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What we know about pollen

Honey and wax are the most widely known and probably the oldest harvests from bees. In the 1950s royal jelly appeared to some beekeepers as a "miracle" substance by which they could make fortunes. But, to produce royal jelly in saleable quantities, it is necessary to work hard to a rigorous timetable throughout the season. Moreover royal jelly is highly perishable, and far more sensitive than honey or wax to storage conditions.

Pollen and propolis are two plant products that bees collect and store; both have biologically "active" (or at any rate interesting) components, and both are at present in demand in various countries. Methods of harvesting pollen have been devised and improved over the past few decades; they will be evaluated in the next issue of *Bee World*. In contrast, methods of harvesting propolis are still crude, and there has been hardly any development of special techniques.

Reliable information about pollen itself, incorporating what has been discovered in recent years, has not been easy to come by, but this situation has now been remedied by the publication of a new book—*Pollen: biology, biochemistry, management*, by Professor R. G. Stanley of Florida, USA (who died before the book was published), and Professor H. F. Linskens of Nijmegen, Netherlands. Only a small part of the book is concerned with pollen in direct relation to bees: Chapter 7 deals briefly with pollen collection and storage, pollen loads, digestion of pollen by bees and its nutritive value to them; pollen substitutes; pollen in analysis of honey.

Some beekeepers collect pollen for sale; others, hearing that this might produce an income additional to that from selling honey or hiring bees for pollination, are interested in doing so. Stanley and Linskens' book lists 28 commercial firms from which pollen can be bought, and some of these firms depend on independent beekeepers for their supplies. Of the 28, 18 are in USA, 2 each in Australia, Canada, France and Sweden, and 1 each in the UK and the German Federal Republic.

Some wind-pollinated plants produce large quantities of dry, small-grain pollen, which can be harvested without the aid of bees, by methods described in the book. Bee-collected pollen is harvested by allowing bees to enter the hive only through a grid or perforated screen whose holes are so small that the pollen loads on the hind legs are removed and fall into a collecting tray.

Storage conditions are of the utmost importance in maintaining the viability of pollen. They are also important for pollen intended for other uses, in that damage by mould and fermentation must be prevented. Relative humidity needs to be low, and the temperature at or below 0°C. The gases in the storage atmosphere are also important. Freeze-drying is in general an effective technique, but it reduces viability, and nutritional value of the pollen for bees. Optimal storage conditions vary for different pollens.

Composition of pollen

The following figures on the composition of pollen are quoted from the book; necessarily summarized, they refer to many different samples of pollen, from different plant species, and are therefore not consistent among themselves. Most of the substances listed are present only in minute quantities.

1. Gross composition (as % of pollen dry matter) for wind-pollinated plants, whose water content is commonly 20–25 %:

ash	1·8–3·7
carbohydrate	13–37
fibre (residue)	5·3
protein	6–28
lipid	1·2–3·7

2. Major mineral composition of ash (%):

total ash	2·4–6·4
potassium	0·3–1·2
sodium	0·1–0·2
calcium	0·03–1·2
magnesium	0·1–0·4
phosphorus	0·3–0·8
sulphur	0·2–0·4
water	6–17

Trace elements (i.e. minerals present in smaller amounts): aluminium, boron, chlorine, copper, iodine, iron, manganese, nickel, silicon, sulphur, titanium, zinc.

3. Carbohydrates (% of total dry weight):

total	1–37
reducing sugars	0·04–8
non-reducing sugars	0·1–19
starch	0·0–22

Simple sugars (% of total of all three):

fructose	3–44
glucose	3–35
sucrose	22–93

Related compounds found in pollen: callose, pectin and other polysaccharides, cellulose, sporopollenin, lignin.

The following groups of compounds have also been identified in pollen:

4. Organic acids, including phenolic acids: *p*-hydroxybenzoic, *p*-coumaric, vanillic, protocatechuic, gallic, ferulic.

5. Lipids: polar lipids, monoglycerides, diglycerides, triglycerides, free fatty acids (palmitic, stearic, oleic, linoleic, linolenic); hydrocarbons and associated alcohols; sterols (β-sitosterol, cholesterol, fucosterol, 24-methylene-cholesterol, campesterols, sigmasterol, C_{29}-di-unsaturated sterols).

6. Terpenes.

7. Free amino acids: alanine, arginine, aspartic acid, glutamic acid, glycine, histine, leucine/isoleucine, lysine, methionine, phenylalanine, proline/hydroxyproline, tyrosine, valine.

