A Taxonomic Study of Sixty Pollen Grains Collected by Honey Bees

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Pollen may enter the hives of honey bees in three ways. The major source of pollen in the hive is collected by pollen-collecting bees. Honey bees collect the pollen grains from the anthers and pack them into small balls on their hind legs. These balls or pellets of pollen are then carried to the hive where they are stored or used as food. Bees may become dusted with pollen in their quest for nectar, and thus they return to the hive covered with pollen. It has been observed many times that these bees are always cleaned up before they return to the field; thus they contribute some to the pollen supply. In addition, pollen grains are abundant in nectar, and hence the bees naturally collect some pollen as they collect nectar.

From a taxonomic study of hive pollen one may determine the sources of honey as well as the plants visited for pollen. It was as a result of a study of major pollen sources for honey bees in Indiana that the author became interested in the taxonomic study of the pollen grains.

In order to study the pollen grains collected by honey bees one may collect ripe anthers from the flowers on which honey bees are observed working. This is often a time consuming task, and the supply of pollen obtained is very small. In this case, however, the source is never questioned. If one desires larger quantities of pollen, one can secure it by means of a pollen trap placed in front of the hive entrance so that the pellets are removed from the bees as they enter the hive. The identification of such pollen then becomes some problem.

The process of handling the pollen collected in either manner should be the same. In the present study the anthers or pellets were desiccated in a calcium chloride drier and then stored in gelatine capsules or air tight glass vials until ready for critical study.

The descriptions of the pollen grains given in the following section were obtained from slides prepared in the following manner. Desiccated pollen was placed on a slide and several drops of tertiary butyl alcohol were added to soften the grains. The slide was then heated gently and additional drops of tertiary butyl alcohol added to remove any oils that might be present on the grains. A drop of liquid glycerine jelly to which had been added a small amount of basic fushin was added and a cover slip applied. The size of the grains is based on an average of ten grains.

Photomicrographs of the pollen grains which appear in Plate A were made with a Bausch and Lomb microscope, camera, and lamp. Eastman Panatomic-X 3¼x4¼ sheet film was used, and it was developed in D-76. The grains were photographed at approximately 500 magnifications.

The morphological characters that are of greatest value in the identification of pollen grains are the number and arrangement of the furrows and pores, the sculpturing of the exine, and the size and shape of the grains (Zander, 1941 and Erdtman, 1943). The size and shape of the

