tiered; striae mounts various sizes and orientation, and closely packed. 3 shape types with dominance of ellipsoidal grains (80% in Uc); (H diameter of ellipsoidal grains 30.1 : 45.2 /μm (Uc : Ac) and EAc + 50.3%).

(iii) Hybrid-I: G. *superba* X G. *lutea*  
2n = 22

(Note: Because of the paucity of the material available, only LM studies could be undertaken).

Sterility high (70% in Uc). Monads and dyads present. Monads—spheroidal, ellipsoidal, spindle shaped or of various other irregular shapes. Spheroidal grains with many apertural types namely (1) Gigantiporate-operculate, (2) Normali porate operculate, (3) Pontoper-  
culate, the area of attachment of the operculum to the general surface being small or large, straight or zig zag or in other configurations, (4) Trichotomocolpate, and (5) Trichotomo-operculate, the trichotomous aperture
occurring sometimes in the centre of the operculum (Text fig. 19J-L). Apertural types, as in spheroidal grains totally absent in ellipsoidal and spindle shaped grains. Exine ornamentation of a mixed type, being striato-reticulate, regulate (corrugate; Text fig. 18), the exine pattern varying sometime even in various regions of the same grain. (Apparently, all the types have their origin in the basic single tiered striate form from which by division or fusion of muri, the various other forms have originated). Exine surface in ellipsoidal and spindle shaped forms, striato reticulate and also sometimes clearly reticulate; muri mounts somewhat lost there being continuous fusion of the adjacent mounts. Multiplicity of ornamentation types as of apertural types present in spheroidal grain (Plates, III-IV, Figs. 9-20).

(a) **Shape types**: 3 basic shape types and other irregular types (Ue); (ref. Table-V and Text figs. 22).

* Spheroidal grains - 30%
* Ellipsoidal, Spindle and other shape types - 70%

(c) **Size measurements**: \( E \times E_1 \) diameter of spheroidal grains (range) - 28.0 x 28.0 to 50.0 x 45.0 ; 33.5 x 28.0 to 61.5 x 59.0 \( \mu m \) (Ue ; Ac). \( E \) diameter of ellipsoidal, spindle and other types - 31.6 ; 41.0 \( \mu m \) (Ue ; Ac)/EAc + 29.8\%.
(For other details refer Table - VI and Text figs. 23-24).

(c) **Marker features:** High sterility. 3 basic shape forms. Spheroidal grains with new apertural types (operculate forms); other shape types with basic monocolpate apertures. A variety of exine ornamentation types in all the pollen grains, often the exine ornamentation varying in different areas of the same grain. Largest sized spheroidal grains.

2. **HYBRID GROUP II:** *(Tetraploids)* $4x = 44$

The hybrid group II of *Gloriosa* involve three tetraploids species namely, *G. virescens*, *G. carsonii*, and *G. richmondensis* and three of their respective hybrids. In general morphology the pollen grains conform with the descriptions given for the genus in general earlier.

1. *G. virescens* Lind. (Parent)

   $2n = 44$

   (a) **Supra surface morphology (SEM);** *(Plate-V Figs. 21-23):* Grains 1-colpate. Exine surface striato-fossulate, even branched, unpitted, lirae fossulate-vermiculate-canaliculate, ventriculate in intersector;
striae single tiered, starting off directly from the colpi margins (Figs. 21-22); lirae disrupted into longitudinal fossulate bits by the bridging of the lirae intermittently formed due to the union of adjacent parallel striae; fossulate lirae assume various shapes such as, fossulo-ventriculate and fossulo-verbatim.

(b) **Sub surface morphology (LM)**; (Plate-V Figs. 24-25): Striae mounts circular to elongate; striae gaps sparse and distant; striae orientation of a mixed type varying in different grains, the most common type being angular and concentric together on the distal face and horizontal striae (perpendicular to the colpus) on the proximal face.

(c) **Shape types**: 2 shape types. Spheroidal type absent (Uo); (Table-V and Text fig. 22).

**Ellipsoidal grains** - 73.0%
**Spindle shaped grains** - 27.0%

(d) **Size measurements**: E diameter - (Uo + Ac) / EAc
**Ellipsoidal grains** - 29.1 ± 43.5 μm/± 49.4%
**Spindle shaped grains** - 25.8 ± 31.8 μm/± 46.5%

(For other details refer Table-VII and Text figs. 23-24).
(e) **Marker features**: Striato-fossulate ventriculate exine ornamentation. Striae single tiered and even, being separated by fossulate and fossulo-ventriculate lirae and the complete fossulo-ventriculate condition in the intersector region. Only 2 shape types, the spheroidal type being absent; dominance of ellipsoidal grains (73% in Uc); (E diameter of ellipsoidal grains 29.1 : 43.5 μm (Uc : Ac) and EAc + 49.4%).

(ii) *G. carsonii* Baker (Parent)

2n = 44

(a) **Supra surface morphology (SEM)**; (Plate-VI Figs. 26-27): Grains I-collpate. Exine surface striato-reticulate (dominantly reticulate with few lirae at places). Striae single tiered; (apparently the original striate form has become irregularly curved and the lirae has become dissected by bridges to produce the reticulate condition with lumina and lirae in various sizes and shapes).

(b) **Sub surface morphology (LM)**; (Plate-VI Figs. 28-29): Reticulate condition clear with connate columella heads.
(c) **Shape types:** 3 shape types (Uc); (ref. Table-V and Text fig. 22).

Spheroidal grains - 7.0% (absent in Ac material)
Ellipsoidal grains - 80.0%
Spindle shaped grains - 13.0%

(d) **Size measurements:** E diameter - (Uc:Ac)/EAc

Spheroidal grains - 25.3 μm (Uc)
Ellipsoidal grains - 29.9 μm; 37.4 μm/+ 25.0%
Spindle shaped grains - 29.4 μm; 37.0 μm/+ 25.8%

(For other details refer Table-VII and Text figs. 23-24).

(e) **Marker features:** Striate-reticulate exine ornamentation with single tiered undecorated striae; striae bridges angular and in various ways; columella heads connate. 3 shape types with dominance of ellipsoidal grains (80% in Uc); (E diameter of ellipsoidal grains 29.9 μm (Uc : Ac) and EAc + 24.9%).

(iii) *G. richmondensis* Hort. (Male parent)

2n = 44

(a) **Supra surface morphology** (SEM); (Plate-VII Figs. 30-31): Grains l-colpate. Exine surface striate, striae matted, single tiered, slightly curved and
sparingly interrupted by striae bridges; striae zig zag and unpitted; lirae divided into fossulate bits at places.

(d) **Sub surface morphology (LM); (Plate-VII Figs. 32-33):** Striae mounts dominantly smaller and continuous with ill defined striae gaps; striae orientation in various directions particularly on the proximal face.

(e) **Shape types:** Only ellipsoidal grains present spheroidal and spindle types totally absent (Table V and Text fig. 22).

(d) **Size measurements:** E diameter - (Uc:Ac)/EAc

Ellipsoidal grains - 31.4 ± 44 μm/+ 40.0%

(For other details refer Table-VII and Text figs. 23-24).

