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Pollen spectrum of Finnish honey

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Abstract. Pollen spectra were analysed on 160 honey samples representing the whole beekeeping area of Finland in the years 1977 and 1978. A semi-quantitative method of pollen analysis based on line counts was developed. It was found efficient for determining the relative numbers of pollen grains in the honey samples.

On average, ca. 16 pollen types were identified per sample. The number of honeydew elements was low in all samples. *Brassicaceae* pollen was the dominant type. The other most frequent and abundant types were pollen grains of *Trifolium repens*+ *T. hybridum*, *Salix* spp., "the *Rosaceae* group" (*Prunus, Malus, Sorbus* spp.), *Apiaceae*, and *Filipendula ulmaria*. These pollen types constituted 90.8 % (1977) and 90.3 % (1978) of all the pollen examined. Between 1960–1963 and 1977–1978 the average proportion of *Brassicaceae* pollen has risen, while the proportion of *T. repens* + *T. hybridum* pollen has decreased, evidently due to the changes in agricultural practices.

The seasonal variation in the pollen spectrum was explained by the weather conditions. Regionally characteristic pollen spectra were not found, although *Brassicaceae* pollen was typical of the honeys of agricultural zones I and II, due to cultivation of *Brassica* oilseed crops in those regions.

The positive correlation of the proportion of *Brassicaceae* pollen with the total pollen count is discussed in connection with the problem of determining the botanical origin.

Introduction

In melissopalynology, the microscopic elements of honey are studied. These are mostly pollen grains of flowering plants, or algae and fungus spores and hyphae mainly present in the original nectar or honeydew.

The pollen spectrum is examined by counting the numbers of different kinds of pollen grains in the honey sample. In qualitative pollen analysis, the results are either presented as frequency classes as first described by ZANDER (1935), or as percentages if the statistical conditions are fulfilled. In quantitative pollen analysis, the absolute pollen counts in a given amount of honey are determined (LOUVEAUX et al. 1970, 1978).

The objective of the study may be to find out the geographical origin of the honey, or the floral sources (botanical origin), to determine the season of production, or to identify honeydew honeys. The main problem in analysing the botanical origin of honey is that different nectar plants yield different amounts of pollen to honey in the same amounts of nectar. Thus, a direct correlation may not be assumed between the pollen and nectar contributions of a plant to the honey.

MARTIMO (1945) published the results of pollen analysis of 21 Finnish honey samples and discussed their botanical origin. AARIO (1961) studied the pollen spectra of 85 Finnish honeys in order to describe the regional conditions for beekeeping. PUROKOSKI and FORSIUS (unpulished[1]) analysed 120 samples in 1962-1963, their main interest being the chemical composition.

The purpose of this study was to describe the average pollen spectrum of Finnish honey, and to analyse the most important factors responsible for its variation. The problem of determining the botanical origin is briefly discussed; this is still under study, and the results will be published later.

Material

The material originated from the years 1977 and 1978. The request for a honey sample, with instructions regarding the sampling procedure, was mailed to 83 beekeepers in 1977. They were selected from the registers of the beekeeping associations so as to provide regionally representative honey material (see Fig. 2). The provincial distribution of the honey samples did not differ from the distribution of active beekeepers reported by RIKALA (1976) (Goodness of fit test: $X^2=13.1<\chi^2_{.05}(v=8)=15.5$).

In 1977, 66 beekeepers replied (80 %). In 1978, in order to obtain samples comparable to those of the previous year, the request was repeated to these 66 active beekeepers, 45 of whom replied (68 %). In addition, five beekeepers participated in 1978 alone. Thus, 71 beekeepers with a total of 81 apiaries participated: 46 apiaries provided samples in both the years, 28 only in 1977, and 7 only in 1978. From each apiary, one to three honey samples and answers to a questionnaire about the apiary were received.

Honey samples

A total of 160 samples was collected:

	1977	1978	Total
From apiaries participating both years	62	61	123
From apiaries participating only one year	29	8	37
Total	91	69	160

[1]) PUROKOSKI, P. & FORSIUS, A. Suomalaisen hunajan koostumuksesta ja siihen vaikuttavista tekijöistä. Manuscr. 60 p. Material originating form 1962, 1963. State Inst. Agric. Chem., Helsinki.

Each sample contained ca. 2 kg of honey. As a request was made for separate samples from each collection in the season, occasionally even three samples per apiary were received. The majority (75 %) of the beekeepers removed the honey only once, at the end of the season, and thus sent one sample only to represent the whole season. The samples were stored in a freezer at – 15 °C.

Inquiry

A questionnaire was employed. In addition to the location of the apiary, the most important information required was: the date of removing the honey, the honey yield, the number of colonies, the race of the bees and the probable nectar sources.

Weather

The season, especially spring, was more favourable for bees in 1978 than in 1977 (Table 1). At the end of August, the growing season was one week more advanced in 1978 than in 1977, as measured by the effective temperature sum (Σ °C > + 5 °C). The effective temperature sum reached at the end of September in 1977 was 85 % of the normal value for the growing season, and in 1978 it was 95 %.

Table 1. Temperature (°C) and hours of sunshine in Finland in May- August 1977 and 1978 (ANON. 1977a, 1978a). Average deviations form normal temperatures are weighted according to the distribution of the honey samples. (Means of 17 weather stations, see Fig. 2.)

	Temperature		Mean	Hours of sunshine	
	1977	1978	1935–1960	1977	1978
May	0	+1.2	8.1	214	327
June	+0.1	+0.4	13.4	290	287
July	−1.9	−1.6	16.7	193	234
August	−1.3	−1.8	15.0	211	179

Methods

Pollen analysis

The honey sample was dissolved in water, and the solid particles were centrifuged for the microscopical analysis. The pollen grains and honeydew elements were identified and counted. The method was semiquantitative, modified from the quantitative method of Z. Demianowicz (LOUVEAUX et al. 1978).

Preparation of slides. From the original honey sample a 10 g subsample was taken and dissolved in 20 ml of distilled water, and centrifuged for 10 min at 3 500 r/min, after which the supernatant liquid was drawn off. A further 10 ml of water was added to the sediment and centrifuged 5 min at 3 500 r/min, after which the liquid was drawn off. The sediment was transferred with a capillary pipette to a microscope slide, and dispersed evenly over an area of 20 mm × 20 mm. The slide was dried for 24 h at 30 °C. The mounting medium was glycerine jelly.