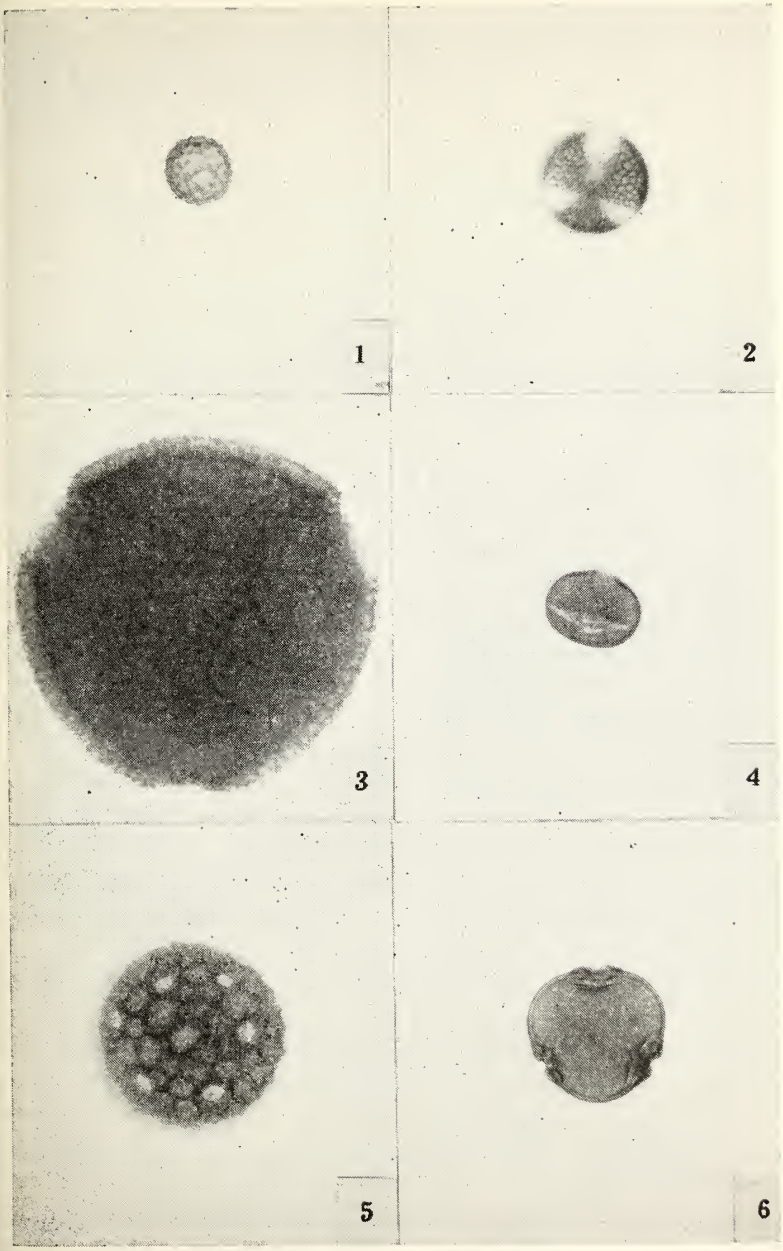

Plate A. Six pollen grains frequently collected by honey bees.

Fig. 1. *Ambrosia elatior* L. x500
Fig. 2. *Brassica nigra* (L.) Koch. x500
Fig. 3. *Geranium maculatum* L. x500
Fig. 4. *Melilotus alba* Desr. x500
Fig. 5. *Polygonum Persicaria* L. x500
Fig. 6. *Tilia americana* L. x500

grains are helpful, but they may be subject to great variation in some genera. In addition they vary somewhat due to the method in which the grains are processed. Since pollen grains of the same or closely related species tend to be alike if the environmental factors are uniform (Wodehouse, 1935), it usually is not practical to attempt to identify hive pollen more than to genera.

A brief description of sixty pollen grains collected by honey bees in Indiana follows. The sources are in alphabetical order as follows:

Acer saccharum Marsh. (Sugar Maple) Size: 33 microns; Shape: Oblately spheroidal; Furrows: 3 wide, conspicuous; Sculpturing: Exine finely granular.

Aesculus glabra Willd. (Ohio Buckeye) Size: 20 microns; Shape: Spheroidal; Pores: 3; Sculpturing: Exine granular.

Althaea rosea (L.) Cav. (Hollyhock) Size: 116 microns; Shape: Spheroidal; Pores: Numerous, but not conspicuous; Sculpturing: Exine about 5 microns thick, covered with sharp, conical spines 9 microns long.

Ambrosia elatior L. (Common Ragweed) Size: 18 microns; Shape: Spheroidal; Pores: 3; Sculpturing: Exine covered with short, reduced spines about 2 to 3 microns apart.

Apocynum cannabinum L. (Hemp Dogbane) Size: Tetrad 25 microns; Shape: Tetrad; Pores: 0; Sculpturing: Exine finely granular.

Arctium minus (Hill) Bernh. (Common Burdock) Size: 41 microns; Shape: Spheroidal; Pores: 3, conspicuous; Sculpturing: Exine thick with short, conical spines.

Asparagus officinalis L. (Garden Asparagus) Size: 25 microns x 21 microns; Shape: Ellipsoidal; Furrows: 1; Sculpturing: Exine smooth.

Aster pilosus Willd. (Heath Aster) Size: 22 microns; Shape: Spheroidal; Pores: 3; Sculpturing: Exine spines about 3 microns long, texture finely granular.

Berberis Thunbergii DC. (Japanese Barberry) Size: 38 microns; Shape: Oblately spheroidal; Furrows: 3, spiral or unequally spaced; Sculpturing: Exine granular.

Brassica nigra (L.) Koch. (Black Mustard) Size: 30 microns; Shape: Spheroidal; Furrows: 3; Sculpturing: Exine heavily reticulate.

Campanula americana L. (Tall Bellflower) Size: 41 microns; Shape: Spheroidal; Pores: 3 to 6, conspicuous; Sculpturing: Exine thick and reticulate.