(e) **Marker features:** Plain striate exine ornamentation, with zig-zag, dissected, matted, single tiered striae and sparsely interrupted by striae bridges. Only ellipsoidal grains present having E diameter 31.4 ± 44.0 μm (Uc : Ac) and EAc + 40%.

(iv) **Hybrid 2: G. virescens Lind X G. carsonii Baker**

\[ 2n = 44 \]
(a) **Supra surface morphology (SEM)**; (Plate-VIII Figs. 34-36): Grains l-colpate. Exine surface striato intertwined foveolate; striae double tiered; foveoles produced by the intertwining of the lower and upper tiers of striae (in which the striae criss cross); striae bridges clearly of low height deeper on one side; striae and lirae unpitted; striae broad and in a low curve.

(b) **Sub surface morphology (LM)**; (Plate-VIII, Figs. 37-38): Striae mounts not differentiated; striae orientation polar to parallel on proximal face and slightly angular on distal face.

(c) **Shape types**: Only ellipsoidal grains present. Spheroidal and spindle types totally absent (Table-V and Text fig. 22).

(d) **Size measurements**: E diameter -(Uc:Ac)/EAc

Ellipsoidal grains - 30.4 ± 38.3 µm/+ 27.5%

(For other details refer Table VII and Text figs. 23-24).

(e) **Marker features**: Striato intertwined foveolate exine ornamentation; foveoles formed by the intertwining of the double tiered unpitted striae; only ellipsoidal grains
present having E diameter of 30.4 : 38.8 μm (Uc : Ac) and EAc + 27.5%. 


2n = 44

(a) **Supra surface morphology (SEM)**; (Plate-IX Figs.39-40): Grains l-colpate. Exine surface reticulate striate; striae double tiered and uneven; lirae locunlar; reticulum formed as a result of the intertwining of the striae leaving large elongated lumina with sparsely placed striae bridges; lumina wider and elongate; striae and lirae profusely pitted with small puncta.

(b) **Sub surface morphology (LM)**; (Plate-IX Figs. 41-42): Striae mounts circular; striae gaps present, striae orientation somewhat angular.

(c) **Shape types**: 3 shape types (Uc); (Table - V and Text fig.22).

Spheroidal grains - 5.3% (absent in Ac material)
Ellipsoidal grains - 88.9%
Spindle shaped grains - 6.3%
(d) **Size measurements**: E diameter = (Uc/Ac)/EAc

- Spheroidal grains = 21.4 μm (Uc)
- Ellipsoidal grains = 29.4 : 44.6 μm+/− 51.7%
- Spindle shaped grains = 29.8 : 48.3 μm+/− 62.2%

(For other details refer Table-VII and Text figs.23-24).

(e) **Marker features**: Pan-punctate reticulate-striate exine ornamentation having puncta on striae and lirae; striae double tiered with lacunar lirae being separated by irregularly shaped bridges. 3 shape types with dominance of ellipsoidal type (88.4% in Uc); (E diameter of ellipsoidal grains 29.4 : 44.6 μm (Uc : Ac) and EAc + 51.7%).

(vi) **Hybrid 4**: G. *virescens* Lindl. × G. *richmondensis* Hort.

2n = 44

(a) **Supra surface morphology** (SEM); (Plate-X Figs: 43-45): Grains 1-colpate. Exine surface partially intertwined striato-fossulate to fossulo-venticulate (as a result of the curving of the striae and their fusion at the points of contact); striae broader, curved, the fossulae more parted (than that in G. *virescens*); striae uneven, double tiered, adjacent ones variously connate and irregular
leaving sub-ventriculate, fossulate, lacuna the wider end of the fissure being always at one end (Fig.44); at places 3-4 adjacent striae appear together being united; striae and lirae unpitted.

(b) Sub surface morphology (LM); (Plate-X Figs. 46-47): Striae mounts undifferentiated and continuous; striae orientation somewhat angular on both the faces.

(c) Shape types: Only 2 shape types, the sphericidal being absent (Uc); (Table-V and Text fig.22).

 Ellipsoidal grains  -70.0%
 Spindle shaped grains -30.0%

(d) Size measurements: E diameter - (Uc:Ac)/EAc

 Ellipsoidal grains  - 32.0 ± 39.0 μm/+ 21.0%
 Spindle shaped grains - 31.9 ± 39.7 μm/+ 21.3%

(For other details refer Table VII and Text figs.23-24).

(e) Marker features: Exine surface partially intertwined striato-fossulate to fossulo-ventriculate (as in G. virescens, but the hybrid differs by the fusion of adjacent striae and the reduction of the lirae into fossulo-subventriculate depressions). Striae double tiered only
2 shape types with dominance of ellipsoidal grains (70%); spheroidal grains absent; (8 diameter of ellipsoidal grains 32 : 39 μm (Uc : Ac) and EAc + 21%).

3. OCTOPOID GROUP 8x = 88

The octoploid group of *Gloriosa* studied is comprised of 2 species namely *G. superba* and *G. magnifica*.

(i) *G. superba* L.

2n = 88

(a) *Supra surface morphology (SEM)*; (Plate-XI, Figs.48-49): Grains 1-colporate. Exine surface striate; striae broad, irregularly parted with longitudinal low depressions; striae surface punctate; striae puncta various sizes and shapes as a result of a fusion of adjacent puncta; lirae irregular in shape and size being wide or narrow.

(b) *Sub surface morphology (LM)*; (Plate-XI Figs.50-51): Striae mounts somewhat circular and striae gaps profuse; striae orientation angular radiating in two directions towards the poles.

(c) *Shape types*: 2 shape types, the spheroidal grains being absent (Uc); (Table-V and Text fig. 22).

- Ellipsoidal grains - 51.0%
- Spindle shaped grains - 49.9%
(d) Size measurements: E diameter: (Uc:Ac)/E Ac

Ellipsoidal grains - 38.6 ± 48.8 μm/+ 26.4%
Spindle shaped grains - 35.8 ± 48.2 μm/+ 34.6%
(For other details refer Table-VIII and Text figs. 23-24).

(e) Marker features: Fossulo-punctate striate exine ornamentation; lirae grooved, the lumina being distinctly elongate, and irregularly shaped; striae puncta of various shapes and sizes. Only 2 shape types present, the ellipsoidal and spindle types occurring almost in same percentage.

(ii) G. magnifica L.

2n = 88

(a) Supra surface morphology (SEM); (Plate-XII Figs. 52-53): Grains 1-colpate. Exine surface striato criss-cross foveolate; striae double tiered and matted; foveoles semi circular in shape (as if representing arches) formed by the curving of striae which come up from underneath the adjacent striae; lower and upper striae tiers appear to be knitted into one another at right angles.
(b) **Sub surface morphology (LM); (Plate-XII, Figs. 54-55):** Striae islands circular, angular and in different sizes, striae orientation nearly parallel to the equatorial diameter in the proximal face.

(c) **Shape types:** 3 shape types (Uc); (Table-V and Text fig. 22).

   - Spheroidal grains - 6.5%
   - Ellipsoidal grains - 83.4%
   - Spindle shaped grains - 10.1%

(d) **Size measurements:** E diameter - (Uc:Ac)/EAc

   - Spheroidal grains - 26.4 : 23.0 μm/+ 6.3%
   - Ellipsoidal grains - 34.1 : 43.6 μm/+ 27.9%
   - Spindle shaped grains - 33.2 : 46.3 μm/+ 39.5%

(For other details refer Table-VIII and Text figs. 23-24).