8. Nucleic acids: desoxynucleic acid, riboxynucleic acid.

9. Enzymes: 24 oxidoreductases, 21 transferases, 33 hydrolases, 11 lyases, 5 isomerases, 3 ligases and others.

10. Vitamins: B_2, B_3, B_5, B_6, C, E, H; i.e. riboflavin, nicotinic acid, pantothenic acid, pyridoxine, ascorbic acid, tocopherol, biotin.

11. Nucleosides.

12. Carotenoids (at least 11), flavonoids (at least 8).

13. Growth regulators: auxins, brassins, gibberellins, kinins; also growth inhibitors.

Uses of pollen

Commercial applications of pollen have included the following:

plant breeding programmes
fruit pollination (using pollen dispensers)
studying and treating allergic conditions such as hay fever
extracting certain components
producing pollen supplements for feeding to bees
feeding human beings and domestic animals, alone or with honey or royal jelly.

Pollen of specific (or even varietal) plant origin is required for the first three uses, and sometimes for the fourth; the first two need viable *pollen grains*. General pollen harvesting is therefore likely to be for the final two applications. Studies of European pollens have shown that, for feeding to bees, the following pollens are among the best: *Crocus*, *Salix*, *Papaver*, *Trifolium*, *Castanea*, *Raphanus*, *Sinapis*, *Erica* and tree fruit. *Taraxacum* pollen, and *Ulmus* and some others carried by wind, are also good. But *Corylus*, *Alnus*, *Betula* and *Populus* are not, and *Pinus*, *Picea*, *Abies* and *Cedrus* are especially bad. It is interesting that *mixtures* of pollens are more effective for feeding to bees than single-species pollens. A few pollens contain substances that are toxic to bees, for instance *Rhododendron*, *Ranunculus* species (due to anemonine content), *Aesculus* and *Tilia* (saponin), *Hyoscyamus* (an alkaloid), *Asclepias* species (galitoxins).

Pollen is an important natural component of the diet of bees and many other insects. Its ingestion by certain flower-visiting birds and bats may well be incidental, as no role for pollen has yet been established in their nutrition.

Experiments in animal rearing have shown that pollen has potential uses. With piglets, calves and broiler chickens, for instance, the incorporation of a small percentage of pollen in the rations was found to lead to increased weight gains and other useful effects. Presumably the important question is whether pollen is the most cost-effective additive of its kind. This depends on the cost of alternatives, as well as the cost of pollen, which in some circumstances can be quite low. In Rumania, for example, pollen is a by-product of corn production (*Zea mays*), obtained when the plants are detasselled; pollen is removed at the rate of 50 kg per hectare of land used for the crop.

The sale of pollen for human consumption may appear to be a tempting outlet for commercial pollen production. But people who could afford to pay a realistic price for pollen are likely to be receiving an adequate diet already, and thus to be in different circumstances from the experimental animals referred to above. Stanley and Linskens' final sentence on nutritive supplements is: "Pollen probably is truly beneficial, although the benefits, we suspect, can be equalled by many other less expensive, more readily available foods."

This leaves two questions open. Would pollen benefit people not receiving an adequate diet? And does pollen have specific medicinal (pharmacological) effects, apart from its nutritive value? The first question is not raised by Stanley and Linskens, but the answer is surely yes, provided the pollen contains substances that are lacking in the diet. Whether the use of pollen as an additive is feasible, economic and acceptable are separate questions. It is, however, worth bearing in mind that pollen is produced in almost all inhabited parts of the world, and is largely unharvested. In primitive honey-hunting days the whole combs from bees' nests were eaten; the honey, pollen and bee brood together constituted a very useful and acceptable food.

Specific pharmacological properties of pollen have been and are being explored in various countries, and a fair proportion of the pollen produced commercially is sold on the basis of such properties. Stanley and Linskens quote, with caution, some measure of support for the use of pollen in treating certain affections: chronic prostatitis, bleeding stomach ulcers, respiratory infections, and allergy reactions. They add that "the benefits of pollen to humans is an area still subject to question". More research is clearly needed before the sale of pollen preparations as pharmaceuticals would be allowed by the laws of all countries.

Pollen: biology, biochemistry, management was published by Springer-Verlag, Berlin, in 1974. It is obtainable from BRA, price £11 or US $24·40, +postage and packing £0·50 or $1·50.