Catalpa bignonioides Walt. (Catalpa) Size: Tetrad 58 microns; Shape: Tetrad; Pores: 0; Sculpturing: Exine thick and reticulate.

Cirsium arvense (L.) Scop. (Canada Thistle) Size: 42 microns; Shape: Spheroidal; Pores: 3, conspicuous; Sculpturing: Exine thick, with high ridges and lacunae, covered with long, sharp spines over 3 microns in length.

Claytonia virginica L. (Virginia Spring Beauty) Size: 55 microns; Shape: Spheroidal; Furrows: 3, conspicuous; Sculpturing: Exine, thick, granular.

Cornus florida L. (Flowering Dogwood) Size: 22 microns; Shape: Oblately spheroidal; Pores: 3, conspicuous; Sculpturing: Exine granular.

Corylus americana Walt. (American Hazelnut) Size: 20 microns; Shape: Oblately spheroidal; Pores: 3, conspicuous; Sculpturing: Exine smooth, slightly expanded at the pores.

Cucumis sativus L. (Cucumber) Size: 50 microns; Shape: Oblately spheroidal; Pores: 3, conspicuous; Sculpturing: Exine smooth.

Cucurbita Pepo L. (Pumpkin) Size: 136 microns; Shape: Spheroidal; Pores: 4 or more, large conspicuous, scattered over the surface of the grain; Sculpturing: Exine covered with large spines.

Dianthera americana L. (Dense-flowered Water Willow) Size: 38 microns x 23 microns; Shape: Ellipsoidal; Pores: 3, only one or two appearing in any view; Sculpturing: Exine finely granular.

Dipsacus sylvestris Huds. (Common Teasel) Size: 86 microns; Shape: Oblately spheroidal; Pores: 3, conspicuous; Sculpturing: Exine with short, conical spines and irregular branching at the pores.

Fagopyrum esculentum Moench. (Buckwheat) Size: 58 microns x 42 microns; Shape: Ellipsoidal; Pores: 3, only one or two appearing in any view; Sculpturing: Exine thick, coarse, granular.

Fragaria virginiana Duchesne. (Virginia Strawberry) Size: 23 microns; Shape: Angular; Furrows: 3; Sculpturing: Exine granular, granules appearing in rows.

Geranium maculatum L. (Wild Geranium) Size: 91 microns; Shape: Oblately spheroidal; Pores: 3, conspicuous; Sculpturing: Exine, thick, palisade-like.

Grossularia Cynostabi (L.) Mill. (Pasture Gooseberry) Size: 25 microns; Shape: Spheroidal; Pores: 4 or more, conspicuous; Sculpturing: Exine smooth.

Helianthus annuus L. (Common Sunflower) Size: 28 microns; Shape: Spheroidal; Pores: 3, conspicuous; Sculpturing: Exine thick with spines about 5 microns long.

Hydrophyllum appendiculatum Michx. (Appendated Waterleaf) Size: 18 microns; Shape: Oblately spheroidal; Furrows: 3, wide, conspicuous; Sculpturing: Exine smooth, thin.

Ipomoea purpurea (L.) Roth. (Common Morning-glory) Size: 92 microns; Shape: Spheroidal; Pores: Numerous, conspicuous; Sculpturing: Exine thick, covered with sharp, conical spines enlarged at the base.

Leonurus Cardiaca L. (Common Motherwort) Size: 18 microns; Shape: Spheroidal; Pores: 3, conspicuous; Sculpturing: Exine smooth.

Liriodendron Tulipifera L. (Tulip Tree) Size: 66 microns x 40 microns; Shape: Ellipsoidal; Furrows: 1; Sculpturing: Exine pitted, with conspicuous warts.

Lonicera japonica Thumb. (Japanese Honeysuckle) Size: 50 microns; Shape: Oblately spheroidal; Pores: 3, conspicuous; Sculpturing: Exine covered with small, sharp spines about 2-3 microns long.

Malus pumila L. (Common Apple) Size: 38 microns; Shape: Angular, many abortive grains and irregular grains in a pollen sample; Furrows: 3; Sculpturing: Exine granular.

Medicago sativa L. (Alfalfa) Size: 25 microns x 21 microns; Shape: Ellipsoidal; Furrows: 3, one or two appearing in any view; Sculpturing: Exine granular.

