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Pollen Incidence and Wind Transport in Central Hokkido (II)

By

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北海道中央部における空中花粉の落下と風による運搬 (II)

五十嵐　八枝子*

Abstract

Four pollen traps at different levels (0.2 m, 10 m, 17 m, 24 m) were placed in a natural broad-leaved forest near Tomakomai City, central Hokkaido, and examined for 6 consecutive years, from 1977 to 1982. Pollen and spores were collected for 10 day periods from March until October, and for 30 days each from November until February. Pollen and spore incidence during the flower period, refloatation after the flower period and wind transport were observed. Results showed that the highest incidence occurred during the flower period. Pollen incidence of *Quercus, Betula, Alnus, Carpinus* and *Fraxinus* was especially high. Pollen refloatation of *Quercus, Betula, Alnus, Carpinus, Fraxinus* and *Pinus* was observed at high percentages. It was concluded that *Cryptomeria, Fagus* and *Tsuga* were transported by the wind. Their maximum values of mean percentages of the AP total amount for 4 years in each trap were calculated as 8.42, 1.23 and 0.01, respectively.

Key words: Pollen, Spore, Incidence, Wind transport, Refloatation.

Contents

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Introduction

In order to reconstruct correctly paleovegetation from fossil pollen and spores assemblages, it is important to investigate the deposition mechanism of pollen and spores. Many studies concerning this problem have been reported (TAUBER, 1967; KERCHAW and HYLAND, 1975; KRZYWINSKI, 1977; KOTZAMANIDOU and NILSSON, 1977), but there have been few reports on continuous observations made over a long period of time. The author collected pollen and spores by the so-called sedimentation method using traps which were set at 4 different heights in the forest examined during 6 consecutive years. Partial results of a 2-year investigation were already reported (IGARASHI, 1979). The present paper describes the results of a 6 years' investigation of the incidence of arboreal pollen and it's transport by the wind.

I. Collection sites and methods

The traps were set in the Tomakomai Experiment Forest, Hokkaido University near Tomakomai City, which is located in the extreme southwest of central Hokkaido (Fig. 1). The forest extends over flat hills at about 55 m above sea level and faces the Pacific Ocean. Two-thirds of the area of the forest is a natural

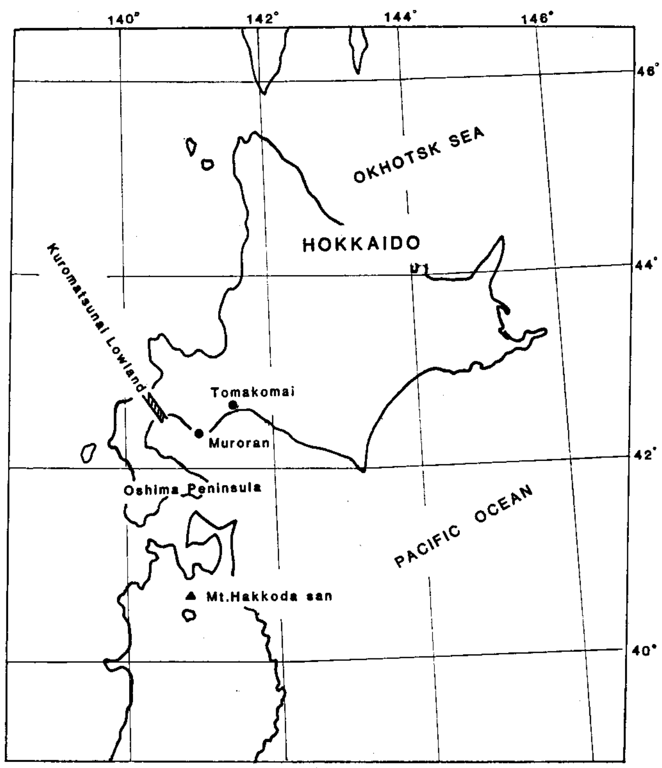

Fig. 1. Map showing locations of surveyed area and sites discussed in the paper.

deciduous broad-leafed forest of 2,700 ha. that is composed mainly of *Acer, Tilia, Quercus, Fraxinus, Alnus, Carpinus* and *Betula* (KUDO et al., 1916). The remaining area is a planted forest of *Larix, Picea, Abies* and *Pinus* (Fig. 2).

The pollen traps were stainless steel cylinders measuring 16 cm long by 16 cm in diameter. Each trap was placed under a small roof measuring 70 cm from the bottom of the cylinder to prevent overflowing by rain. The traps were exposed to the air during the collection period. In summer the cylinders were coated on the inside with glycerine jelly and in the autumn and winter with glycerine.