Harvesting pollen from hives

Pollen is now a commercial product, sold by many firms and used for various purposes in different countries: in pharmacy; in "health" foods and preparations; in animal rearing; in pollen supplements for feeding to bees; for specifically controlled pollination. The composition and properties of pollen are dealt with[2] in the previous issue of *Bee World*, which also lists some commercial pollen dealers†. An increasing number of beekeepers are finding it worth while to harvest pollen, using traps fitted to their hives*; pollen traps may be home-made or bought from a bee supply firm. Yields per hive vary according to the plant source, colony strength, weather, and type of trap. A daily harvest up to ½ kg or even 1 kg is possible during prolific flows; a good average yield for the season would be perhaps 8–10 kg.

Pollen traps

A pollen trap has two essential parts. One is a wire screen (grid) or perforated sheet of plastic or metal, fixed across the hive entrance so that a worker bee returning to the hive has to squeeze through one of the holes, her pollen loads being scraped off in the process; often two parallel screens close together are used. The other part is the pollen tray, which is covered by a screen too fine to let bees pass. The pollen is removed regularly from the tray by the beekeeper.

Different types of pollen trap differ in the following characteristics:

(*a*) the hive entrance may be in one of several positions on the hive;
(*b*) the grid or screen may be vertical, horizontal or sloping;
(*c*) the pollen receptacle may be underneath, in front of, or near the top of the hive;
(*d*) the receptacle may be emptied from the front, side or back.

The following account explains why these various arrangements have been used and evaluates their suitability for different purposes.

Traps fitted outside the normal hive entrance

In early pollen traps, a wire grid or perforated sheet was placed vertically across the normal bottom flight entrance. The whole fitting was attached like a porch which could easily be removed and replaced. Modern versions of such traps are suitable for students making observations on the bees' foraging activities, especially if the cover is made of transparent material. They are not suitable for commercial pollen harvesting, since their capacities and pollen yields are too small.

The entrance screen(s) where the pollen is scraped off the bees' legs can conveniently be of 5-mesh wire netting (5 meshes per inch, 2 per cm); if there are two screens, they should be 6 or 7 mm apart.

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* A 32-page illustrated booklet, "Pollensammeln heute" [Pollen collection today] has recently been published by B. Dany, 8 München 83, Plettstrasse 39, Germany, price DM 6·80.

† The two articles are available together as reprint M86 "Pollen and its harvesting" from Bee Research Association, price 35p or $1·10, post free.

The horizontal screen covering the pollen tray is just outside the hive entrance in this type of pollen trap, and can have 6 meshes per inch ($2\frac{1}{2}$ per cm), or more. The floor of the pollen tray should be of cloth or other material that allows any water to escape, and air to circulate round the pollen, to prevent deterioration.

Pender Bros. Pty Ltd., Maitland, NSW, Australia, sell one type of these traps[11], and there are suppliers in many other countries.

Traps incorporated in the floor board

One way of protecting trapped pollen from weather damage is to position the collecting tray (and the screens) under the hive, and this is conveniently done by incorporating them into the floorboard. In the USA, Nye has designed one such trap[13], the drawer in which the pollen has collected being removed from the side, without disturbing the bees. In France, Richardeau's pollen trap[15], with vertical trapping-screens, incorporates a free exit for drones and for hive waste. Similar models can be purchased from Thomas fils, Fay-aux-Loges, France, and elsewhere.

If the trapping-screens are under the hive instead of across the entrance, it becomes possible to increase their area by fixing them horizontally instead of vertically; the bees then enter the hive from beneath, over a large area. This makes it possible to collect pollen on a commercial scale, but it presents a new problem: debris from the hive can fall directly into the trap as well as pollen, and contaminate it.

One of the types most widely used for large-scale pollen collection is the OAC pollen trap, designed at Ontario Agricultural College, Canada, in the early 1960s[8,18]. A commercial model is available, e.g. from F. W. Jones and Son Ltd, Bedford, Quebec, Canada. This type of trap can be made fairly easily. It consists of two parallel 5-mesh wire screens (2 per cm) set 6–7 mm or more apart, and mounted together on wood, the unit fitting over a standard floorboard, on which the pollen-collecting tray slides. It provides good ventilation for the colony, and the pollen tray is removed from the back of the hive without disturbing the bees. One recent publication on the OAC trap, with slight modifications, is by Jaycox in the USA[9], and his diagrams are reproduced in Fig. 1. Another modification, by Chambers in Australia[4] (Fig. 2), deals with the problem of debris—which could include foul brood scales—by fixing a "dirt tray" above half the pollen-collecting tray; this does, however, reduce the area of the pollen-removing screens.

Beekeepers who want to explore the possibilities of commercial pollen harvesting could well start from one of these designs.