Melilotus alba Desr. (White Sweetclover) Size: 25 microns x 21 microns; Shape: Ellipsoidal; Furrows: 3, one or two appearing in any view; Sculpturing: Exine granular.

Mentha piperita L. (Peppermint) Size: 25 microns x 22 microns; Shape: Ellipsoidal; Furrows: 6, not conspicuous; Sculpturing: Exine smooth.

Monardia fistulosa L. (Wild Bergamot) Size: 49 microns x 38 microns; Shape: Ellipsoidal; Furrows: 6, conspicuous; Sculpturing: Exine smooth.

Nepeta Cataria L. (Catnip) Size: 33 microns x 28 microns; Shape: Ellipsoidal; Furrows: 6, conspicuous; Sculpturing: Exine smooth.

Parthenocissus quinquefolia (L.) Planch. (Virginia Creeper) Size: 33 microns; Shape: Spheroidal or nearly so; Pores: 3; Sculpturing: Exine granular.

Polanisia graveolens Raf. (Clammyweed) Size: 20 microns; Shape: Oblately spheroidal; Furrows: 3, narrow; Sculpturing: Exine granular.

Polygonum Persicaria L. (Lady's Thumb) Size: 58 microns; Shape: Spheroidal; Pores: Numerous; Sculpturing: Exine thick, reticulate, with high vertical ridges.

Populus deltoides Michx. (Cottonwood) Size: 27 microns; Shape: Spheroidal; Pores and Furrows: 0; Sculpturing: Exine granular.

Prunus serotina Ehrh. (Black Cherry) Size: 25 microns; Shape: Angular, many abortive and irregular grains in pollen sample; Furrows: 3; Sculpturing: Exine granular.

Pychanthemum flexuosum (Walt.) BSP. (Slender Mountain-mint) Size: 25 microns x 17 microns; Shape: Ellipsoidal; Furrows: 6, not conspicuous; Sculpturing: Exine smooth.

Ranunculus recurvatus Poir. (Hooked Buttercup) Size: 40 microns; Shape: Spheroidal; Furrows: 3, not conspicuous; Sculpturing: Exine granular.

Rhamnus Frangula L. (Glossy Buckthorn) Size: 20 microns; Shape: Oblately spheroidal; Pores: 3, conspicuous; Sculpturing: Exine finely reticulate.

Rhus aromatica Ati. (Fragrant Sumac) Size: 30 microns; Shape: Spheroidal; Furrows: 3; Sculpturing: Exine granular.

Robinia Pseudo-Acacia L. (Black Locust) Size: 30 microns; Shape: Oblately spheroidal; Furrows: 3, narrow; Sculpturing: Exine smooth.

Rosa setigera var. tomentosa T. & G. (Prairie Rose) Size: 30 microns; Shape: Angular; Furrows: 3; Sculpturing: Exine granular.

Rubus occidentalis L. (Common Blackcap Raspberry) Size: 25 microns; Shape: Angular; Furrows: 3; Sculpturing: Exine granular.

Salix discolor Muhl. (Pussy Willow) Size: 18 microns; Shape: Spheroidal; Furrows: 3; Sculpturing: Exine heavily reticulate.

Sambucus canadensis L. (Elderberry) Size: 17 microns; Shape: Spheroidal; Pores: 3; Sculpturing: Exine smooth.

Sassafras albidum (Nutt.) Nees. (Sassafras) Size: 42 microns; Shape: Spheroidal; Pores and Furrows: 0; Sculpturing: Exine covered with short conical spines.

Solidago nemoralis Ait. (Old-field Goldenrod) Size: 22 microns; Shape: Spheroidal; Pores: 3; Sculpturing: Exine spines about 3 microns long, texture finely granular.

Staphylea trifolia L. (American Bladdernut) Size: 42 microns; Shape: Oblately spheroidal; Pores: 3, furrows conspicuous; Sculpturing: Exine reticulate.

Symphoricarpos orbiculatus Moench. (Coralberry) Size: 38 microns; Shape: Oblately spheroidal; Pores: 3; Sculpturing: Exine smooth.