(e) **Marker features:** Striato-criss cross foveolate exine ornamentation; double tiered matted striae, the lower and upper tiers appear to be knitted into one another at right angles. 3 shape types with dominance of ellipsoidal (83.4% in Uc); (E diameter of ellipsoidal grains - 34.1 : 43.6 μm (Uc : Ac) and EAc + 27.9%.
III  **ANALYSIS OF THE DATA**

1. **GENERAL ANALYSIS**

In *Gloriosa* the pollen grains are characterised by the fundamental monocotyledonate, aperture and the striate exine surface pattern. The apertural character is somewhat uniform in the various species studied while the exine ornamentation pattern varies substantially as to be of use in taxonomic, evolutionary and genetical considerations. Another pollen feature of comparative importance in the genus is the occurrence of three shape types namely the spheroidal, ellipsoidal and spindle shaped (Text figs. 2A-2C). The spindle shaped grains are morphologically sterile (without protoplasm) and do not have much significance. The ellipsoidal type is considered to be typical, because its predominance in the pollen mass of any one taxon (see Table-V). From an analysis of several monocotyledones having the monocotyledonate sporomorphs Nair and Chaturvedi (1978) suggested that the ellipsoidal is more primitive than the spheroidal and that the comparative frequency of the former may provide a working basis for gaining knowledge on the evolutionary levels of any one group of taxa. A general analysis of the pollen characters of *Gloriosa*, as understood from the species, cytotypes and hybrids presently investigated, is given below:
(1) **Aperture and shape:** The ellipsoidal and spindle shaped grains are l-colpate, (ref. Text fig. 3) the colpus covering the length of the whole distal face and even curving to a certain distance on the proximal face. In the spheroidal grains, generally the aperture is of furrow type (colpate). However, a porate-operculate situation, the operculum even bearing trichotomous or furrow form of secondary apertures, has been noticed only in the spheroidal grains of the diploid hybrid *G. superba* × *G. lutea* (Text figs. 19A-L).

(ii) **Exine ornamentation:** The fundamental striate form of ornamentation is characterised by even and uninterrupted striae and lirae, alternating with each other and may be designated as the "Plain striate form", (ref. Text fig. 20), but such a typical form does not occur in the species of *Gloriosa* presently studied. However, the nearest to such a condition occurs in *G. richmondensis*, in which the striations are slightly curved and sparsely interrupted by striae bridges (ref. Plate VII, Figs. 30-33).

In general, striae are arranged in two ways namely (i) the single tier, and (ii) the double tier (ref. Text fig. 13A-B). In the former all striae are of the same height, while in the latter, one tier is at a higher level and the other at a slightly lower level. The lower and
upper tiers appear to be knitted into one another either in right angles as in *G. magnifica* or in curves as in *G. virescens X G. carsonii* which may be termed as the "criss-cross" type and "inter-twined" type respectively (see Text fig. 11 & 13 B).

In the Plain striate form (not found in the present study) the striae are often beset with low striae gaps distinguishable at sub-surface levels. When the striae gaps become deeper, reaching the level of the lirae, a condition with disrupted striae is reached. On the other hand when the striae becomes dented from the sides along its height a zig-zag striae condition is reached as in *G. richmondensis*. The disrupted or zig-zag striae forms may be considered to constitute a second stage in the morphological evolution of the striate ornamentation.

Another stage is marked by the disruption of the lirae into longitudinal fossulate bits by the bridging of the lirae caused due to the union/fusion of adjacent parallel striae intermittently. The fossulate lirae assume variations shapes such as fossulo-ventriculate, fossulate or vermiculate as seen in *G. virescens*. In principle, this condition is reached by the curvation of the adjacent striae and their fusion at the points of contact between
each other. This type may be considered to represent the fossulo-striate stage of morphological evolution.

In yet another case as in *G. superba* (2x), the lirae are dissected into reticulate areas, by means of horizontal bridges connecting the adjacent parallel striae. Such a situation marks the striato-reticulate stage.

Along the line of the two-tier striae form, the lirae are either divided into fossulate bits as in *G. carsonii* X *G. virescens*; at places on the grains surface of *G. richmondensis*, where the striae form is of the inter-twined type as found in *G. virescens* X *G. carsonii*.

In majority of both the single tier and double tier striae forms the striate exine surface is unpitted. In some pollen forms, the exine surface is beset with profuse pits both on striae and lirae as seen in *G. carsonii* X *G. virescens* or only on the striae as in *G. superba* (3x), the adjacent puncta sometimes uniting into long or short depressions, and they are designated here as pampunctate and striae-punctate respectively (Text figs. 9-10).
Considering all the above morphological situations, as understood from the plants presently investigated the possible lines of morphological evolution may be built (ref. Text fig. 20). The plain striate form with long, even uninterrupted striae is the basic form from which two lines have possibly evolved, one marked by the single tier form and the other by the double tier form.

Along the single tier line, the first stage is marked by the dissected and zig-zag striae form from which have evolved the punctate and the non-punctate lines respectively. The non-punctate seems to have become resolved into two lines of evolution namely, the "striato fossulate ventriculate" (formed by striae curvations) and the "striato-reticulate" lines (formed by horizontal bridging of the lirae). The punctate line is constituted of three forms namely "pan-punctate" (Puncta all over) from which have evolved the striae-punctate (puncta on striae alone) and striato undulate punctate (lumina being reduced to puncta) forms. Along the line of double tier striae forms have evolved the "intertwined" (partial or entire) and the "criss cross" types having the foveolate forms succeeding the fossulate one.
The species, hybrids and cytotypes of *Gloriosa* studied can be fitted into the scheme of morphological evolution outlined above. The typical basic plain striae type is not present among the materials studied presently but the nearest to the type is represented by *G. richmondensis* (4x) with sparsely disrupted zig-zag striae. It may be noted that in this discussion the type as the one found in *G. richmondensis* being basic is described as the "Plain striae type". The other lines of morphological evolution are represented as follows: (A) Non-punctate; (i) Striato fossulate-ventriculate form represented by *G. virescens* (4x), (ii) Striato-foveolate form, the reticulation being formed by the striae at one level where the striae bridges formed in irregular lines, represented by *G. carsonii* (4x), or horizontal striae bridges formed in parallel lines represented by *G. superba* (2x), (iii) Striato-fossulate form with partially intertwined striae is represented by the hybrid *G. virescens* X *G. richmondensis* (4x), (iv) Striae intertwined foveolate form represented by the hybrid *G. virescens* X *G. carsonii* (4x), (v) Striae criss-cross foveolate form represented by *G. magnifica* (8x). (B) Punctate; (vi) Panpunctate form represented by the hybrid *G. carsonii* X *G. virescens* (8x),
(vii) Striae-punctate form represented by *G. superba* (8x), (viii) Striato-undulate punctate form represented by *G. lutea* (2x).

