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POLLEN AS FOOD AND MEDICINE—A REVIEW¹

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Linskens, H. F. (Department of Experimental Plant Ecology, NL-6225 ED University Nijmegen, The Netherlands) and W. Jorde (Förderverein Allergieforschung, Mönchengladbach e.V. D-41061 Mönchengladbach, Germany) POLLEN AS FOOD AND MEDICINE—A REVIEW. *Economic Botany* 51(1): 78–86. 1997. Pollen, the male gametophyte of flowering plants, is a high energy material, which is collected by insects and stored as food reserve. Pollen has been used traditionally by humans for religious purposes and as supplementary food. Pollen is a concentrated, energy and vitamin rich food that in contemporary times is not only consumed as a dietary component, but also is used in alternative medical treatments. Pollen has potential importance as a supplementary and survival food, and for conditioning of athletes. Pollen has been used medically in prostatitis, bleeding stomach ulcers and some infectious diseases, although such use has been questioned by the medical profession. Pollen may also be used for treatment and prevention of the high-altitude-sickness syndrome. Because some individuals are allergic to pollen, and various pollen species contain specific allergens, individual sensitivities must be tested before pollen is used as a treatment or as a supplementary food.

Blütenstaub als Lebensmittel und als Heilmittel. Die Pollenkörner (d. i. der mehlartige Blütenstaub) sind die männlichen Gametophyten der Blütenpflanzen. Der Pollen ist ein energiereiches Material, das nicht nur von Insekten gesammelt und als Reservestoff gelagert wird, sondern er wird auch vom Menschen seit prähistorischen Zeiten als Zusatznahrung und zu religiösen Zwecken verwendet. Die chemische Zusammensetzung zeigt den Pollen als konzentriertes, energie- und vitaminreiches Nahrungsmittel, das heute nicht nur als zusätzliche Diätkomponente Verwendung findet, sondern auch in der alternativen Heilkunde als wirksames Heilmittel gilt. In der Zukunft wird Pollen daher als Zusatznahrungsmittel weiter an Bedeutung gewinnen. Er findet Anwendung beim Überlebenstraining und als Zusatznahrung für Athleten bei der Wettkampfvorbereitung. Obwohl in der Schulmedizin gewisse Vorbehalte bestehen, wird Pollen auch als Heilmittel verabreicht, so zum Beispiel bei Prostataentzündung, blutenden Magengeschwüren sowie bei einigen Infektionskrankheiten. Pollen wird erfolgreich zur Verhütung und Behandlung von Höhenkrankheiten genutzt. Da ein Teil der menschlichen Bevölkerung allergisch gegenüber Pollen reagiert und die verschiedenen Pollenarten spezifische Allergene enthalten können, muß vor der Verwendung von Pollen als Lebens- oder Heilmittel die allergische Empfindlichkeit der Pollenkonsumenten getestet werden.

Key Words: pollen; supplementary foodstuff; allergenicity; cross reactions.

Beekeepers know that the source of honey is the nectar gathered from flowers by bees. Inside the bee's honey stomach which is situated behind its foregut (stomodeum) nectar is transformed and subsequently secreted either to be fed to the adult bees or to be stored in the combs. Honey is the bee's main source of carbohydrate. Pollen, is the chief source of protein not only for bees but also for many other solitary insects and insects living in colonies. Therefore pollen must be considered genuine foodstuff in the way the authoritative German dictionary

“Duden” puts it, “a commodity for eating or drinking meeting the requirements of daily life.”