The reference slides of 135 species of flowering plants for identifying the pollen grains were prepared by the method described by LOUVEAUX et al. (1970).

Counting and identifying the microscopic elements. On each slide, all the pollen grains and honeydew elements were counted and identified on a 20-mm line across the 20 mm × 20 mm square. The eyepiece micrometer (Leitz Wetzlar SM-Lux: eyepiece Periplan GF 12.5×M, objective Phaco NP1 40/0.65) was used as the line indicator. Particles that were only adjacent to the scale of the micrometer were also included. The line was always started at the same distance from the edge of the square (Fig. 1). The use of the same kind of line in each sample gave a basis for quantitative comparisons. This was considered to be an important advantage of the method.

From each honey sample two slides were prepared. The accuracy of the counts was evaluated by comparing the results of the parallel counts in a sample of 14 pairs of slides. The total numbers of pollen grains counted on the two parallel slides correlated statistically very significantly with each other ($F_{(1,13)}=104.4^{***}$, $r^2=89$ %). Thus, two slides and counts per honey sample gave a reliable estimate of the pollen spectrum of the sample.

The pollen types were identified with the aid of the reference slides. The pollen of *Myosotis* spp. was not counted, because it is highly over-represented (e.g. MAURIZIO 1949, DEMIANOWICZ 1961, LOUVEAUX et al. 1970). The occurrence of *Myosotis* pollen was noted, however. The other pollen types were grouped into the pollen of nectariferous and non-nectariferous plants, according to the information available in the literature (e.g. CRANE

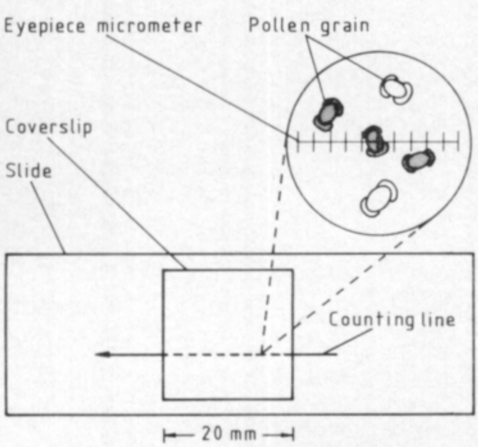

Fig. 1. The line method for counting the microscopic elements. In this schematic visual field three pollen grains (the darkened ones) were included in the count.

1975, HANSSON 1976, HOWES 1979). The honeydew elements were identified according to the instructions given by ZANDER and MAURIZIO (1975).

The results are given as means of the parallel counts. By the proportion of a pollen type is meant the percentage of its grains in the total pollen count. The mean of the proportions is called the average proportion of the type. As the proportions are of minor informative value and the average proportions may be misleading, the proportions were calculated only for comparisons with earlier studies in which they were used. By frequency of a pollen type the number (or percentage) of samples in which it was observed is indicated.

Processing the data

The samples of 1977 and 1978 were mainly treated separately. The variation in the pollen spectra was analysed separately for the two seasons. The factors considered were: intercorrelations between pollen types, annual variation, regional variation, and variation connected with the bee race.

To study the annual variation, only those apiaries were included from which one or more honey samples were received in both 1977 and 1978. Thus, the annual comparisons were based on 62 samples in 1977 and 61 parallel samples in 1978. The regional division adopted in studying the regional variation is based on the length of the thermal growing season. It is used by the National Agricultural Extension Organisation in the recommendations for field crop varieties. The zones are numbered from south to north: Zone I, Zone II, Zone III and Zones IV+V (Fig. 2). In the statistical analysis, three groups of bees were distinguished: Italian bees (*Apis mellifera ligustica* Spin.), dark bees (*A. m. mellifera* L.) and bees of mixed race.

The statistical analyses were done by the H-programmes of the Computing Centre, University of Helsinki.

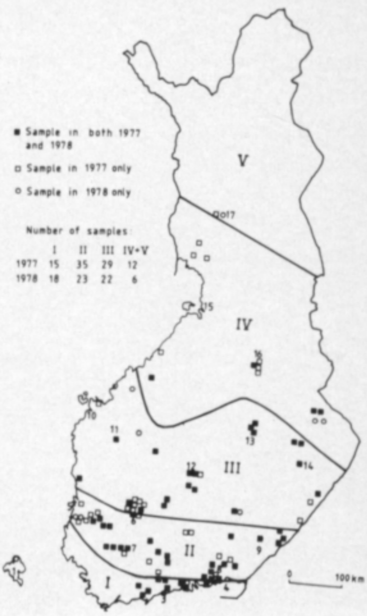

Fig. 2. Distribution of the honey samples in the agricultural zones I-V. (The weather stations are numbered from 1 to 17, means given in Table 1.)

Table 2. Distribution of the apiaries and the honey samples by the race of the bees (%).

	1977		1978	
	Apiaries	Samples	Apiaries	Samples
Italian bees	49	46	51	48
Dark bees	10	13	13	14
Caucasians	2	3	2	3
Bees of mixed race	39	38	34	35
Total	100	100	100	100

The inquiry: results and discussion

Of the honey samples, 47 % were produced by Italian bees, 37 % by bees of mixed race, and the remaining 16 % mainly by dark bees (Table 2). According to the data of RIKALA (1976), the material was racially representative of Finnish bees.

The average size of the participating apiaries was 6.6 colonies in 1977 (71 answers) and 6.0 colonies in 1978 (50 answers). In 1975 the average in Finland was 4.4 colonies per apiary (RIKALA 1976).

Sixty-five per cent of the honey samples were extracted in August (Fig. 3). The majority of the beekeepers removed the honey only once, at the end of the season: 77 % in 1977 and 70 % in 1978.

The honey yield varied from 3 to 90 kg/colony. The average yield of the apiaries participating in both the years was 29 kg/colony in 1977 (50 answers) and 37 kg/colony in 1978 (41 answers). The difference between the years, 20.6 % units, was significant ($t_{(89)}=2.16^{*}$). As the weather was less favourable for bees in 1977 than in 1978, the honey yields were smaller. Weather is the key factor for the honey yield (RIKALA 1976). – The way in which the material was collected may be considered to have been selective for more active and interested beekeepers than average. This is probably reflected in the data on the number of colonies and the yield per colony.