(iii) Shape forms (see Text fig. 22): The shape classes also provide interesting statistical data. All the grains are ellipsoidal in *G. richmondensis* (4x) and the percentage of the ellipsoidal is 83.4 in *G. magnifica* (8x), 80.0 in *G. lutea* (2x) and *G. carsonii* (4x), 75.5 in *G. superba* (2x), 73.0 in *G. virescens* (4x) and 51.0 in *G. superba* (8x). Among the hybrids, *G. superba X G. lutea* is characterised by a low percentage of ellipsoidal (13.0%) but a higher percentage of the spindle shaped grains (70.0%), and in others, the percentages of ellipsoidal are high being 100.0% in *G. virescens X G. carsonii*, 88.4% in *G. carsonii X G. virescens*, and 70% in *G. virescens X G. richmondensis*.

(iv) Size measurements (ref. Text fig. 23): The size measurements made relate to the long (*E*) and short (*E₁*) equatorial diameters. For purposes of comparison, *E* diameter of the ellipsoidal grains alone have been considered. The size differences are of no significant value in the taxonomy of *Gloriosa*, although it may be
pointed out as example that the average E diameter in unacetolysed ellipsoidal grains is 38.6 μm in G. superba (8x), 34.1 μm in G. magnifica (8x), 31.4 μm in G. richmondensis (4x), 29.9 μm in G. carsonii (4x), 29.5 μm in G. virescens (4x), 30.2 μm in G. lutea (2x), and 28.4 μm in G. superba (8x).

(v) Effect of acetolysis (ref. Text fig. 24): The increase in E diameter of ellipsoidal grains due to acetolysis is 24.9% in G. carsonii (4x), 26.4% in G. superba (8x), 27.9% in G. magnifica (8x), 30.2% in G. superba (2x), 40% in G. richmondensis (4x), 49.4% in G. virescens (4x) and 50.3% in G. lutea (2x). Apparently, there is a differential increase due to acetolysis in different taxa which may be considered to suggest the compactness or otherwise of the arrangement of sporopollenin material in the elements comprising the exine wall. However, the above data do not show any significant correlation with the facts of morphological evolution as resolved from the exine surface ornamentation.

2. CYTOPALYNOLOGICAL ANALYSIS

In the genus Gloriosa the basic chromosome number is 11 (x = 11) and the species of Gloriosa investigated include two diploids namely, G. superba, G. lutea (2x=22);
three tetraploids such as G. virescens, G. carsonii, G. richmondensis \((4x = 44)\) and two octoploids namely G. superba, G. magnifica \((8x = 88)\). Further, interspecific hybrids between two diploids such as G. superba X G. lutea \((2x = 22)\), and three different combinations of tetraploid hybrids namely G. virescens X G. carsonii, G. carsonii X G. virescens, and G. virescens X G. richmondensis \((4x = 44)\), have also been studied.

In making cytopalynological analysis the various character groups are given below:

1. **Exine ornamentation** (ref. Text fig. 21): In the diploids, G. superba and G. lutea, the exine ornamentation being straito-reticulate and striate-undulate-punctate respectively are of an advanced type. Among the tetraploids G. carsonii has a straito-reticulate pattern, while G. virescens and G. richmondensis have straito-ventriculate-fossulate, and plain striate patterns respectively.

The analysis of the exine ornamentation suggests the occurrence of similar evolutionary directions at octoploid level and also at the tetraploid hybrid levels, leading to the punctate pattern in one group represented by octoploid G. superba, (strate punctate) and
**G. carsonii** x **G. virescens** the tetraploid hybrid (pan-punctate) and the foveolate pattern in another group represented by **G. magnifica** the octoploid (striate criss-cross foveolate), and **G. virescens** x **G. carsonii** the tetraploid hybrid (striate intertwined foveolate). This means that similar evolutionary directions occur at higher ploidy levels and hybrid levels which give the impression that the species **G. magnifica** (8x) at least is a natural hybrid.

The above data do not provide a picture of the directions of pollen morphological evolution strictly in conformity with the pattern of cytological evolution. According to the lines of morphological evolution as earlier outlined, the nearest to the plain striate form is the basic form, which is present in **G. richmondensis**, a tetraploid species. Similarly, the striato reticulate ornamentation is an advanced feature in morphological evolution and such a feature occurs in the diploid species. It is therefore felt that the species investigated may have independent origins from a hypothetical diploid (pending further investigations of other species of the genus) species of the genus along three lines namely, the diploid line, the tetraploid line and octoploid line, on each of which
there are species at various stages of evolution (Text fig. 21). Such a scheme of evolution is as follows (A) Diploid line: *G. superba* (striato-reticulate), *G. lutea* (striato-undulate punctate), (B) Tetraploid line: *G. richmondensis* (striate; striae dissected and zig-zag), *G. virescens* (striato-fossulate ventriculate), *G. carsonii* (striate-reticulate), (C) Octoploid Line: bifurcating into *G. superba* (striat-fossulate punctate) and *G. magnifica* (striato criss-cross foveolate). The reticulate pattern in the diploid *G. superba* (2x = 22) and the tetraploid *G. carsonii* (4x = 44) may also be considered to indicate the phylogenetic affinities between the two species. It is of significance to point out that the octopoloids in general do indicate advanced features by having the punctate striae and the criss cross striato-foveolate pattern. The occurrence of these patterns in the tetraploid hybrids *G. carsonii* X *G. virescens* and *G. virescens* X *G. carsonii* respectively is another evidence of the advancement of such features.

(ii) Shape forms (ref. Text fig. 22): The percentage occurrence of the shape types does not fully correlate with the evolutionary patterns of ornamentation. In general, the occurrence of spheroidal grains is more in the diploid taxa of *Gloriosa*, being 22.0% in *G. superba*, 14.5% in
q. lutea and 17.0% in the hybrid q. superba x q. lutea but among the 6 tetraploid taxa studied only two taxa namely q. carsonii with 7.0% and the hybrid q. carsonii x q. virescens with 5.3% possess spheroidal grains and in the rest they are totally absent. In the octoploid taxa, only q. magnifica possess 6.5% of spheroidal grains and the q. superba (8x) completely lacks spheroidal grains. This indicates that with the increasing ploidy level, the occurrence of spheroidal grains either decreased or even absent altogether.

The ellipsoidal grains constitute the dominant type in all the taxa presently studied except the diploid hybrid q. superba x q. lutea where it is just 13.0%. In the diploid line, the percentages are more or less similar in q. superba (75.5%), and q. lutea (80.0%), while in the tetraploid line, the ellipsoidal grains are 100.0% in q. richmondensis and the hybrid q. virescens x q. carsonii and in other taxa, the percentages fall within a near range being 80.0% in q. carsonii, 73.0% in q. virescens, 88.4% in q. carsonii x q. virescens and 70.0% q. virescens x q. richmondensis. On the octoploid line, the two species are on different directions, being 51.0% in q. superba (8x) and 83.4% in q. magnifica. It is significant to note that in q. superba the ellipsoidal grains form 75.5% in the diploid, but only 51% in the octoploid.
The spindle shaped grains are present in low percentages in the diploids than in the tetraploids and octoploids, being 2.5% in *G. superba* (2x), 5.5% in *G. lutea* (2x), 13.0% in *G. carsonii* (4x), 27.0% in *G. virescens* (4x) 6.3% in the hybrid *G. carsonii* X *G. virescens*, 30.0% in *G. virescens* X *G. richmondensis* (4x), 49.0% in *G. superba* (8x), and 10.1% in *G. magnifica* (8x). Thus it is clear that the occurrence of spindle shaped grains in the diploid *G. superba* is less (2.5%) and more in the octoploid *G. superba* (49%). The spindle shaped grains are altogether absent in *G. richmondensis* (4x) and the hybrid *G. virescens* X *G. carsonii*.