THE CHEMICAL COMPONENTS OF POLLEN

During the Second World War (Vivino and Palmer 1944) suggested that so-called bee bread, i.e., pollen gathered by bees and stored in the bee-hive, might represent a sizeable reserve of high grade foodstuff. They estimated that the amount of pollen collected each year in the USA totalled 80 000 t, which was comparable to the annual honey yield at that time (Todd and Bretherick 1942). Various studies have shown a great diversity within the chemical composition of

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TABLE 1. FOOD COMPONENTS OF POLLEN.¹

Food elements in % dry weight		Fatty acids (rel %)	
Dry substance	83	C _{14:0}	3.7
Fat	11	C _{16:0}	24
Proteins	23	C _{16:1}	4.1
Total carbohydrates calculated		C _{18:0}	4.1
as invert sugar	36	C _{18:1}	19
Glucose	14	C _{18:2}	17
Fructose	19	C _{18:3}	38
Ash	2.4		
Lipids calculated as lecithin	1.7		
Phytosterins	1.6		
Others	13		

¹ Lauks Testing Laboratories, Inc., Seattle, Washington.

pollen, resulting from differences in plant sources, different methods of analysis, and different seasons of the year. It is also of importance whether pollen was gathered by bees or collected by hand directly from the flower (Herbert and Shimanuki 1978). Table 1 gives a broad outline of the components of mixed pollen. Other analyses of the pollen of diverse species are reviewed by Stanley and Linskens (1984). The data reviewed by these authors shows that the content of protein, fat, phosphorus and iron makes pollen's nutritive value comparable to that of dried beans, peas and lentils while it contains even more calcium and magnesium than legumes. Pollen gathered by bees is particularly rich in vitamins, with a far higher concentration of pantothenic acid, compared to beef, eggs, cauliflower, potatoes and tomatoes. During the summer, the concentration of nicotinic acid in blended pollen rises close to that of beef and beef liver. Such pollen contains more nicotinic acid than peas and dried beans and is surpassed only by yeast and wheat bran. Pollen's ascorbic acid content is similar to that of fresh lettuce, endive, cooked potatoes and tinned tomatoes. No other plant material but yeast contains more riboflavine. Therefore pollen's riboflavine content compares to that of skimmed milk powder.

Like other plant material pollen contains little of vitamins E and D but features a high content of vitamin B 12, the latter being one of the reasons for using pollen as a pharmaceutical preparation (Tull 1987).

How can pollen's importance as foodstuff be evaluated? To answer this question one has to distinguish between the direct, intended and the indirect, non-intended intake of pollen.

POLLEN CONSUMPTION

DIRECT INTAKE

To our knowledge the consumption of pollen has never been part of the European tradition of eating habits, as it has among American Indian cultures. Observers such as Bourke (1892) and Palmer (1878) have related how American Indians made extensive use of pollen as food, often in times of hardship. Coprolites (desiccated human excreta) dating back to the period of 1400–200 B.C. that were found in West Texas caves proved to contain large numbers of pollen grains, i.e., the highly resistant exines, or outer two layers of the pollen wall (Reinhard, Hamilton, and Hevly 1991). The fact that more than 4% of the pollen species analyzed came from entomophilous plants and that one million pollen grains per gram of fecal material were common, suggests that pollen or food containing pollen had been collected to be used for food. Pollen of mustard, cabbage, willow and maize were dominant in the analyzed coprolites. The absence of cuticle or other resistant fragments or evidence for the presence of leaves, roots or tubers suggests intentional pollen consumption.

Clah (1974) described the collection of maize pollen by Navajo women and children in the mornings of calm summer days. The tassels were shaken to liberate the pollen which was then caught in large bowls. This procedure was accompanied by ritual chanting which was supposed not only to keep the pollen fresh but also to ensure a greater yield. The pollen was then sifted and kneaded like dough, which gave it a more yellowish color. After it had been dried in the sun the pollen mass was ground into a fine yellow powder (Clah 1974). Other Indian peoples in the United States were known to collect the pollen of cattail (*Typha* spp.) (Morton 1975; Saunders 1978), which provides an excellent flour that is rich in protein. Pollen has been mixed with wheat flour and used for baking bread (Peterson 1978), or has been cooked with corn-mush or eaten unprocessed. It has been used for thickening soup (Tomikel 1976), preparing dough for muffins and for imparting a yellow color to rice dishes and has been dried and stored for winter (Tull 1987).