Four traps were placed at Station 1, 2 and 3 in the forest (Fig. 2). Station 1 is a 31 m high tower which was built for the purpose of observing vegetation, animals and weather in the forest. Three traps were set on the southern balconies of the tower (Fig. 3). One trap was set on a balcony 24 m above the ground level and above the cannopy. The second one was placed on a balcony of 17 m, the same level as the cannopy, and the third one was set at 10 m, the tree trunk level. The fourth trap was set on a stand 0.2 m above the ground. In 1977 the fourth trap was placed under the open cannopy about 200 m south from the tower (Station 2)and from 1978 to 1982 it was moved to a moor about 3.5 km southeast of the tower (Station 3, Fig. 2).

Collections were made at intervals from 27 May, 1977 until 2 June, 1982. The traps were changed every 10 days from March to October and every 30 days from November to February, with modifications made when deemed necessary.

Pollen and spores collected in every collection period were identified under a microscope of 400 magnification after acetorisis liquid treatment.

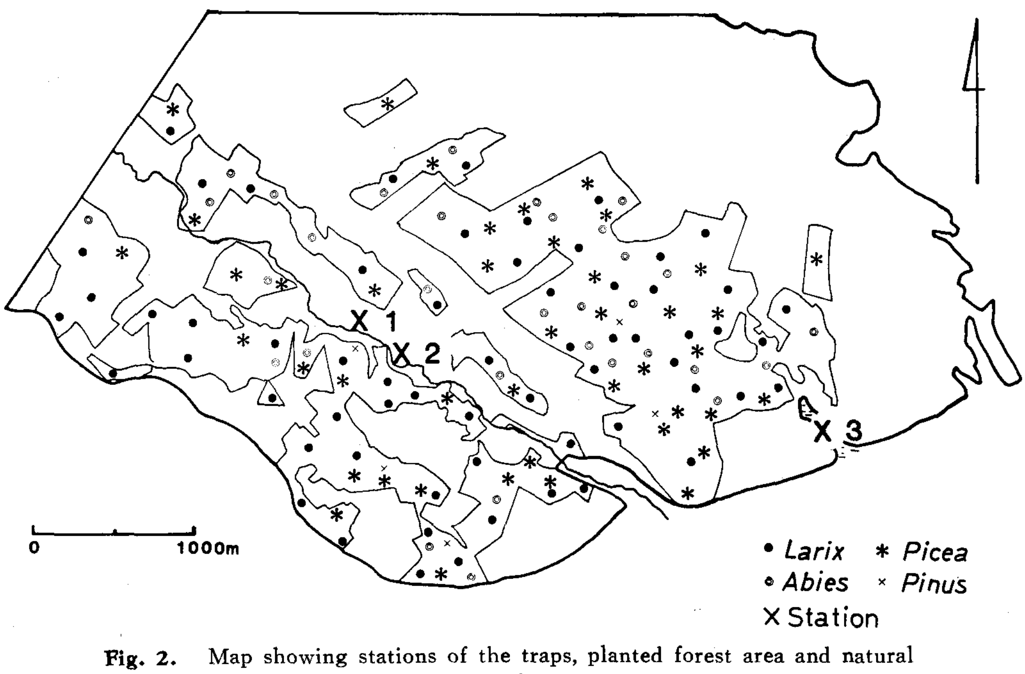

Fig. 2. Map showing stations of the traps, planted forest area and natural deciduous forest area (no marking) in the surveyed forest.

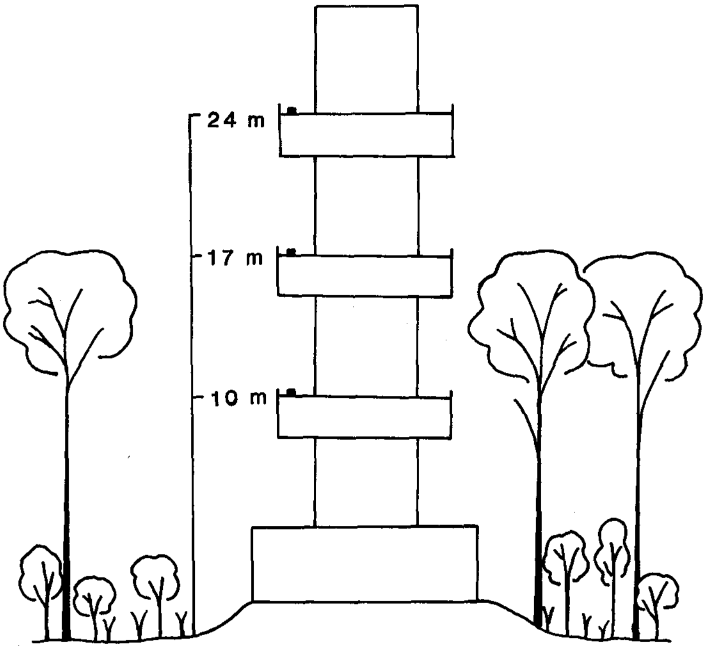

Fig. 3. Three traps placed on balconies of the tower (Station 1).