Another trap, designed in France[5], has a smaller screen: a plastic sheet perforated with 700 holes each 5 mm in diameter, which is used in either a horizontal or an oblique position.

Traps fitted at the upper part of the hive

Difficulties experienced in using traps below the hive, (such as contamination, already referred to), led to experiments in which the trap was incorporated at the middle or top. Lavie and Fresnaye in France experimented with a pollen trap inside the top of a hive, using a top entrance[12]; these showed that the pollen was usefully dried by the rising warmth of the hive. The higher pollen yields claimed for such a trap were further improved by making an additional hole at the back of the hive; this serves as a drone exit, for waste removal by the bees, and for extra ventilation.

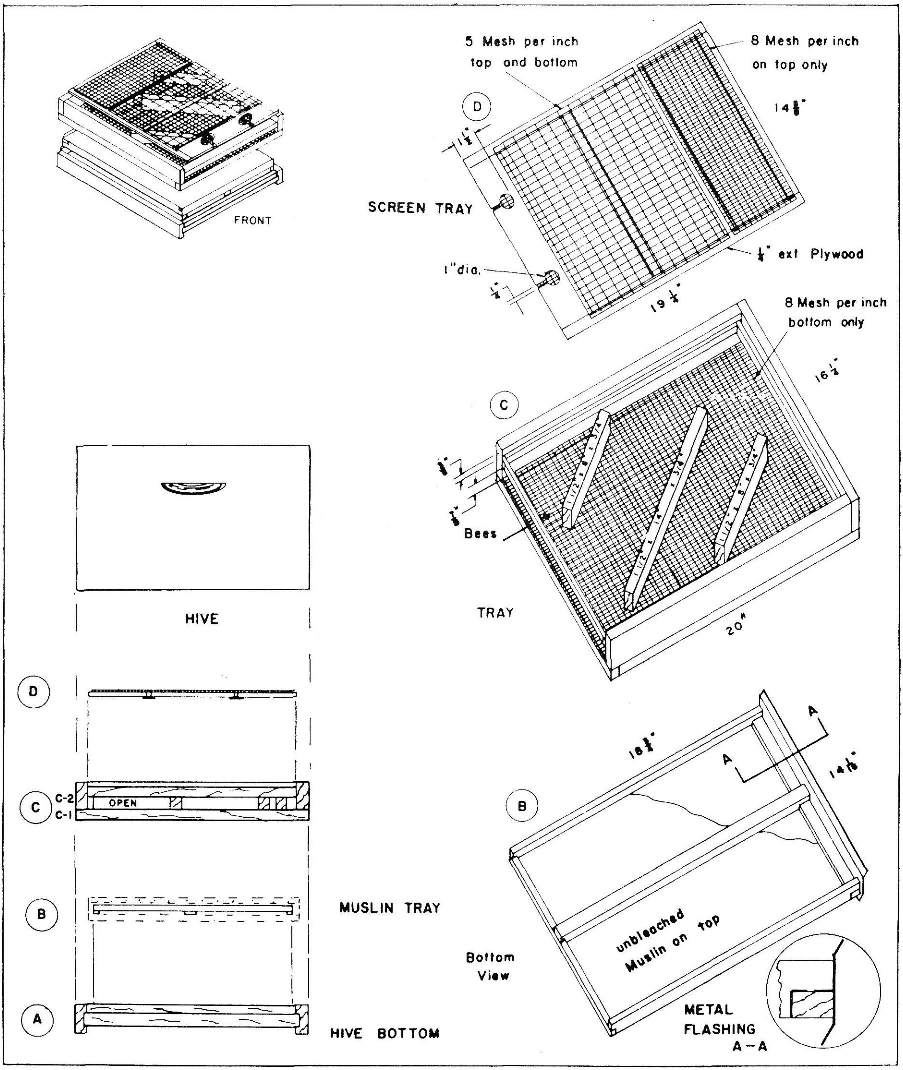
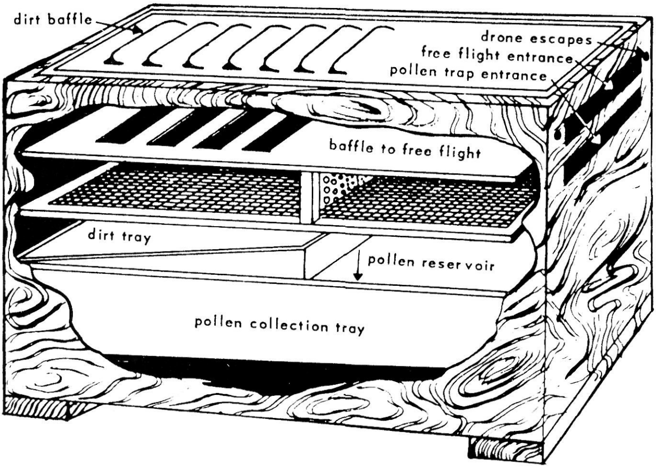