SACRED POLLEN

Among many American Indian tribes pollen played an important role at religious ceremonies

(Bourke 1892; Clah 1974; Tull 1987) and one of the most important contents of the Apache medicine bundle was cattail pollen, known as "Hoddentin" or "Hadentin," meaning "cattail powder." A century ago, Apache men on raids are reported to have carried a small pouch of this precious powder on them and to take pinches of it to forestall exhaustion. A pollen brew or an extract of pollen was also known to be a refreshing beverage (Bourke 1892).

Aztecs made use of pollen: "Yiauhtli," i.e., ragweed pollen, was sprinkled onto the faces of captives who were to be sacrificed (Newman 1984). Heyden (1987: 117) interprets the description by the sixteenth century author, Sahagún, of the material used in this ritual as a "powder made of yauhtli . . . *Tagetes lucida*."

Ragweed pollen was also given to the Aztecs' divine king Moctezuma as an offering while pollen cake was offered to the war-god Huitsilopochtli. Women of Minorca are said to have smeared their faces with pollen at summer solstice in an effort to win back their lost youth—an idea that seems to have survived and found its way into modern cosmetics in the shape of pollen facial masks. Modern artists like Wolfgang Laib, born in 1950, have discovered pollen as an artistic medium (Newman 1984).

INCIDENTAL INTAKE OF POLLEN

The most important form of incidental oral intake of pollen is commonly overlooked: the consumption of flowers or buds (Clifton 1984). When eating capers, the flower buds of the caper shrub, (*Caparis edulis* L.), pollen grains may either still be contained in their anthers or retained by the closed bud itself.

With the growth of interest in cooking with florets (Clifton 1984; Haule 1972) and the use of herbal teas such as orange blossoms or camellia flowers (*Camellia sinensis* L.) or drinking camomile tea has come an increase in the incidental consumption of pollen. Caution in this regard, however, is warranted in view of reports of strong allergic reactions (Lewis 1992) both to camomile tea (Benner and Lee 1973; Casterline 1980; Subiza et al. 1989) and to camomile inhalation (Senff et al. 1989).

Whole *Calendula officinalis* L. (pot marigold) florets, including the pollen, is used as yellow food dye in place of saffron. In Italy the fresh zucchini fruit (summer squash, *Cucurbita pepo* L.) is much used as a vegetable. Its withered

florets still hanging from the fruit are rich in pollen. Candied flowers of the violet (*Viola odorata* L.) contain pollen, as do the buds of the garden nasturtium, or Indian cress (*Tropaeolum majus* L.) which are a popular substitute for the more expensive capers. Borage (*Borago officinalis* L.) flowers taken in wine have been used to treat hypochondria while pollen of dandelion (*Taraxacum officinale* Weber) and red flame lily (*Hemerocallis aurantiacum* L.) have been used as food coloring. Elderberry inflorescences (*Sambucus niger* L.), either with their pollen just released or still contained in the anthers, can be dipped in dough and fried. In China, pollen is administered in capsules, tablets and pastes and in the preparation of wine and soft drinks (Xu and Zhuang 1991). Amongst American Indians in the southern part of the USA inflorescences of the epiphytic *Tillandsia erubescens* (Laferriere, Weber, and Kohlhepp 1991) are prized for their sweetness.

POLLEN CONTAINED IN HONEY

Pollen contained in honey may be considered a biological contamination if it got there with the pollen pellet or with the nectar. Honey may also have been contaminated while being extracted, handled and drawn off by the beekeeper.

Pollen found in honey may be instrumental in helping to determine the origin of a particular lot of honey (Stanley and Linskens 1984) because pollen grain exines are often species specific and can be identified and counted. Thus honey extracted from lavender (*Lavandula*), robinia (*Robinia*) and clover (*Trifolium*) contains about 20000 pollen grains/10 g honey while honey from heather (*Erica*), plumtree blossoms (*Prunus*) or dandelion (*Taraxacum*) contains some 50000 pollen grains/10 g. More than 100000 pollen grains/10 g can be found in honey from rape (*Brassica napus* L.), chestnut (*Castanea*) and buckwheat (*Fagopyrum*).