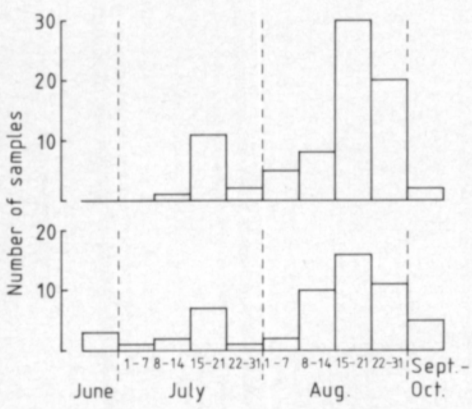

Fig. 3. Distribution of the honey samples according to the time of removal of the yield. (Only samples with exact date are included.)

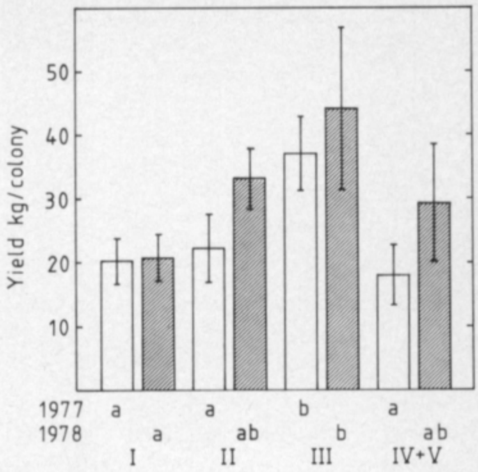

Fig. 4. Average honey yields in zones I–IV+V in 1977 and 1978 (shaded). In this and the following figures means followed by different letters are significantly different at the 5 % level, Tukey-Kramer method. The vertical lines indicate standard deviations.

The honey yields showed significant regional variation, being lowest in Zone I and in Zone IV+V (Fig. 4). No generalizations should be made from these, as only two seasons were observed. However, it seems at least that southern Finland is not in a more advantageous position for beekeeping than the central parts of the country (see also RIKALA 1976).

According to the beekeepers, the most important honey-yielding plants in May were: *Salix* spp., *Taraxacum* spp. and *Tussilago farfara* L., and in June: *Taraxacum* spp., *Rubus idaeus* L. and *Malus domestica* Borkh., and in 1978 also the cultivated *Ribes* spp. In June the wild forest berries, *Vaccinium* spp., were often mentioned, but e.g. *Prunus padus* L. and *Sorbus aucuparia* L. were listed only seldom.

In July, the most important plants were said to be *Epilobium angustifolium* L. and *Trifolium* spp., followed by *Rubus idaeus* and in 1978 also by the cultivated oleiferous *Brassica* spp., rape and turnip rape. In August, the most important crop plants listed were *Epilobium angustifolium* (also in July), followed by heather *Calluna vulgaris* (L.) Hull and *Trifolium* spp.

Results of pollen analysis

General description

Appendix 1 gives the annual means and standard deviations of the pollen counts, the frequencies of the pollen types in the material, and the zonal means of the counts for each pollen type and for the honeydew elements.

A total of 70 pollen types were identified. Of these, 26 were identified to the species level, 37 types to the generic level, and 7 to the family level. The number of new pollen types found decreased progressively with the number of samples examined (Fig. 5). The number of pollen types found in a sample ranged from 7 to 30, averaging 16 (1977) and 18 (1978). Most types represented nectariferous plants. One quarter represented non-nectariferous plants, the commonest of these being the wind-pollinated *Alnus*, *Betula*,

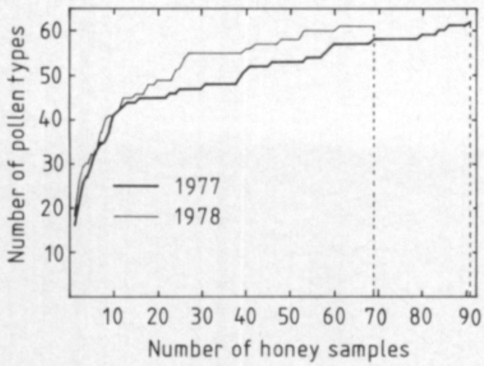

Fig. 5. Number of the pollen types found in relation to the number of samples examined.

Rumex, Plantago spp. and *Poaceae,* and the insect-pollinated anemones (*Anemone, Hepatica,* or *Pulsatilla* spp.).

When the overall mean is taken as 100, the lowest total pollen count was 6 and the highest 414. *Myosotis* pollen was found in 5 % (1977) and 20 % (1978) of the samples. The numbers of honeydew elements found in a sample averaged 15 (1977) and 12 (1978); in all samples, the number of pollen grains exceeded the number of honeydew elements.

The nine clearly most frequent and numerous pollen types (Fig. 6) constituted 90.8 % (1977) and 90.3 % (1978) of all the pollen examined. Of this, the proportion of *Salix* pollen was 6 % in 1977 but 18 % in 1978. The *Brassicaceae* alone were represented by 47 % (1977) and 39 % (1978) of the grains counted. The count of *Trifolium repens* L. + *T. hybridum* L. was