II. Meteorological data

Meteorological data observed in the surveyed forest during 1956 to 1965 (Hokkaido University Experimen Forest, 1967) were as follows:

Mean temperature of June	-6.8°C
Mean temperature of August	19.45°C
Annual mean temperature	5.99°C
Precipitation	1350.5 mm

Mean temperatures of each period of 10 days during which observasions were made at Station 1 (Fig. 1) from 1977 to 1982 are shown in Fig. 4 (Hokkaido University Experimen Forest, 1978～1983).

III. Pollen incidence

Arboreal pollen (AP) taxa found in the traps during the 6 years were as follows: *Pinus, Larix, Picea, Abies, Cryptomeria,* Cupressaceae, *Tsuga, Taxus, Sciadopitys, Quercus, Betula, Alnus, Ulmus, Corylus, Salix, Fraxinus, Cornus, Tilia, Juglans, Acer, Ostrya, Populus, Castanea, Magnolia, Morus, Fagus, Carpinus Sorbus, Phellodendron,* Araliaceae, *Aesculus, Cercidiphyllum,* Celastraceae, *Eleagnus, Hydrangea, Ligustrum, Celtis, Sambucus,* Ericaceae, *Rhus* and Spiraceae.

Grass pollen obtained were as follows: Rosaceae, *Sanguisorba, Potamogeton, Geum, Rumex, Urtica, Lysimachia, Chenopodium, Polygonum, Campanula, Persicaria, Artemisia,* Carduoideae, Cichorioideae, *Plantago,* Cruciferae, Umbelliferae, Caryophyllaceae, Ranunculaceae, *Epilobium,* Saxifragaceae, *Chloranthus, Thalic-*