The presence exotic pollen grains in a honey sample indicates that it must have been imported. Hence adulteration of honey can be detected, but the addition of local pollen to imported honey may conceal its origin. The fact that honey is generally contaminated with pollen means that any consumer ingesting honey necessarily eats pollen as well. The exact amount of pollen being consumed depends not only on the specific kind of honey, but may also be influenced by the way honey is drawn off, with pollen likely to sedi-

ment when honey is strained or left to stand for a longer while. Batches where pollen was allowed to sediment therefore are found to possess a far higher pollen content than those drawn off immediately. The chemical and physical properties, like viscosity, specific gravity and sugar concentration, are also likely to be factors which determine the pollen content of honey. In summary, one can say that consuming honey necessarily means consuming pollen; it is little wonder that a honey allergy may in fact be a concealed pollen allergy (Helbling and Wüthrich 1987; Helbling et al. 1992).

POLLEN AS MEDICINE

According to the "Bundesanzeiger" (No. 11 of 17 January 1991) the German Federal Board of Health has officially recognized the use of pollen as medicine. Pollen of various flowering plants—either as crude pollen or as a preparation in appropriate dosage—may be administered as an invigorating tonic against general debility or against lack of appetite. Pollen has been administered in cases of chronic prostatitis and has been reported to be helpful (Ask-Upmark 1963; Becker and Ebeling 1988; Buck and Ebeling 1992; Buck et al. 1989; Denis 1966; Krieg 1988; Seito 1967). Thus in urology "Cernitol," an extract of rye pollen, is made use of as an anticongestive. Although the exact mode of action is still obscure, evidence gained from experiments suggests that the extract's liposoluble fraction contains the material responsible for inhibiting the biosynthesis of prostaglandin and leukotrienes. Loschen and Ebeling (1991) found it is fair to assume that if it is administered as a drug in cases of benign prostatic hyperplasia pollen is capable of acting as an anticongestive and antiphlogistic and of producing relaxing and antiproliferative effects.

Georgieva and Vasilev (1971) reported that bleeding gastric ulcers responded well to a pollen cure during an examination of 40 patients who were administered a daily dose of 250 mg of pollen twice daily. Only pollen collected by bees was used in these treatments and unlike that collected directly by humans the pollen contained in a pellet is blended with a bee's endogenous substances. Chinese experiments (Peng et al. 1990) investigating the effectiveness of pollen as a drug against hypobaropathy (high altitude disease) used rats and mice kept under low partial oxygen pressure to simulate an altitude

of 12000 masl. Those animals that were fed various pollen species, cattail (*Typha* sp.); maize, (*Zea mays* L.); field bean (*Vicia faba* L.); sunflower, (*Helianthus annuus* L.); buckwheat, (*Fagopyrum esculentum* Moench), and *Sapium sebiferum* (L.) Roxb., proved to have higher survival rates than control animals which had not been fed pollen. Tests with humans carried out in two different years demonstrated that subjects who had been administered pollen 3–7 days prior to moving to an altitude of 5000 m above masl showed either no symptoms of hypobaropathy or far less than other test individuals who had taken no pollen or had been given other drugs. Peng and co-workers concluded that consuming pollen can increase the ability to adapt to high altitudes with low oxygen content.

Although literature advocating naturopathy (e.g., Gulden 1978; Schilcher and Gärtner 1990; Schmidt 1973, 1974) suggests numerous other ranges of application, there is only partial clinical evidence to support these. Hernuss (1975) mentions one case where a pollen diet was used as an adjuvant during radiotherapy of gynecological carcinomata. Pollen gathered by bees has also been administered orally to patients suffering from pollen allergy. In these cases of oral immunotherapy (desensitization), it has been claimed, pollen may possess an immunogenic effect (Stickl 1980).