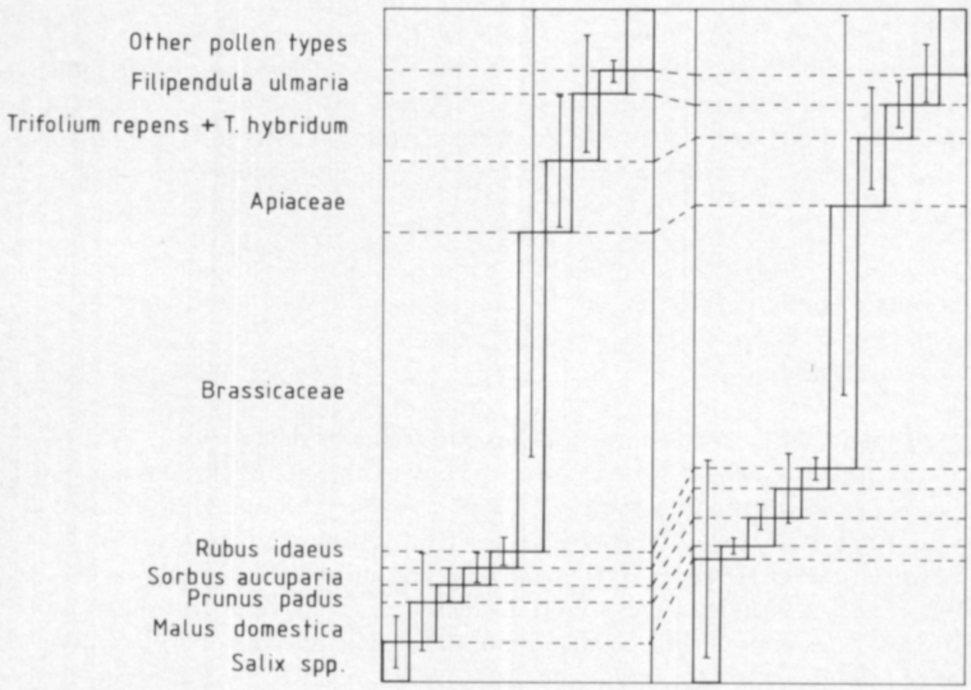

Fig. 6. Relationships of the average counts of the different pollen types. (The order of the types is roughly according to the flowering periods. 1977 left, 1978 right.)

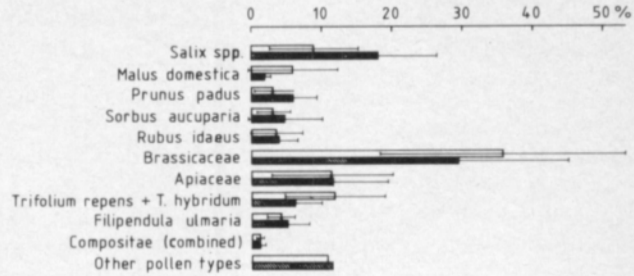

Fig. 7. Average proportions of the pollen types in 1977 and 1978 (shaded).

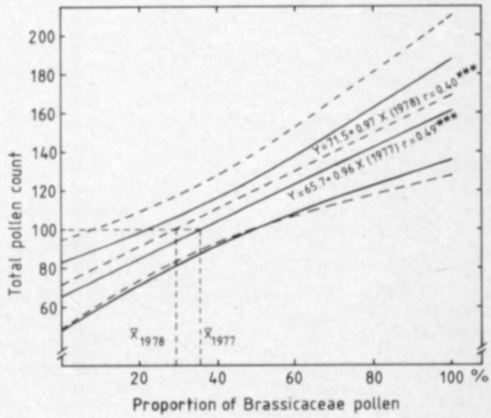

Fig. 8. Regression of the total pollen count on the proportion of *Brassicaceae* pollen. The mean $\bar{y}$ is treated as 100. 95 % confidence limits for the estimated mean of y are given.

lower, but the frequency of this type was higher: it was found in every sample. Pollen grains of *Prunus padus, Malus domestica, Sorbus aucuparia* and *Rubus idaeus* ("the *Rosaceae* group") were numerous, but the species were difficult to distinguish from each other by the microscopic procedure. The counts given for pollen types within the group should be considered estimates. The counts of *Apiaceae* pollen and pollen of *Filipendula ulmaria* (L.) Maxim. were almost the same in the two years. The deviations of the pollen counts were high due to the positive skewness of the frequency distributions.

The picture of the quantitative relationships of the pollen types obtained by averaging the pollen counts (Fig. 6) differed from that obtained by averaging the proportions (Fig. 7). E.g. the average proportion of *Brassicaceae* pollen was 36 % (1977) and 30 % (1978).

Total pollen count in relation to *Brassicaceae* pollen

The total pollen count was positively correlated with the proportion of *Brassicaceae* pollen (Fig. 8). The coefficient of determination was 24 % (1977)

and 16 % (1978). The regression line obtained in 1978 was similar to that obtained in 1977.

Relation of *Salix* pollen with other pollen types

Especially in 1978 the counts of pollen of *Alnus, Betula, Acer* spp. and anemones were positively correlated with the count of *Salix* pollen (t-test, H_o:ϱ=0). The correlation coefficients and the levels of significance were:

		1977 (df=89)	1978 (df=67)
Salix	– *Alnus*	.391***	.507***
	– *Betula*	.160	.302*
	– *Acer*	.077	.391***
	– anemones	–	.270*

Annual variation

On average, the number of pollen types in the 1978 samples exceeded the number in the 1977 samples by three (t(114)=3.98***).

Pollen of anemones was found only in 1978 samples, and the pollen of *Caragana arborescens* Lam. and *Liliaceae* was also almost restricted to that year. The total count of pollen of non-nectariferous plants was higher in 1978 than in 1977 due to *Rumex* and *Plantago* pollen (App. 1).

The average count of *Salix* pollen was higher in 1978 than in 1977. *Malus domestica* pollen occurred in higher quantities, although less frequently, in 1977 than in 1978. Pollen of *Trifolium repens* + *T. hybridum* was best represented in the 1978 samples (Table 3).

Table 3. The statistically significant changes in the counts of the pollen types from 1977 (n=62) to 1978 (n=61) (t-test), and the corresponding changes in frequencies.

	1977	1978	Change	t-value	f
Salix spp.	35.5	116.8	+81.3	3.21**	+11
Malus domestica	52.8	11.2	−41.6	2.64**	+23
Trifolium repens + *T. hybridum*	71.9	28.5	−43.4	2.26*	–

Regional variation

The total pollen counts of the honey samples (Fig. 9), and the counts and frequency of *Brassicaceae* pollen (Fig. 10) were highest in the southern samples and lowest in the northern samples. Especially in the southern samples, the annual variation in the occurrence of *Salix* pollen was evident (Fig. 11A). Regional differences in the average counts of *Prunus padus* pollen was

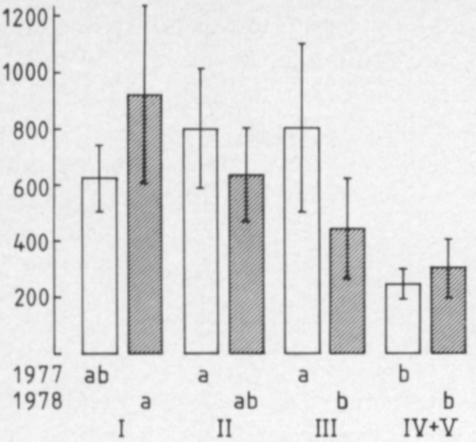

Fig. 9. Zonal averages of the total pollen counts in 1977 and 1978 (shaded). 5 % level, Tukey-Kramer method.