The above data indicates that the occurrence of spheroidal grains is relatively more and that of spindle shaped grains is less in the diploid taxa, whereas in the tetraploid and octoploid taxa, the occurrence of spheroidal grains is less or nil and the spindle shaped grains also occur. In general the ellipsoidal grains constitute the dominant type in all the cytotypes presently studied. It appears that both *G. richmondensis* and the hybrid *G. virescens* X *G. carsonii* are different from any other material in having only ellipsoidal grains.
(iii) **Size measurements** (ref. Text fig. 23): The longest equatorial diameter of unacetolysed ellipsoidal grains does not provide any clue in cytopalynophylogenetic analysis. For example, on the diploid line the average E diameter is 28.4 µm (range, 25.2 - 31.5 µm) in *G. superba*, 30.1 µm (27.3 - 33.6 µm) in *G. lutea*, and 31.6 µm (28.0 - 36.5 µm) in the hybrid *G. superba* X *G. lutea*. On the tetraploid line, it is 29.1 µm (23.1 - 31.5 µm) in *G. virescens*, 29.9 µm (27.3 - 32.5 µm) in *G. carsonii*, 31.4 µm (28.0 - 36.5 µm) in *G. richmondensis*, 30.4 µm (28.0 - 33.5 µm) in the hybrid *G. virescens* X *G. carsonii*, 29.4 µm (25.2 - 33.6 µm) in the hybrid, *G. carsonii* X *G. virescens*, and 32.0 µm (28.0 - 36.5 µm) in the hybrid *G. virescens* X *G. richmondensis*.

Thus with regard to E diameter (UA) the pollen of diploid and tetraploid taxa are more or less nearer to each other. This suggests that the genus as a whole is a very natural one and this fact is also substantiated by the basic striate pattern occurring in the genus. However, the average E diameter in unacetolysed grains in the octoploid is higher than either the diploids or tetraploids being 38.6 µm (range 33.6 - 42.0 µm) in *G. superba* (8x),
and 34.1 μm (range 30.4 - 37.8 μm) in G. magnifica which is in conformity with the general belief that the pollen size increase is related to the increase in ploidy level.

(iv) Effect of acetolysis (ref. Text fig. 24): In general, there is an increase both in E and E₁ diameters of ellipsoidal grains due to acetolysis except in G. superb (2x) where there is a decrease of 0.9% in E₁ diameter. Further, in a majority of the cases the increase is more in E diameter than the E₁, except in the hybrid G. superb X G. lutea (2x) and G. richmondensis (4x) where the increase is more in E₁ diameter. The data on the effect due to acetolysis do not provide any stable evidence for correlation with ploidy status of the materials. Overall, there is a greater increase in some materials namely G. lutea (50.3%), G. virescens (49.4%), hybrid G. carsonii X G. virescens (51.7%); and G. richmondensis (40.0%), while the increase in other materials is relatively less being 30.2% in G. superb (2x), 29.8% in G. superb X G. lutea (2x), 25.0% G. carsonii (4x), 27.5% in G. virescens X G. carsonii (4x), 25.0% in G. virescens X G. richmondensis (4x), 26.4% in G. superb (8x), and 27.3% in G. magnifica (8x).
3. POLLEN ANALYSIS OF HYBRID GROUPS

Two hybrid groups namely, the Diploid hybrid group and Tetraploid hybrid group have been studied and the analysis of the data on the pollen morphological characters are as follows:

(i) **DIPLOID HYBRID GROUP** (2x = 22)

This group comprises of *G. superba* the female parent, *G. lutea* the male parent, and their hybrid *G. superba X G. lutea*.

(a) **Exine ornamentation** (ref. Plates I-IV Figs.1-20)

The exine ornamentation is striato-reticulate in *G. superba*, and striato-undulate-punctate in *G. lutea*, while in the hybrid the grains are of a mixed type being striato-reticulate, regulate and corrugate forms, thus differing from either parents. Further, in either parents the spheroidal grains are l-colpate, like that in ellipsoidal and spindle forms, but in the hybrid, the spheroidal grains are characterised by operculate apertures along with secondary formations of trichomocolpate, monocolpate apertures.

(b) **Shape forms** (ref. Text fig.22): There are all the three shape forms in either parents and their hybrid,
Spheroidal grains form 22.0% in *G. superba* (female parent), 14.5% in *G. lutea* (male parent), and 17.0% in the hybrid which is the intermediary situation between the parents. The ellipsoidal grains from the major shape type in either parents being 75.5% in *G. superba*, and 80.0% in *G. lutea*, the same occur in just 13.0% in the hybrid. The percentage of spindle grains is much less in the parents being 2.5% in *G. superba* and 5.5% in *G. lutea* but the same (spindle and other striate grains) constitute 70.0% of the total pollen mass in the hybrid. Thus in the parents, the ellipsoidal form constitute the major shape form, while in the hybrid the spindle form is the major shape form. Therefore, the constitution of pollen mass in the hybrid is completely different from that in the parents.

(c) **Size measurements** (ref. Text fig. 23): The average $E$ diameter in unacetolysed ellipsoidal grains is 28.4 $\mu$m (range, 25.2 - 31.5 $\mu$m) in the female parent *G. superba*, 30.1 $\mu$m (27.3 - 33.6 $\mu$m) in the male parent *G. lutea*, and 31.6 $\mu$m (28.0 - 36.5 $\mu$m) in the hybrid *G. superba* X *G. lutea*. Thus the $E$ diameter is more in the hybrid then its parents but still it is closer to the male parent. It is important to note that the size of the spheroidal grains (Uc) of the hybrid is remarkably
large (range 28.0 - 50.0 μm) as compared to that of its parents.

(d) **Effect of acetolysis** (ref. Text fig. 24): The increase due to acetolysis in E and E₁ diameters of ellipsoidal grains is 30.2% and - 0.9% (decrease) respectively in the female parent *G. superba*, 50.3% and 29.5% respectively in the male parent *G. lutea*, and 29.8% and 39.9% respectively in the hybrid. This suggests that the hybrid shows differential response to acetolysis than its parents. Thus the introduction of new characters in pollen morphology of the hybrid different from either parents is exemplified with regard to exine ornamentation and also apertural types. Considering all the materials presently investigated, the occurrence of the operculate forms in the hybrid is remarkable phenomenon. The size of the spheroidal grains in the hybrid is remarkably larger being 28.0 to 50.0 μm (range) in unacetolysed material. While the E diameter of ellipsoidal grains of the hybrid shows its nearness to the male parent, the data on the increase in size due to acetolysis suggests that the hybrid pollen is different from both the parents. The high percentage of spindle and other sterile grains
constituting 70.0% of the pollen mass also shows its nature of hybridity and its genetical imbalance.

(ii) TETRAPLOID HYBRID GROUP

The species (parents) involved in the production of three hybrids are *G. virescens* (male or female), *G. carsonii* (female or male), and *G. richmondensis* (male).