NUTRITIVE VALUE

While pollen's therapeutical value is still being discussed, its nutritive value for animal organisms has never been disputed. Apart from bees there are numerous other insect species—even predaceous mites—which make use of pollen as a food alternative. Yet for Phytoseiidae, i.e., herbivorous mites, its nutritive value is dependant on the kind of pollen consumed (Baier and Karg 1992).

The same applies to the bee: different pollen species have different nutritive values (Stanley and Linskens 1984). Best results can be obtained when a bee is fed with a pollen blend. Pollen collected by bees possesses a higher value than pollen collected by hand. The reasons for discrepancies in nutritive value between various pollen species still remains obscure. The nitrogen content, especially the amount of soluble proteins and amino acids, seems likely to be the decisive factor. Additionally, pollen of ento-

mophilous plants has a higher nutritive value than pollen from anemophilous plants.

Pollen can also be extracted from honeycombs, but such pollen which has been stored in the comb cells and which is commonly known as bee bread has already been transmuted by biochemical processes. Fermentation has led to an enrichment of lactic acid thereby conserving the pollen with the acid content rising from 0.26% to 1.78% and the average content of water soluble protein increasing from 2.9% to 5.6%. Pollen collected by bees possesses higher bactericidal qualities than pollen collected by hand. This may partly account for the antiseptic effect of honey in connection with skin grafting surgery which has been reported recently (Subramanyam 1991).

In this context mention must be made of pollen preparations that are commercially available, as organically transformed pollen which apparently have been exposed to in vitro simulations of enzymatic processes, which normally take place inside the bee hive as well. This again is reflected both in the chemical composition and in the differences in nutritive value between such pollen gathered by bees and pollen subsequently transformed to be stored in combs (Herbert and Shimanuki 1978).

There are only a few clinical and experimental studies that evaluate the nutritive value of pollen in a quantitative way but it seems that depending on the different species of pollen the protein content may range between 5% and 30%, the carbohydrate content between 10% and 40% and that of lipids may be estimated at between 1% to 5%.

Carbohydrate and lipids contained in pollen may contribute to man's food intake. The same applies to the intake of protein. The daily demand of protein of a person weighing 70 kg ranges between 20 and 26.5 g of completely absorbed and transformed protein which is equivalent of 28.5% to 38% protein with a net protein utilization (NPU) of 70% (Tracey 1989). This demand can be met by taking 90 g of pollen per day without having to look for alternative sources of protein. Although this seems not a very likely case—unless we are dealing with a fanatic beekeeper—it is noteworthy that at least part of the man's protein supply can be covered by pollen which therefore must be considered as a supplementary food of potential value (Stanley and Linskens 1984).

In experiments on mice and rats the administration of pollen was reported to have led to an acceleration in growth while smaller quantities administered over a one year period were reported to produce a fertility increase of 70% compared to the control group (Talpay 1981). Furthermore (Bell et al. 1983) reported a favorable amino acid pattern in pollen protein. Some pollen species, however, e.g., some eucalyptus, are hard to digest which suggests the limitations of pollen as foodstuff.

The fact that oral consumption of pollen may not only cause acute hypersensitivity (Cooper et al. 1984; Prichard and Turner 1985; Taudorf and Weeke 1983; Urbanek et al. 1983) but could even lead to acute allergic reactions (Cohen et al. 1979) and anaphylactic shock (Mandsfield and Goldstein 1981) must be considered even more problematic.

POLLEN AS SUPPLEMENTARY FOODSTUFF

Popular literature (e.g., Binding 1980; Bown 1980; Caillas 1959; Caillas and Ronneburg 1989; Hedgepeth 1977; Lauermann 1977; McCormick 1973; Nigelle 1977; Talpay 1981) suggests that pollen as an "alimentary miracle" could be made use of in a number of cases: for inducing appetite, during slimming treatments, against indigestion and neurasthenia, brain damage, and disturbance of growth. There are, however, either no clinical studies to support these applications or such studies were published at inaccessible places in inaccessible literature (e.g., Wang 1986; Xu and Zhuang 1991). It must be stressed that pollen cannot be compared to "drug-taking." The specific effects of pollen are much rather due to the various components, which depending on the season of year, the method of gathering and on the kind of pollen, may have different mechanisms of action.