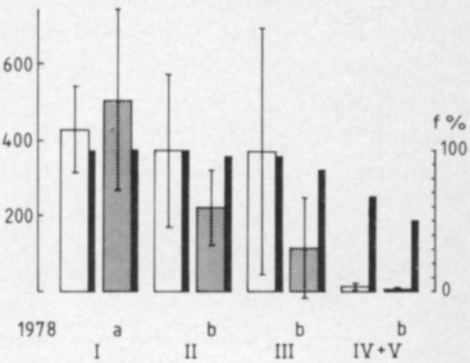

Fig. 10. Zonal averages of the count of *Brassicaceae* pollen in 1977 and in 1978 (shaded). 5 % level, Tukey-Kramer method. Black columns indicate the frequencies of samples containing *Brassicaceae* pollen.

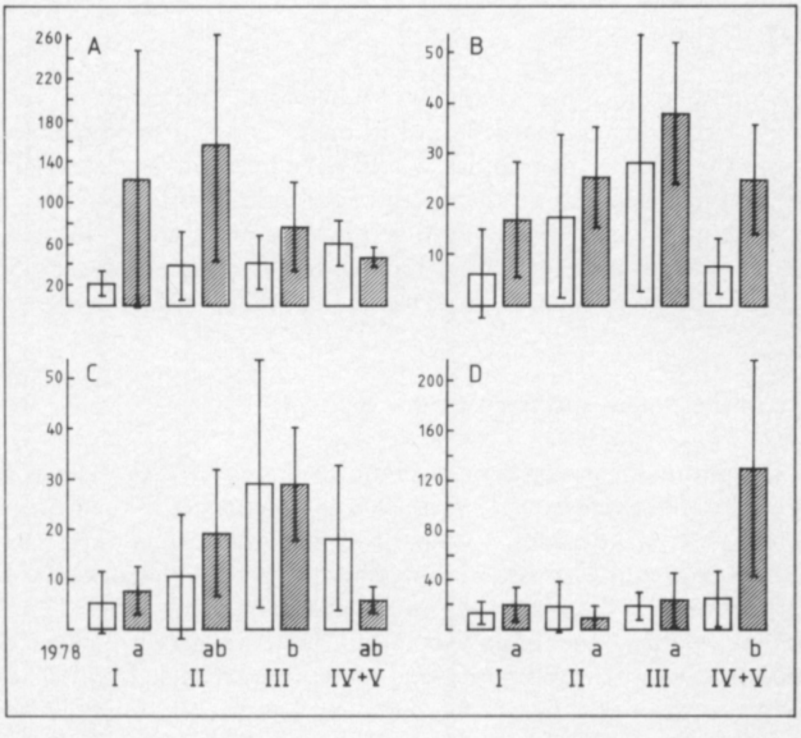

Fig 11. Zonal averages of the counts of pollen of *Salix* spp. (A), *Prunus padus* (B) *Rubus idaeus* (C), and *Sorbus aucuparia* (D) in 1977 and 1978 (shaded). 5 % level, Tukey-Kramer method.

almost the same in 1978 as in 1977, although the variation was not significant (Fig. 11B). Pollen of *Rubus idaeus* was most abundant in the samples from Zone III (Fig. 11C), and pollen of *Sorbus aucuparia* in the samples from the northernmost Zone IV+V in 1978 (Fig. 11D).

None of the pollen types was characteristic of only one region, and the number of pollen types found in the samples from the different regions tended to be the same.

Variation connected with the race of bees

Compared with the honey produced by Italian bees, the honey produced by bees of mixed race had a total pollen count that was 7.0 % units higher in 1977 ($t_{(74)}=1.99^{*}$) and a *Brassicaceae* pollen count that was 57.5 % units higher in 1977 ($t_{(74)}=2.76^{**}$) and 57.1 % units higher in 1978 ($t_{(55)}=2.22^{*}$). On the other hand, the *Salix* pollen count in the 1978 samples was 69.7 % units higher ($t_{(55)}=2.26^{*}$) in the honey of Italian bees, than in the samples produced by bees of mixed race.

Discussion

Number of pollen types

The number of honey samples studied was sufficient to reveal the commonest types of pollen in Finnish honey. Any further types found by increasing the number of samples would have been only occasional. As the number of types depends on the depth of taxonomic differentiation, it is not directly comparable with the results of previous studies. However, the average number of pollen types in Finnish honey does not differ essentially from that in other European honeys (see MAURIZIO 1978).

Change in the pollen spectrum from 1960 to 1978

Of the dominant pollen types in Finnish honey, *Brassicaceae* pollen and pollen of *Trifolium repens + T. hybridum* show changes in their proportions during the past two decades. Comparison with the results of AARIO (1961) and PUROKOSKI and FORSIUS (unpublished) fails to reveal any clear changes in the proportions of the other most common types (Fig. 12). Besides *Brassicaceae* pollen, the grains of "the *Rosaceae* group", *Apiaceae* and *Filipendula ulmaria* show slight rising tendencies in their frequencies.