Taraxacum paulstre var. vulgare (Lam.) Fern. (Dandelion) Size: 35 microns; Shape: Spheroidal; Pores: 3; Sculpturing: Exine thick, with high ridges and lacunae and sharp conical spines 2 microns or under in length.

Tilia americana L. (American Linden, Basswood) Size: 36 microns; Shape: oblately spheroidal; Pores: 3, sunken in the surface of the grain; Sculpturing: Exine reticulate.

Trifolium hybridum L. (Alsike Clover) Size: 25 microns x 21 microns; Shape: Ellipsoidal; Furrows: 3, one or two appearing in any view; Sculpturing: Exine granular.

Ulmus americana L. (American Elm) Size: 28 microns; Shape: Spheroidal; Pores: 3-6; Sculpturing: Exine smooth but with reticulate appearance due to underlying layers.

Vitis aestivalis Michx. (Summer Grape) Size: 16 microns; Shape: Oblately spheroidal; Pores: 3, slightly sunken in the exine; Sculpturing: Exine smooth.

Zea Mays L. (Corn) Size: 91 microns; Shape: Spheroidal or nearly so; Pores: 1; Sculpturing: Exine granular.

The following key was prepared as an aid to the study of pollen grains brought into the hive by honey bees in Indiana. It is based on photomicrographs and the descriptions of pollen in the above section. It is therefore limited to this group of plants and closely related species in each genus.

1. Grains in tetrads 2
   Grains single 3
2. Exine finely granular, tetrad 25 microns ..... *Apocynum cannabinum*
   Exine thick, reticulate, tetrad 58 microns ..... *Catalpa bignonioides*
3. Pores and furrows absent 4
   Pores or furrows present 5
4. Exine covered with short spines, grains 42 microns ..... *Sassafras albidum*
   Exine granular, grains 27 microns ..... *Populus deltoides*
5. Germinal apparatus consisting of a single furrow or pore 6
   Germinal apparatus consisting of more than one furrow or pore 8
6. Pores absent, furrows one 7
   Pores one, furrows absent, grains 91 microns ..... *Zea Mays*
7. Exine smooth, grains ellipsoidal,
   grains 25 microns x 21 microns ..... *Asparagus officinalis*
   Exine warty, rough, boat-shaped, grains
   66 microns x 40 microns ..... *Liriodendron Tulipifera*
8. Exine spiny 9
   Exine smooth, granular, or reticulate 19
9. Grains large, over 75 microns 10
   Grains small, under 60 microns 13
10. Grains spheroidal, spines long 11
    Grains oblately spheroidal, spines
    short, grains 86 microns ..... *Dipsacus sylvestris*
11. Spines straight at the base, grains over 100 microns 12
    Spines bulbous at the base, grains 92 microns ..... *Ipomoea purpurea*

12. Pores conspicuous, spines scattered, grains 136 microns..... *Cucurbita Pepo*
Pores not conspicuous, spines densely covering the exine, grains 116 microns..... *Althaea rosea*

13. Grains spheroidal 14
Grains oblately spheroidal, grains 50 microns..... *Lonicera japonica*

14. Exine with high ridges and lacunae..... 15
Ridges and lacunae absent on exine..... 16

15. Spines sharp, over 3 microns in length, grains 42 microns.... *Cirsium arvense*
Spines sharp, conical, 2 microns or under in length, grains 35 microns..... *Taraxacum palustre*

16. Pores and furrows less conspicuous, grains under 30 microns..... 17
Pores and furrows very conspicuous, grains 41 microns..... *Arctium minus*

17. Spines long, sharp, grains over 20 microns..... 18
Spines short, reduced, grains 18 microns..... *Ambrosia elatior*

18. Spines 5 microns or longer, grains 28 microns..... *Helianthus annuus*
Spines 3 microns or less, grains 22 microns..... *Aster pilosus*
Solidago nemoralis

19. Grains angular, irregular, often abortive..... 20
Grains ellipsoidal 21
Grains spheroidal or oblately spheroidal..... 25

20. Exine granular, granules appearing in rows, grains 23 microns..... *Fragaria virginiana*
Exine granular, granules appearing in no definite pattern, grains over 25 microns..... *Malus pumila*
Rosa setigera
Prunus serotina
Rubus occidentalis