POLLEN HARVEST

This leads to the question, how pollen can be procured. It is commercially available and the 1988 edition of the "Rote Liste," the German equivalent of the *Physician's Desk Reference*, lists numerous commercially produced pollen medicaments for oral or subcutaneous application. All are based on pollen collected by bees or by hand.

Bees while foraging use a somewhat complicated technique creates a pollen pellet. On returning to the beehive these pollen pellets are

stripped off by pollen traps and are collected in the trap box. Depending on the origins of the pollen grains the pollen pellets are differently colored with some even showing stripes if a forager had visited several different flowers during the same collecting flight. The pollen remaining with the bee is then digested in its midgut (mesenteron) where proteolytic enzymes are detectable. The bee utilizes pollen as a source of protein.

Because collecting pollen by hand is so labor intensive it is not very likely to be found in a commercial preparation at the present time.

POLLEN INSIDE THE HUMAN BODY

After pollen has reached the digestive tract the pollen grains start to swell. Due to the uptake of water they increase in size and are enzymatically activated. As could be established so far the process subsequently initiated may be compared to a normal germination. Apart from this, the material contained in the walls of the pollen grain, i.e., pigment, enzymes and allergens are leached out and the acid environment of the stomach causes the intine, i.e., the inner layer of the grain's wall to evaginate. This leads to the formation of structures similar to a germinating pollen tube (Linskens and Mulleneers 1967).

When the swelling process has begun, pollen grains break up and release starch grains which are coated by protein lamella which may be allergenic (Suphioglu et al. 1992). Under the influence of enzymes of the gastrointestinal tract digestion of the pollen proteins, polymer carbohydrates, and lipids takes place. The unbound elements, i.e., sugar, amino acids, vitamins and fatty acid, are subjected to the normal process of resorption.

From the gastrointestinal tract pollen may directly enter the blood stream. Direct absorption of particles between 5 and 200 μm from the epithelial cells of the intestinal wall into the blood flow, persorption, has been detected in dogs, rabbits and humans. After an oral intake of large amounts of pollen grains, e.g., 100–150 g, at least 6000 to 10 000 pollen grains per individual were absorbed into the blood stream where they could be detected by electron microscopy. After various intervals the exine was gradually decomposed (Jorde and Linskens 1974).

Experimental studies on pollen digestibility have been carried out by Franchi (1987) and collaborators, both in vitro and in vivo with hazel

(*Corylus avellana* L.) pollen. The in vitro test has been performed in prolonged contact with HCl or NaOH₃ solutions with addition of surface active agent, or were carried out with digestive enzymes: pepsin, papain and diastase, pancreatin and pancreatic lipase in optimal pH conditions. For the in vivo test mice were utilized, to which a water suspension of pollen was administered by means of gastric intubation. Both in vitro and in vivo experiments delivered the same results: Digestion is time dependant. Substances located on the external surface of the grains and in the poral area, the exine cavities or intine tubules are easily reached by the enzymes and digested. With the in vitro applied enzymes the cytoplasm was not digested. The emptying seems to go on from the pore region to the interior of the pollen grain.

Further experiments of this type need to be carried out with other enzyme systems and with other animals and other pollen species, in order to obtain information about the products of digestion, which may be of nutritional interest. Such experiments could result in a sort of classification of pollen digestibility and their actual utility as food and feed and medicine.

The exines of the pollen grains however cannot be decomposed within the gastrointestinal tract which accounts for the existence of exines in coprolites. Very few animals and microorganisms are capable of enzymatically disintegrating the highly resistant sporopollenin which makes up the pollen grain wall. Therefore only the pollen content and the soluble substances stored in the submicroscopic areas of the grain's wall can be utilized as foodstuff.