Fig. 1. Pollen trap used at the University of Illinois[9].
Dimensions to the nearest mm are:

B	$18\frac{3}{4}'' \times 14\frac{1}{16}''$	$= 47{\cdot}6 \times 35{\cdot}7$ cm
C	$20'' \times 16\frac{1}{4}''$	$= 50{\cdot}8 \times 41{\cdot}3$ cm
C (top left)	$\frac{3}{8}'', \frac{7}{8}''$	$= 1{\cdot}0, 2{\cdot}2$ cm
C (bars) outer	$1\frac{1}{2}'' \times 8'' \times \frac{3}{4}''$	$= 3{\cdot}8 \times 20{\cdot}3 \times 1{\cdot}9$ cm
centre	$1\frac{1}{2}'' \times 14'' \times \frac{3}{4}''$	$= 3{\cdot}8 \times 35{\cdot}6 \times 1{\cdot}9$ cm
D	$19\frac{1}{4}'' \times 14\frac{5}{8}''$	$= 48{\cdot}9 \times 37{\cdot}1$ cm
	$1\frac{1}{2}'', \frac{1}{4}'', 1''$	$= 3{\cdot}8, 0{\cdot}6, 2{\cdot}5$ cm
	5, 8 mesh per inch	= 2, 3 mesh per cm



Sectional drawing showing internal components. Critical measurements are trap mesh, 5 mm (formerly $\frac{7}{10}$ in. punched metal plate) and drone escape, 6.5 mm

Internal working arrangement of the pollen trap and pollen collection box

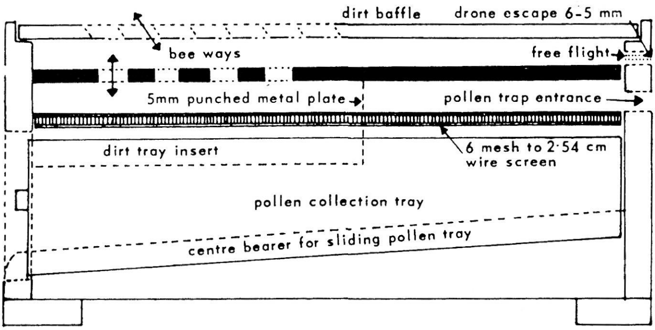


Fig. 2. Pollen trap used in the Department of Agriculture, W. Australia[4].

A trap attached outside the hive need not be used across a bottom entrance. One designed by Kauffeld[10] hangs from the top front edge of the upper of two brood chambers, which is itself set back slightly to provide the entrance for bees going through the pollen trap screens. This trap includes a "trash grid" and a drawer below to catch dead bees, bits of wax, etc. from the hive. Walter T. Kelley Co., Clarkson, KY 42726, USA, is one supplier who makes a pollen trap for hanging on the outside of the hive.

Other traps and devices

Many "traffic control" entrance devices have been described and patented. Some have moving parts[3], and some depend on presenting visual stimuli to the bees[6,16], arranging the exit to look bright to bees inside the hive and the entrance to look dark to bees approaching it from outside.

Another hive entrance, patented in the USA[17], consists of an upward-sloping ramp fitted with adjustable perpendicular projections in staggered rows. The pollen loads are knocked from the bees as they negotiate the gaps, and fall through holes into the drawer below.

Pollen dispensers

A pollen dispenser or "insert" is an entrance device rather like a pollen trap in reverse. Pollen of the required plant variety is fed regularly (by gravity or otherwise) into a trough through which outgoing bees must pass[1]. The bees thus take on their bodies the pollen provided by the beekeeper, and transport it to the flowers they visit. In this way there should be an increase in cross-pollination with the variety of pollen provided, though some trials[7] with almond trees and sweet cherries have not achieved a good set. Lack of success may have been due to the bees clearing a passage through the pollen, which was only inserted twice a day. Pollen inserts in hives in pear orchards have given improved fruit set[19]; their use was recommended in poor flying weather (pollen being inserted 2–3 times an hour) and in orchards with too few trees of the pollinator variety. Later patents, e.g. by C. B. Reed[14], provided for mechanical pollen insertion. An article giving more information on pollen dispensers will be published shortly.

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