The proportion of *Brassicaceae* pollen has grown together with the acreage of cultivated turnip rape, *Brassica rapa* L. ssp. *rapa* v. *oleifera* (Fig. 13). Winter turnip rape was earlier considered to be an important bee plant in Finland (AARIO 1961, PUROKOSKI and FORSIUS, unpublished). With the

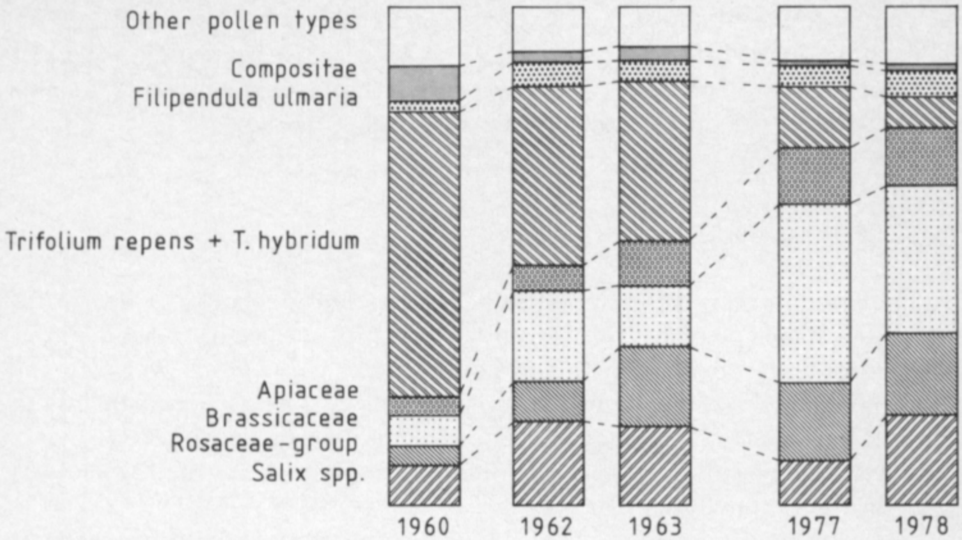

Fig. 12. Relationships of the average proportions of the commonest pollen types in Finnish honey samples in 1960 (AARIO 1961), 1962 and 1963 (PUROKOSKI and FORSIUS, unpublished), and in 1977 and 1978.

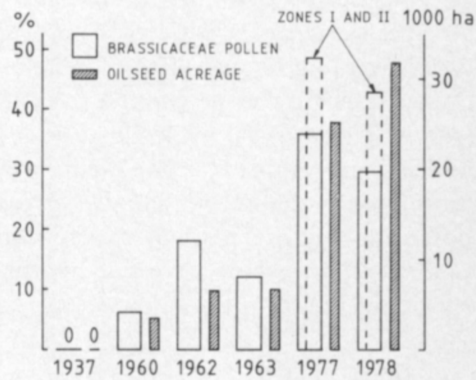

Fig. 13. Average proportion of *Brassicaceae* pollen in honey samples and the acreage of *Brassica* oilseed crops (ANON. 1962, 1981). Observation from the year 1937 by MARTIMO (1945), other years as in Fig. 12.

change to the later flowering spring varieties, the importance of turnip rape as a nectar yielder has evidently risen. Furthermore, the migratory beekeeping organised for pollinating the stands favours turnip rape and rape at the cost of other bee plants. Rape, *B. napus* L. v. *oleifera,* is also a good bee plant (e.g. HOWES 1979). However, the acreage of rape is ca. 10 % of the total acreage of oil plants in Finland, whereas that of turnip rape is ca. 90 %.

The proportion of pollen of white and alsike clover, *Trifolium repens* and *T. hybridum,* has decreased in parallel with the increase in the proportion of *Brassicaceae* pollen. It is noteworthy that the frequency of clover pollen has not fallen. Current agricultural practices unfavourable for clover are: the use of rapidly growing, shading grass species in pastures, relatively heavy nitrogen fertilization, and the general decrease in cattle farming and pastures, especially in southwestern Finland. RAVN et al. (1975) noted a similar reduction of clover pollen in Danish honey.

The total pollen count in honey has apparently increased together with the proportion of *Brassicaceae* pollen. Thus the decrease in the importance of white and alsike clover as bee plants is probably smaller than is suggested by the decrease in the proportion of their pollen.

Problem of botanical origin

The pollen grains are assumed to bear some linear relation to the nectar contributions of the plants. However, some plants may yield nectar without being represented by pollen in the honey (DEMIANOWICZ 1964). On the other hand, the relative abundance of pollen of non-nectariferous plants in the pollen spectrum of honey indicates that pollen of nectariferous plants may also be present in honey although the corresponding nectar did not occur in the raw material (for example *Myosotis*, see p. 406).

The positive correlation observed between the proportion of *Brassicaceae* pollen and the total pollen count also indicates that the growth in the proportion of *Brassicaceae* pollen was largely achieved by an increase in the number of *Brassicaceae* pollen grains, rather than by a decrease in the number of other kinds of pollen grains per unit honey weight. Consequently, the change in the proportion of *Brassicaceae* pollen does not indicate a directly corresponding change in the contribution of *Brassicaceae* nectar. Thus, the pollen spectrum alone is not a reliable index of the botanical origin of honey (see also DEMIANOWICZ 1961, 1968). Furthermore, the total pollen count varies from sample to sample and averaging the percentages obtained for the samples by qualitative analysis gives a misleading basis for deducing the botanical origin. This was clearly illustrated by the differences in the quantitative relationships revealed by the average proportions and the average counts in the samples studied.

Honeydew

According to LOUVEAUX et al. (1978) the origin of honey may be determined from the pollen spectrum only if the ratio of honeydew elements to pollen grains is below one. According to this, the proportion of honeydew was not significant in the present honey samples. However, a more detailed study is required to find out the real importance of honeydew in Finland.

Seasonal changes in pollen spectra

Bee plants flowering in spring. The annual variation in the count of *Salix* pollen was concentrated in the southern regions: towards the north the arrival of spring and the flowering of *Salix* become increasingly later and rapider, and the critical difference between the years in the progress of spring occurred as early as May. The importance of *Salix* spp. in providing pollen for the bees in spring is indicated by the correlation of the content of *Salix* pollen with the numbers of pollen grains of non-nectariferous plants flowering in spring, especially *Alnus* spp. The 1978 honey samples contained three times more *Salix* pollen than the 1977 samples. As the honey yields were also higher in 1978 than in 1977, this agrees with the assumption that a connection exists between the utilization of *Salix* pollen, the spring development of the bee colonies and their later productivity.

Pollen of *Malus domestica* was found more seldom, but in greater quantities in the less favourable season 1977 than in 1978. This indicates that, when needed and when its flowering is successful, *Malus domestica* (as well as e.g. *Vaccinium* spp. flowering at the same period) may substitute for *Salix* spp. as a pollen plant.