Insects like some beetles may crush pollen with their mandibles before ingestion, others, following ingestion and germination of the pollen, digest and extract pollen contents. The peach palm beetle (*Cyclocephala amazona*, on the palm *Bactris gasipaes*) ingests trichomes, which possess no nutritional value, to help crushing the pollen walls. These trichomes are specialized cells (brachysclereids) with heavily lignified walls and have a mechanical function within the gut of the beetle analogous to that of the stones used by birds and, as evident in fossil remains, dinosaurs in their digestive tracts.

CROSS REACTIONS

In order to examine a patient's sensitivity to allergens contained in foods it may be important

to determine whether this patient has consumed pollen substances unintentionally. There seems to be evidence of a cross reaction between chamomile tea and pollen of germander (*Ambrosia*) and other compositae pollen probably originating in plants brought from America (Subiza et al. 1989; Lewis 1992). There is clinical evidence that patients suffering from Type I allergy are likely to have an intolerance to fruit and/or legumes (Lowenstein and Erikson 1983; Thiel 1991). Erikson, Formgren, and Svevonius (1982) called the agent responsible "BRRF" (birch-pollen related foodstuff). A birch pollen allergy appears to cross react with apples, carrots and celery tuber (Halmepero and Lowenstein 1985; Wüthrich et al. 1990). With some patients such cross reactions may lead to intolerance of carrots, celery tuber and some herbs.

From RIST (radio-immuno-sorbent test) studies focusing on the immunoglobulin E a link of birch pollen and apple extracts it could be deduced that birch pollen protein and apple protein have common IgE-linking epitopes. The cross reaction of birch and apple pollen allergens are coded by nucleic acids which appear to have a significant homology. These studies (Ebner et al. 1991) support the idea that the antigens of birch pollen and apple possess common epitopes. These antigens are responsible for the IgE-cross reaction causing allergic reactions.

Pollen is a foodstuff suitable for human consumption but if taken by an allergic patient it may have complex implications for that persons immunological processes. Because of this it is strongly advised that a patient's general allergic disposition be analyzed before advocating pollen as supplementary foodstuff. Despite the fact that pollen stores are rich supplies of nutrient which makes it fit for consumption it must be recommended only with restraint because of its allergenic potential.

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BOOK REVIEW

Dwarf Mistletoes: Biology, Pathology, and Systematics. 1996. F. G. Hawksworth and D. Wiens. *Agriculture Handbook 709.* United States Department of Agriculture, Forest Service. Washington, D.C. xiv + 410 pp. (hardcover). Cost not given.

Dwarf Mistletoes is a wonderful book that will be THE resource on dwarf mistletoes for years to come. Beautifully laid out (except, inexplicably, for the front cover with a title difficult to discern against the mistletoe background), this world class monograph is carefully planned, thorough, well documented, and readable. After the succinct introduction, the life cycle of *Arceuthobium* is discussed, emphasizing seedling establishment of the parasite. I find the diagram of the life cycle and the figure of the intriguing ballistic fruits (pages 8 and 9) to be especially useful for classes when discussing fruit dispersal and phanerogamic parasites. Following chapters discuss sexual reproduction, biogeography, host relationships (especially important since dwarf mistletoes are serious forest pathogens), ecology (including biotic relationships other than host-parasite), physiology, pathology, and control. In short, everything you want to know about dwarf mistletoes is here including a table documenting those established

beyond their natural ranges, medicinal uses, etc., etc.

Approximately half of the book deals with taxonomy, including molecular systematics. The “formal taxonomy” section includes distribution maps, excellent color photographs (although some are too dark in my copy), and list of specimens examined. Most helpful, however, are the observations of the authors, both keen students of nature who convey their fascination with dwarf mistletoes even in the “formal taxonomy.” The list of references is exhaustive and the indices functional. This book is in memory of the first author, Frank Hawksworth, who died while this book, a successor to a 1972 edition, was being written. Frank’s enthusiasm, keen observation, and love of mistletoes is appropriately enshrined in this outstanding volume. Every library will want a copy as a resource for foresters, plant pathologists, ecologists, systematists, and students of parasitic plants. Supplies of the 1972 volume ran out. Get yours before the same happens to this even more valuable edition!

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