(A) Hybrid-1: *G. virescens* × *G. carsonii

\[4x = 44\]

(a) Exine ornamentation (ref. Plate-VIII Figs. 34-38): It may be pointed out that the pollen of the hybrid is entirely different from either parents in exine surface ornamentation. In the male parent *G. carsonii* the exine surface is striato-reticulate, but the reticulation is formed as a result of bridging of the lirae whereas in the female parent *G. virescens*, the exine ornamentation is striato fosulate-ventriculate. But in the hybrid the exine is striato - intertwined foveolate formed as a result of the intertwining of the striae. The striae are broad and in low curve in the hybrid than in either parents. Further, the striae are single tiered in the parents and double tiered in the hybrid.
(b) **Shape forms** (ref. Text fig.22): In the male parent *G. carsonii* all the 3 shape forms are present, but in the female parent *G. virescens* only 2 shape forms are present, the spheroidal form being absent. In the hybrid *G. virescens X G. carsonii* only ellipsoidal grains are present. The absence of spheroidal grains in the hybrid shows the resemblance towards its female parent *G. virescens*, but unlike the parents, the spindle form is totally absent in the hybrid.

(c) **Size measurements** (ref. Text fig.23): In the hybrid *G. virescens X G. carsonii* the average E diameter in unacetolysed ellipsoidal grains is 30.4 μm (range 28.0 - 33.5 μm) which shows resemblance towards its male parent *G. carsonii* where the same is 29.9 μm (27.3-32.5 μm).

(d) **Effect of acetolysis** (ref. Text fig.24): The increase due to acetolysis in E diameter of ellipsoidal grains is 27.5% in the hybrid *G. virescens X G. carsonii*, which is nearer to the male parent (24.8%) than the female parent (49.5%).

Thus the hybrid possess a mixture of characters of both the parents with regard to the occurrence of shape forms, size and effect of acetolysis. But the exine
pattern is quite different from either parents. Therefore, it is logical to conclude that the hybrid has assumed new characters.

(B) Hybrid-2: *G. carsonii X G. virescens*

4x = 44

(a) Exine ornamentation (ref. Plate-IX Figs.39-42): The hybrid is remarkably different from either parents in its exine ornamentation. In the other reciprocal hybrid *G. virescens X G. carsonii*, striato intertwined foveolate condition occurs apparently formed by the intertwining of the striae. A fundamentally similar intertwining situation occurs in this hybrid *G. carsonii X G. virescens* but here the lumina are wider, and elongate, and striae and lirae are punctate and high as compared to the non-punctate and low striae in the other reciprocal hybrid *G. virescens X G. carsonii*. Both the parents have a single tiered striae pattern whereas the two reciprocal hybrids possess double tiered striae.

(b) Shape forms (ref. Text fig. 22): The reciprocal hybrid *G. carsonii X G. virescens* possess all the 3 shape forms as in the female parent, but the occurrence of spheroidal and spindle forms is much less being 5.3% and 6.3%
respectively than its parents where the spindle form occur in 13% in *G. carsonii* (female) and 27% in *G. virescens* (male). The percentage of ellipsoidal grains in the hybrid is 88.4% which shows its nearness again to the female parent.

(c) **Size measurements** (ref. Text fig.23): In the reciprocal hybrid *G. carsonii* X *G. virescens*, the average E diameter in unacetolysed ellipsoidal grains is 29.4 μm (range 25.2 - 33.6 μm) which shows the intermediate situation between the parents.

(d) **Effect of acetolysis** (ref. Text fig.24): The increase due to acetolysis in E diameter of ellipsoidal grains is 51.7% in the reciprocal hybrid *G. carsonii* X *G. virescens* which again shows its nearness to the male parent (49.4%) than the female parent (24.9%). Even in the increase of E₁ diameter, the hybrid (24.0%) shows resemblance to the male parent (26.0%) than the female parent (34.0%).

The overall situation shows that the pollen of the hybrid is remarkably different from either parents. The reticulate striae situation of the hybrid occur in *G. carsonii*, but the formation of the reticulum in the
hybrid is by the intertwining of the double tiered striae, while that in *G. carsonii* is due to the bridging of the single tiered striae. Moreover the pampunctate and double tiered striae condition is an entirely new feature. The hybrid shows resemblance to the female parent with regard to the occurrence of shape forms, to male parent with regard to the effect of acetolysis in *E* diameter of ellipsoidal grains, but is intermediate between the parents in case of *E* diameter of ellipsoidal grains. It may therefore be concluded that the pollen grains of the hybrid have assumed new morphology along a line different from that of the other reciprocal hybrid *G. virescens* × *G. carsonii*.

(C) Hybrid: 3. *G. virescens* × *G. richmondensis*

4x = 44

(a) **Exine ornamentation** (ref. Plate-X Figs. 43-47): Comparing the pollen of the hybrid with either parents, it is clear that the striato-fossulate pattern of the hybrid is somewhat intermediate between the plain striae pattern in the male parent *G. richmondensis* and striato-fossulo-ventriculate pattern in the female parent *G. virescens*. In fact, the striato-fossulate condition also
occurs at places on the grain surface of *G. virescens*. On comparison of the SEM pictures of either parents and of the hybrid, it may be noticed that the striae are broader and curved and the fossulae are more parted in the hybrid than that in the female parent.

(b) **Shape forms** (ref. Text fig. 22): The hybrid *G. virescens* × *G. richmondensis* possess both ellipsoidal and spindle shaped grains (70% and 30% respectively) almost in the same percentage as in the female parent *G. virescens* (73% and 27%). But the male parent *G. richmondensis* possess only ellipsoidal grains. Thus in general, the data indicates the resemblance of the tetraploid hybrids to their female parents in the respect of their constitution of shape forms.

(c) **Size measurement** (ref. Text fig. 23): The average E diameter in unacetolysed ellipsoidal grains of the hybrid is 32.0 μm (28.0 - 36.0 μm) which definitely shows affinity to its male parent *G. richmondensis* where the same is 31.4 μm (28.0 - 36.5 μm).

(d) **Effect of acetolysis** (ref. Text fig. 24): Increase due to acetolysis in E diameter of ellipsoidal
grains is 21% in the hybrid which does not show any resemblance to its parents (49.4% in female and 40% in the male).

On the whole it appears that the pollen of the hybrid have assumed new morphology possessing some characters of either parents.
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DIAGRAMATIC REPRESENTATION OF POLLEN CHARACTERS WITH REFERENCE TO GLORIOSA AND AMARYLLIS

1. Bilateral tetrad showing the distal and proximal poles and also the placement of the colpus and colpi lips in individual microspores.

2. Shape types and its variance (shown by hatch lines and marked $a_1$ & $a_2$)
   A. Spheroidal type; B. Ellipsoidal type;
   C. Spindle type.