Mid season bee plants. The few species represented more often in the honey of 1977 than in the samples of 1978 were apparently compensatory sources for bees. *Trifolium* spp. seems to have a certain ability to even out the annual variation. It would be desirable to find out what bee plants are productive even in relatively poor weather conditions.

In 1978 the bees were able to visit the non-nectariferous pollen plants more intensively than in 1977. *Plantago* spp. are known as pollen plants (HANSSON 1976). The variation in the frequency and numbers of *Rumex* grains was similar to that of *Plantago* pollen. Also, bees have been reported to collect pollen intentionally from *Rumex* spp. (KÄPYLÄ and NIEMELÄ 1979), so it may have a more important function as a bee plant than is yet known.

Altogether, the supply of bee plants was richer in 1978 than in 1977. The importance of the main species was emphasized in 1977 at the cost of minor and occasional species.

Regional characteristics

Brassicaceae pollen was most abundant in the honey of the southern regions, as turnip rape, the main source of *Brassicaceae* pollen, is cultivated there (mainly in zones I and II). Turnip rape is evidently one of the main honey yielders wherever cultivated. On the other hand, *Brassicaceae* pollen is clearly over-represented in relation to the nectar that it contributes to the honey. Thus, the total pollen count of the honey samples was highest in the southern regions. In view of its over-representation and the fact that beekeeping in Finland is concentrated in the same regions as the cultivation of turnip rape, the predominance of *Brassicaceae* pollen in Finnish honey is understandable.

Characteristic pollen spectra clearly differentiating the honeys of the different regions did not exist. This result was expected, as the beekeeping area is a relatively small and phytogeographically uniform area. The regional differences found were merely quantitative and give only a rough indication of the geographical origin of honey within Finland.

As the spring development of Italian bees is more rapid in favourable conditions, in 1978 this race was able to utilize *Salix* spp. better than bees of mixed race. This may be partly due to the fact that the most skilful and active beekeepers mainly keep Italian bees. The average difference in honey yields, which was ca. 20 % units in the favour of the Italian bees in both the years, was not significant, however.

If it is assumed that the amount of pollen entering honey with nectar does not vary with the race, then the Italian bees did not use turnip rape (indicated by *Brassicaceae* pollen) as much as the bees of mixed race. This was not due to differences in distribution, as the proportions of apiaries with the different breeds was the same in all the regions in both the years. A partial explanation may be that as the Italian bee has the longest tongue (glossa), it is able to utilize a greater variety of crop plants than the other races in Finland.

The number of apiaries of Caucasian bees or even dark bees participating in this study was so small that comparison of the result is not possible.

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SELOSTUS

Suomalaisen hunajan siitepölyspektri

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Artikkeli on osaraportti laajemmasta hunajan koostumusta käsittelevästä tutkimuksesta. Osatutkimuksen tavoite oli suomalaisen hunajan siitepölyspektrin kuvaaminen. Siitepölyspektri-tutkimusta käytetään lähinnä hunajan maantieteellisen alkuperän ja botaanisen alkuperän (mesilähteiden) määrittämisessä.

Vuosina 1977 ja 1978 koottiin kaikkiaan 160 hunajanäytettä 71 mehiläishoitajalta ja 81 mehiläistarhasta. Aineisto edusti suomalaista hunajaa sekä alueellisesti että mehiläisrotujen osalta. Kaikista näytteistä tehtiin siitepölyanalyysi. Aiemmista mikroskopointimenetelmistä kehitettiin linjalaskentaan perustuva puolikvantitatiivinen sovellutus, joka mahdollisti näytteiden siitepölypitoisuuksien vertailun. Näytteiden keruun ohella suoritettiin kyselytutkimus, jolla näytteen lähettäneiltä mehiläishoitajilta koottiin hoitotoimiin sekä tarhaan ja sen ympäristöön liittyvää tietoa.

Tutkimukseen osallistuneiden tarhojen keskikoko oli 6–7 mehiläiskuntaa. Hunajan keskisato oli 1977 29 kg ja 1978 37 kg yhdyskuntaa kohden. Hunajanäytteistä 65 % oli lingottu elokuussa; noin 75 % hoitajista korjasi vain yhden sadon kesässä. Mehiläishoitajien antamien tietojen mukaan näytteistä 47 % edusti italialaista mehiläisrotua, 37 % sekarotuisia mehiläisiä ja loput 16 % lähinnä pohjoismaista rotua.

Näytteistä tavattiin keskimäärin 16 siitepölylajia. Kaikkiaan eriteltiin 70 lajia tai lajiryhmää. Ristikukkaissiitepöly oli vallitseva: sen osuus kaikesta hunajanäytteistä laskeutusta siitepölystä oli 47 % vuoden 1977 aineistossa ja 39 % vuoden 1978 aineistossa. Muut useimmin ja runsaimmin esiintyneet lajit olivat valko- ja alsikeapilan, pajujen, ruusukasvien kuten "*Rosaceae*-ryhmän" (tuomi, pihlaja, omena, vadelma) ja mesiangervon sekä sarjakukkaisten siitepöly. Nämä lajit muodostivat 90.8 % (1977) ja 90.3 % (1978) kaikesta tutkitusta siitepölystä. Vuosien 1960–1963 hunajiin verrattuna ristikukkaissiitepölyn osuus oli noussut ja valko- ja alsikeapilan siitepölyn osuus vastaavasti laskenut. – Mesikasteosasten määrä oli jokaisessa näytteessä pienempi kuin siitepölyhiukkasten määrä.

Tutkimusvuosien välinen vaihtelu siitepölyspektrissä selittyi sääolojen vaihtelulla. Tyypillisiä siitepölyspektrejä alueellisen alkuperän osoittamiseksi ei havaittu, vaikkakin ristikukkaissiitepöly oli leimaa antava eteläisimpien viljelyvyöhykkeiden hunajille. Ristikukkaissiitepölyn esiintymisen vaihtelua selitti parhaiten rypsin viljelyalan kasvu ja viljelyn keskittyminen eteläisille vyöhykkeille. Mm. tarkastelemalla ristikukkaissiitepölyn osuuden ja hunajan kokonaissiitepölypitoisuuden välistä positiivista korrelaatiota todettiin, että siitepölyspektri ei sellaisenaan sovellu hunajan botaanisen alkuperän osoittajaksi.