21. Pores present 22
Pores absent 23

22. Exine thick, coarse, granular, grains 58 microns x 42 microns..... *Fagopyrum esculentum*
Exine finely granular, grains 38 microns x 23 microns... *Dianthera americana*

23. Furrows 6, exine smooth..... 24
Furrows 3, exine granular, grains 25 microns x 23 microns..... *Melilotus alba*
Medicago sativa
Trifolium hybridum

24. Furrows conspicuous, grains around 35 microns or larger..... *Nepeta Cataria*
Monardia fistulosa
Furrows not conspicuous, grains around 25 microns or smaller..... *Mentha piperita*
Pychanthemum flexuosum

25. Pores absent, furrows 3..... 26
Pores 3 or more..... 36

26. Grains oblately spheroidal..... 27
Grains spheroidal 31

27. Grains over 30 microns..... 28
Grains under 20 microns..... 30

28. Furrows equally spaced, grains under 35 microns..... 29
Furrows spiral or unequally spaced, grains 38 microns... *Berberis Thunbergii*

29. Furrows wide and conspicuous, exine granular, grains 33 microns..... *Acer saccharum*
Furrows narrow, less conspicuous, exine smooth, grains 30 microns..... *Robinia Pseudo-Acacia*

30. Furrows wide, conspicuous, exine smooth, grains 18 microns..... *Hydrophyllum appendiculatum*

Furrows narrow, less conspicuous,
exine granular, grains 20 microns.....*Polanisia graveolens*

31. Exine heavily reticulate..... 32
Exine granular or smooth..... 33

32. Grains 30 microns .....*Brassica nigra*
Grains 18 microns .....*Salix discolor*

33. Grains 40 microns or over 34
Grains 30 microns or under 35

34. Furrows very conspicuous, grains 55 microns.....*Claytonia virginica*
Furrows not conspicuous, grains 40 microns.....*Ranunculus recurvatus*

35. Exine granular, grains 30 microns.....*Rhus aromatica*
Exine smooth, grains 18 microns.....*Leonurus Cardiaca*

36. Pores usually 4 or more..... 37
Pores 3 40

37. Exine thick, reticulate, grains 40 microns or over..... 38
Exine thin, smooth, grains 30 microns or under..... 39

38. Exine with high, vertical ridges, grains 58 microns....*Polygonum Persicaria*
Exine with no vertical ridges, grains 41 microns.....*Campanula americana*

39. Exine reticular appearance, grains 28 microns.....*Ulmus americana*
Exine smooth, grains 25 microns.....*Grossularia Cynosbati*

40. Grains 40 microns or larger 41
Grains 35 microns or less 43

41. Exine smooth or reticulate, grains smaller..... 42
Exine thick, palisade-like, grains 91 microns.....*Geranium maculatum*

42. Furrows absent, exine smooth, grains 50 microns.....*Cucumis sativus*
Furrows present, exine reticulate, grains 42 microns.....*Staphylea trifolia*

43. Pores sunken in the exine..... 44
Pores on the surface of the exine..... 45

44. Exine reticulate, grains 36 microns.....*Tilia americana*
Exine smooth, grains 16 microns.....*Vitis aestivalis*

45. Furrows absent or not conspicuous..... 46
Furrows present and conspicuous..... 48

46. Grains about 20 microns..... 47
Grains 38 microns.....*Symphoricarpos orbiculatus*

47. Exine smooth, slightly raised at the pore.....*Corylus americana*
Exine finely reticulate, not raised at the pore.....*Rhamnus Frangula*

48. Grains spheroidal 49
Grains oblately spheroidal, grains 22 microns.....*Cornus florida*

49. Exine granular, grains over 20 microns..... 50
Exine smooth, grains 17 microns.....*Sambucus canadensis*

50. Grains 33 microns.....*Aesculus glabra*
Grains 20 microns .....*Parthenocissus quinquefolia*

These investigations indicate that one can determine the plant genera that bees visit by a taxonomic study of hive pollen. Since honey bees are relatively constant in their collecting, usually only one kind of pollen is found in each pellet. In some cases where pollen grains of related genera are quite similar such as is found in the Rosaceae and Leguminosae, the time of flowering may be helpful. In the most difficult cases direct observations of bees working on the flowers must be made. In all cases the latter is the most dependable as far as determining the actual plant source.

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