3. Size measurements of a monocotate grain.

4. Diagram showing the proximal and distal faces (in lateral view).

5. Diagram showing the apertural apparatus consisting of a single colpus and colpus lips (in oblique lateral view).

6. Wall strata showing the various layers.

Abbreviations: GL - columella; GL - colpi lips; 
CC - colpus; DF - distal face;
DP - distal pole; E - long equatorial diameter; 
E2 - short equatorial diameter; 
BE - nexine; EM - exine; FL - foot layer; In - intine; IT - infrategillum;
LE - lateral end; P - polar diameter;
PF - proximal face; PP - proximal pole;
ST - supra tegillum
TEXT FIGS. 7-13

DIAGRAMATIC REPRESENTATION OF THE STRIATE ORNAMENTATION AND ITS DERIVATIVES IN GLORIOSA

7. Three dimensional diagram of two adjacent striae intervened by the lirae. Upper half shows the surface islands as seen from the surface of the striae.

8. Three dimensional diagram of two adjacent striae connected by striae bridges.

9. Striate ornamentation with puncta all over the striae and the lirae (Puncto-punctate)

10. Striate ornamentation with large puncta on the striae alone (Striate - punctate)

11. Criss cross-foveolate pattern of striae ornamentation.

12. Various shapes of fossulate lumina (lirae)

   A - Vermiculate; B - Canalicate; C - Lenticulate ;
   D - Ventriculate, E - Lacunar

13. Nature of striae

   A - Single tier; B - Double tier

Abbreviations: Ht - height of columella; Lr- lirae; Lrp - lirae puncta; St - striae; St Br - striae bridges; Stm - striae mount; Stp - striae puncta; StR - striae ridges.
TEXT FIGS. 7-13
14. Palynogram showing the exine surface at distal face (A), exine strate (B), and exine surface on the proximal face (C).

15. Exine ornamentation at the upper (A) and lower (B) fooci (Note: the striae and the lirae).

16. Two adjacent striae closely placed with narrow striae bridges (Note: the dissected lirae).

17. Striato-undulate - punctate ornamentation of \textit{G. lutea}

   (a). Surface showing the puncta on the undulate surface

   (b). Surface depicting two adjacent fused striae leaving large puncta in between

18. Rugulate surface in upper focus (seen only in some grains)

\textbf{Abbreviations}: \textit{Op} - colpus; \textit{Lr} - lirae; \textit{St} - striae; 
\textit{St Br} - Striae bridge; \textit{St S} - striae surface; \textit{P} - puncta; \textit{Ru} - rugulate nature
TEXT FIGS. 14-18
TEXT FIG. 19

APERTURAL TYPES IN THE SPHEROIDAL GRAINS OF
G. SUPERBA × G. LUTEA (HYBRID) 2n = 22

A - D: Giganti porate - operculate types
(Note: the various shapes of the
operculum (demarcated in the centre).

E. Normali porate - operculate (central
circular area) type.

F - I: Pontoperculate forms (Note: the various
shapes of the operculum).

J. Trichotomo - operculate type (Note: the
trichotomous aperture at the centre of
the operculum).

K. Pontoperculate condition with an ellip-
tical pore at the centre of the operculum.

L. Trichotomo colpate type.
MORPHOLOGICAL EVOLUTION OF EXINE ORNAMENTATION IN THE TAXA OF GLORIOSA.

CRISS-CROSS FOVEOLATE
G. magnifica (8x = 88)

STRIAE PUNCTATE
G. superba (8x = 88)

STRIATO UNDULATE PUNCTATE
G. lutecia (2x = 22)

STRIATO RETICULATE
G. caronii (4x = 4)
G. superba (2x = 22)

INTERTWINED FOVEOLATE
Hybrid G. v. x G. C. (4x = 44)

PARTIALLY INTERTWINED
STRIATO-FOSSULATE
Hybrid G. V. x G. R. (4x = 44)

PAN-PUNCTATE
Hybrid G. C. x G. V. (4x = 44)

DISSECTED
G. richmondensis (4x = 44)

ZIG-ZAG

VERMICULATE

FOSSULATE

VENTRICULATE

STRIO-FOSULATE-VENTRICULATE
G. viridacea (4x = 44)

TWO TIER STRIAE FORMS

ONE TIER STRIAE FORMS

PLANE STRIATE FORM
Hypothetical

TEXT FIG. 20
CYTOPALYNOLOGICAL EVOLUTION OF EXINE ORNAMENTATION IN THE TAXA OF GLORIOSA

CRISS-CROSS FOVEOLATE
G. magnifica 8x=88

STRIATO PUNCTATE
G. superba 8x=88

STRIATO-UNDULATE PUNCTATE
G. lutca 2x=22

STRIATO RETICULATE
G. carsonii 4x=44

STRIATO FOSSULATE VENTRICULATE
G. vireocena 4x=44

STRIATO RETICULATE
G. superba 2x=22

STRIATO-RETI CULATE
G. richmondensis 4x=44

STRATE-(DISSECTED, ZIG-ZAG)

Octoploid line

Tetraploid line

PLANE STRIATE FORM
Hypothetical species

TEXT FIG. 21
Effect of Acetolysis on Ellipsoidal Grains of Globosa

Percent of Ellipsoidal vs. Tetraploids vs. Octoploids

Species:
- G. Magnifica
- G. Superba
- Hybrid-G.VXGR
- Hybrid-G.XGY
- G. Richmondensis
- G. Virescens &
- Hybrid-1G.XGY
- Hybrid-2-G.XGY
- G. Carsoii
- G. Skl.
- G. Lutea
- G. Superba &

Legend:
- E-Diameter
- E-O-Diameter
PLATE - I

POLLEN GRAINS OF G. SUPERBA (FEMALE PARENT) 2n=22

Figs. 1-2: SEM photographs (unacetolysed materials)
- Striato-reticulate exine pattern

1. Ellipsoidal grain (proximal face; Note: the wavy striae and with mounts at striae bridge joints; arrow points to elongate, fossulate lirae) - × 2700

2. Spheroidal grains (proximal face; arrow points to the area with criss - cross striae) - × 3070

Figs. 3-4: LM photographs (acetolysed materials)

3. Ellipsoidal grain (distal face in upper focus; Note: the colpus; darker shade represents the striae and lighter shade represents the lirae) - × 2500

4. Exine pattern (proximal face in lower focus; lighter shade represents the striae and darker shade represents the lirae, divided by striae bridges producing a reticuloid appearance) - × 4144
POLLEN GRAINS OF G. LUTEA (MALE PARENT) 2n=22

Figs. 5-6: SEM photographs (unacetolysed materials)
- Striato- undulate- punctate exine pattern.

5. Spheroidal grain (proximal face) - 
   $\times$ 3300

6. Exine pattern (proximal face; Note: large sized puncta representing the $\text{\textMac{\textmacron}r\text{a}}$ and the undulate wavy surface formed apparently by the fusion of adjacent striae) - $\times$ 16900

Figs. 7-8: LM photographs (acetolysed materials)

7. Ellipsoidal grains (distal face in upper focus; Note: the colpus; darker shade represents the elevated areas and the lighter shade represents the adjoining depressed areas and the puncta) - $\times$ 2230

8. Exine pattern (proximal face in lower focus; lighter shade represents the elevated areas and darker shade represents the adjoining depressions) - $\times$ 4144
PLATE - III

POLLEN GRAINS OF G. SUPERBA × G. LUTEA (HYBRID) 2n=22

Figs. 9-14: LM photographs (acetolysed materials) of spheroidal grains showing variations in the operculate apertures and exine patterns.