Appendix 1. Results of the pollen counts.

	Mean and standard deviation				Frequency %		Zonal mean							
	1977		1978				M 1977				M 1978			
	M	D	M	D	1977	1978	I	II	III	IV+V	I	II	III	IV+V
Nectariferous plants:														
Salix spp.	39.6	55.2	112.9	184.1	91	100	21	39	42	60	123	157	76	47
Acer spp.	3.6	11.2	2.5	4.3	24	48	7	3	3	1	4	3	1	–
Liliaceae	0	.1	.5	1.0	1	30	0	–	–	–	0	0	1	0
Malus domestica	41.8	103.4	11.3	14.6	59	80	8	38	80	3	13	14	7	13
Prunus padus	17.8	36.4	27.1	24.4	54	96	6	18	28	8	17	25	38	25
Sorbus aucuparia	18.7	33.6	27.2	65.0	67	71	13	18	19	24	20	9	24	130
Vaccinium myrtillus	.4	2.2	.5	1.4	13	22	0	1	0	0	0	0	1	0
Vaccinium vitis-idae	2.8	5.9	.9	4.8	41	16	3	2	3	4	0	1	2	–
Taraxacum spp.	1.4	2.7	.7	1.0	50	42	0	1	2	1	1	1	0	1
Syringa spp.	.4	1.2	.9	1.9	16	36	0	0	0	0	1	1	1	0
Caragana arborescens	0	.1	4.4	12.9	1	36	–	0	–	–	8	2	5	2
Rubus idaeus	16.6	34.5	17.5	21.3	45	86	5	11	29	18	8	19	27	6
Brassicaceae	331.6	465.1	241.3	346.8	94	90	423	371	369	12	503	222	114	1
Apiaceae	72.8	137.7	63.2	93.3	90	90	34	113	72	8	79	78	51	3
Trifolium repens + *T. hybridum*	71.3	125.0	29.8	43.0	100	100	50	95	63	49	41	23	28	28
Trifolium pratense + *T. medium*	3.6	6.7	7.1	20.4	54	64	5	4	3	0	7	8	7	3
Vicia spp.	1.3	2.4	.7	2.1	48	17	1	2	0	1	0	1	0	0
Filipendula ulmaria	24.2	24.4	28.3	55.1	99	93	21	31	20	17	46	27	20	10
Caryophyllaceae [1)]	.3	.9	.1	.4	16	6	0	0	0	0	0	0	–	0
Tilia spp.	.5	1.9	.1	.8	11	3	1	1	0	–	0	–	–	–
Melampyrum spp.	.3	.9	.9	2.2	14	28	0	0	0	0	0	1	2	–
Linaria vulgaris	10.2	28.0	3.2	11.4	75	48	4	7	20	4	4	6	1	–
Lythrum spp.	1.2	6.2	.2	1.2	12	7	0	2	0	1	0	0	0	–
Galium spp.	.2	.7	.2	.5	9	17	0	0	0	0	0	0	–	–
Epilobium angustifolium	2.5	3.4	1.7	2.3	69	55	1	2	3	4	1	2	2	3
Solidago virgaurea	1.0	3.6	.3	.7	30	17	0	0	2	1	0	0	0	0
Leucanthemum vulgare	1.0	1.5	.9	2.0	48	40	1	1	1	1	1	1	1	2
Centaurea spp.[2)]	1.7	4.4	.4	1.1	44	23	1	3	1	–	0	1	0	–
Carduus crispus, *Cirsium* spp	.2	.7	.7	1.3	14	38	0	0	0	0	0	0	1	1
Cichoriaceae: others[3)]	1.3	3.0	2.0	3.9	44	52	1	2	1	1	2	2	2	2
Calluna vulgaris	5.2	8.8	3.4	5.3	68	55	2	5	6	7	2	4	4	6
Other nectar plants[4)]	2.7	9.4	1.9	5.6	32	29	0	4	2	2	5	0	1	1
Non-nectariferous plants:														
Alnus spp.	.6	2.0	.5	1.1	26	23	0	1	1	0	0	1	0	0
Betula spp.	.3	1.6	1.7	2.6	10	55	0	0	0	1	0	2	2	0
Anemones [5)]	–	–	4.1	16.1	–	29	–	–	–	–	14	1	0	0
Rumex spp.	.7	2.2	2.4	8.3	28	48	0	1	0	2	0	2	4	2
Plantago spp.	.4	1.1	1.7	3.0	18	43	0	0	0	0	3	1	1	1
Poaceae	1.1	2.6	.8	1.6	30	38	2	1	1	0	0	1	1	–
Other pollen plants[6)]	.4	.8	.3	.7	25	19	0	0	0	0	0	0	0	0
Unidentified[7)]	18.3	12.0	14.0	10.9	99	98	14	18	22	14	12	14	16	13
Total number of pollen grains	698.6	475.8	618.5	472.7	.	.	629	799	800	247	920	632	444	303
Myosotis spp.: frequency	.	.	.	.	5	20	1	–	1	3	9	3	2	–
Number of pollen types	15.9	3.8	18.5	4.2	.	.	15	17	17	15	18	19	18	17
Number of honeydew elements	15.3	19.7	12.1	10.6	100	100	14	18	15	10	9	15	13	6

[1)] *Stellaria* spp., *Silene vulgaris*, *S. dioica*

[2)] *Centaurea jacea*, *C. cyanus*

[3)] *Leontodon*, *Sonchus*, *Hieracium* + *Pilosella* spp.

[4)] *Berberidaceae*, *Prunus cerasus*, *Fragaria*, *Rosa* spp., *Geum rivale*, *Melilotus*, *Geranium*, *Lonicera*, *Veronica*, *Ajuga*, *Galeopsis*, *Lamium* spp., *Hyssopus officinalis*, *Campanula* spp.

[5)] *Anemone* + *Hepatica* + *Pulsatilla* spp.

[6)] *Pinus*, *Ranunculus*, *Lupinus*, *Hypericum*, *Viola* spp., *Lysimachia vulgaris*, *Knautia arvensis*, *Polemonium*, *Solanum* spp., *Calendula officinalis*, *Amaryllidaceae*, *Iridaceae*

[7)] Abortive and misshapen pollen grains