10. Spheroidal grain with pontoperculate aperture (Note: wavy margin of the aperture and the area of attachment of operculum to the pollen wall on the right hand side) - × 1750

11. Spheroidal grain with gigantiporate-operculate aperture - × 1750

12. Exine pattern (Fig. 11 enlarged; exine in upper focus; Note: partially reticulate and rugulate exine and striae mounts sparse). - × 4335

13. Spheroidal grain - × 2230

14. Exine pattern (Fig. 13 enlarged; exine in lower focus; Note: fossulate, reticulate lirae and also variously sized striae mounts; also striae bridges dissect lirae into bits of lumina) - × 4632
PLATE - IV

POLLEN GRAINS OF G. SUPERBA × G. LUTEA (HYBRID) 2n=23

Figs. 15-20: LM photographs (acetolysed materials) of ellipsoidal grains showing variations in the exine patterns

15. Ellipsoidal grain (proximal face in lower focus) - × 2550

16. Exine pattern (part of Fig.15 enlarged; Note: the variations the shape and size of the striae and the lirae) - × 4622

17. Ellipsoidal grain (proximal face in lower focus) - × 2072

18. Exine pattern (part of Fig.17 enlarged; Note: areolate pattern (sub-surface) and large size of the lirae (in lighter shade) and striae) - × 4622

19. Ellipsoidal grain (proximal face in upper focus) - × 2072

20. Exine pattern (part of Fig. 19 enlarged; Note: variously shaped and sized lirae and the striae) - × 4622
Figs. 21-23: SEM photographs (fresh materials)
- Striato fossulate - ventriculate -
  vermiculate exine pattern.

21. Ellipsoidal grain (lateral face showing
  the colpus; Note: fossulate, ventriculate
  and vermiculate lirae) - × 3575

22. Ellipsoidal grain (distal face; Note: the
  colpus and also the striae starting off
  perpendicular to the colpus) - × 3080

23. Spindle shaped grain (proximal face) -
  × 2730

Figs. 24-25: LM photographs (acetolysed materials)

24. Ellipsoidal grain (proximal face in lower
  focus; Note: strips of united or free
  striae mounts) - × 1900

25. Exine pattern (part of Fig. 24 enlarged;
  Note: striae mounts) - × 3250
PLATE - VI

POLLEN GRAINS OF G. CARSONII (PARENT) 2n = 44

Figs. 26-27: SEM photograph (fresh materials)
- Striato - reticulate exine pattern.

26. Ellipsoidal grain (distal face showing the colpus; Note: reticulate striae with angular orientation) - x 3600

27. Exine pattern (distal face; Note: reticuloid pattern and a part of the colpus) - x 6600

Figs. 28-29: LM photographs (acetolysed materials)

28. Ellipsoidal grain (proximal face in upper focus; lighter shade represents the striae and darker shade represents the lirae) - x 2230

29. Exine pattern (proximal face in upper focus; lighter shade represents the striae and the darker shade represents the lirae) Note: striae bridge dissecting the lirae into isomorphous units) - x 4144
PLATE - VII

POLLEN GRAINS OF G. RICHMONDENSIS (MALE PARENT) 2n=44

Figs. 30-31: SEM photographs (acetolysed materials)
- Plain striate (dissected-zig zag) exine pattern

30. Ellipsoidal grain (distal face; Note: the wide colpus and dissected and zig zag striae) - x 2520

31. Ellipsoidal grains (proximal face; Note: the lateral end of colpus at the bottom end) - x 2610

Figs. 32-33: LM photographs (acetolysed materials)

32. Ellipsoidal grain (distal face in upper focus; Note: the colpus and parallel arrangement of the striae) - x 2230

33. Exine pattern (proximal face in upper focus; Note: the disrupted and zig-zag striae arranged in parallel rows; striae bridges dissect the lirae into various sized units) - x 4663
PLATE - VIII

POLLEN GRAINS OF G. VIRESCENS × G. CARSONII (HYBRID) 2n=44

Figs. 34-36: SEM photographs (acetolysed materials)
  - Striato intertwined foveolate exine pattern

34. Ellipsoidal grains (lateral face showing the colpus) - × 2565

35. Exine pattern (lateral face; Note: intertwining of the double tiered striae and the resulting foveolate lirae) - × 4800

36. Ellipsoidal grain (distal face; Note: colpi) - × 2500

Figs. 37-38: LM photographs (acetolysed materials)

37. Ellipsoidal grains (distal face in upper focus; Note: the colpus) - × 2486

38. Exine pattern (proximal face in upper focus) - × 4210
PLATE - IX

POLLEN GRAINS OF G. CARSONII × G. VIRESCENS (HYBRID) 2n=44

Figs. 39-40: SEM photographs (acetolysed materials)
- Striato - fossulate - panpunctate pattern.

39. A group of ellipsoidal grains showing both distal and proximal faces (Note: the colpus in the grain on the right hand side) - × 2160

40. Exine pattern (distal face; Note: puncta on both the striae and the lirae and the inter-twining of the double tiered striae and the resulting fossulate lirae) - × 8400

Figs. 41-42: LM photographs (acetolysed materials)

41. Ellipsoidal grains (proximal face; Note: the almost evenly sized striae mounts) - × 3043

42. Ellipsoidal grain (proximal face; upper focus) - × 3238
PLATE - X

POLLEN GRAINS OF *G. VIRESCENE X G. RICHMONDENSIS* (HYBRID) 2n = 44

Figs. 43-45: SEM photographs (acetolysed materials)
- Partially intertwined - striato - fossulate exine pattern

43. Ellipsoidal grain (distal face; Note: fossulate lirae) - x 2500

44. Exine pattern (distal face; Note: fossulate lirae and partial intertwining of the striae in some places) - x 12000

45. Spheroidal grain (distal face) - x 2160

Figs. 46-47: LM photographs (acetolysed materials)

46. Ellipsoidal grain (distal face; Note: the colpus and its wavy margin) - x 2266

47. Exine pattern (proximal face in upper focus; Note: the striae and the lirae arranged in various directions; lirae dissected by striae bridges) - x 3885
Figs. 48-49: SEM photographs (alcohol treated materials) - Striato - fossulate - punctate exine pattern

48. A group of ellipsoidal grains (proximal face) - × 2500

49. Exine pattern (proximal face; Note: the wide striae and fossulate lirae and also puncta on the striae) - × 13920

Figs. 50-51: LM photographs (acetolysed materials)

50. Ellipsoidal grain (distal face in upper focus; Note: the colpus and its wavy margin) - × 1943

51. Exine pattern (proximal face in lower focus; Note: the striae and lirae and distantly placed striae mounts) - × 3885
PLATE - XII

POLLEN GRAINS OF G. MAGNIFICA 2n = 88

Figs. 52-53: SEM photographs (acetolysed materials)
- Striato - criss cross - foveolate.

52. Spheroidal grain (distal face; Note: the colpus) - × 25000

53. Exine pattern (distal face; Note: criss-cross type of intertwining of the double tiered striae and the resulting foveolate lirae) - × 8580

Figs. 54-55: LM photographs (acetolysed materials)

54. Ellipsoidal grain (distal face; Note: the colpus and the striae and the lirae) - × 2590

55. Ellipsoidal grain (proximal face; Note: the striae and foveolate lirae) - × 2590