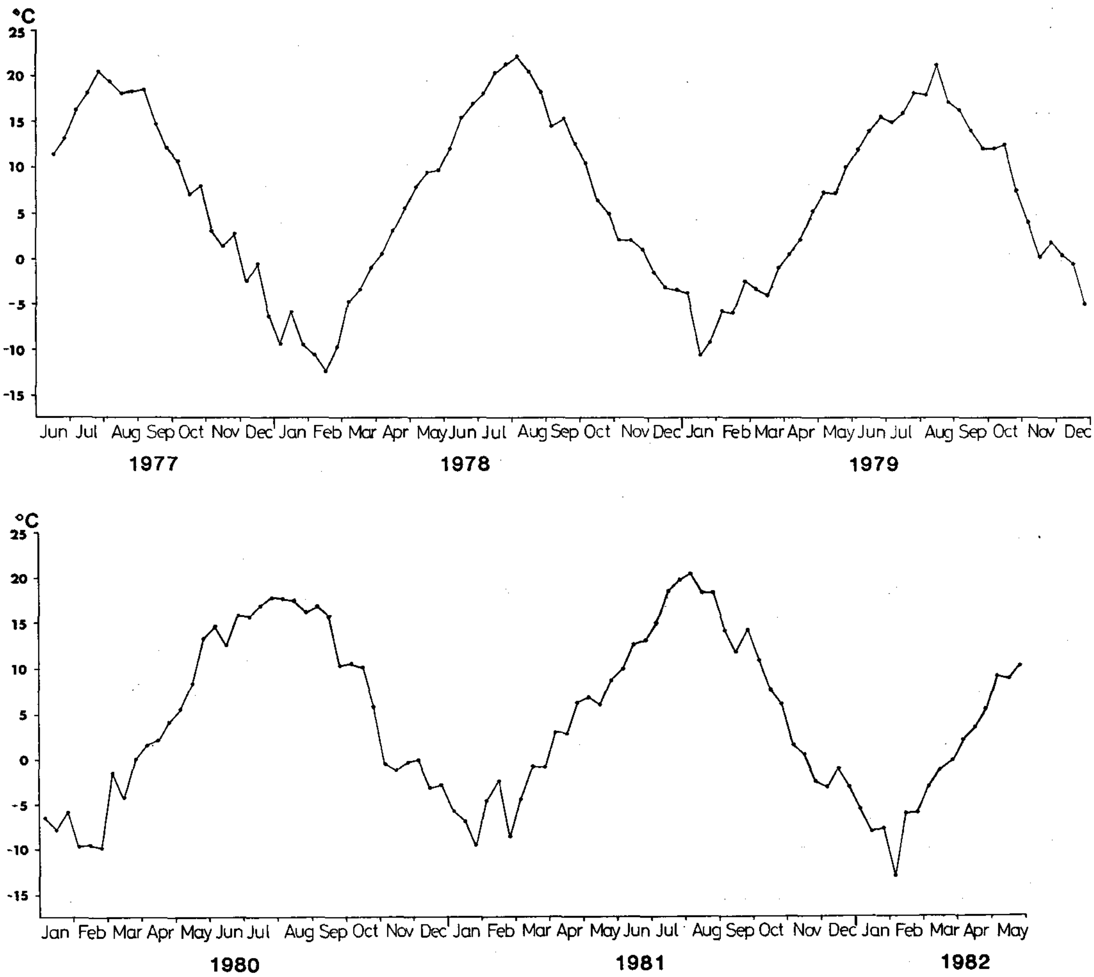

Fig. 4. Mean temperatures of each period of 10 days during which observations were made at Station 1 from 1977 to 1982.

trum, *Typha*, *Menyanthes*, *Myriophyllum*, Labiatae, *Potamogeton*, *Caltha*, *Daphne*, Fumariaceae, *Iris*, Liliaceae, Cyperaceae and Gramineae.

Fern spores were *Lycopodium*, *Osmunda*, Polypodiaceae and *Equisetum*. Moss spore was *Sphagnum*.

Each total amount of AP, grass pollen and spores per 100 cm^2 in each trap in each collection period is shown graphically in Fig. 5. Grain numbers of AP, grass pollen and spores in each trap in each collection period are also shown in Table 1.

Grain numbers in each trap in each collection period changed significantly every year. However, dominant incidence of AP occurred from March and continued about 90 days until June every year. There was generally a sharp increase and a sharp decrease in the amount of pollen. On the other hand, the undergrowth had a longer period of dominant incidence of pollen and spores than the trees, lasting from May until October, but the amount of pollen and spores was less than that of trees.

Of the pollen taxa collected, incidence of *Betula*, *Quercus*, *Alnus*, *Carpinus* and *Fraxinus* was more frequent than that of other trees and undergrowth. This seemed to be due to their many spikes.

Incidence of *Quercus* pollen was the highest of all (Fig. 6), its maximum numbers reaching 99,443 per 100 cm^2 in the 24 m trap in 1981, and 58% of the AP total in the 10 m trap in 1980 (Table 2). Incidence of *Quercus* pollen increased in May and June, and the pollen refloated in a large amount after its flower period.

Incidence of *Betula* pollen was also high (Fig. 7). Its maximum numbers reached 63,507, or 58.92% of the total AP amount in the 24 m trap in 1979 (Table 3). After the flower period of *Betula*, refloatation was also a dominant characteristic.

There was an abrupt increase in the incidence of *Alnus* pollen in the beginning of April, and it decreased suddenly about 30 days afterwards (Fig. 8). Maximum numbers of *Alnus* pollen reached 82,092 or 62.8% of the total AP amount in the 0.2 m trap in 1981 (Table 4).

Table 1. Grain number of tree pollen, grass pollen and spores of fern and moss per 100 cm^2 in each year, in each trap

	0.2 m	10 m	17 m	24 m
1978				
Tree	104,504	62,377	90,535	115,620
Grass	17,580	10,866	14,947	17,172
Fern & Moss	3,648	1,694	1,406	2,118
Total	125,732	74,937	106,888	134,910
1979				
Tree	54,190	79,247	122,222	107,784
Grass	20,790	17,044	30,577	8,295
Fern & Moss	1,101	1,223	1,444	968
Total	76,081	97,514	154,243	117,047
1980				
Tree	31,029	64,998	105,693	58,039
Grass	15,482	14,149	18,693	9,658
Fern & Moss	1,313	817	1,796	2,312
Total	47,824	79,964	126,182	70,009
1981				
Tree	130,745	80,772	91,223	179,905
Grass	22,220	13,739	22,016	30,701
Fern & Moss	976	1,477	1,810	2,109
Total	153,941	95,988	115,049	212,715

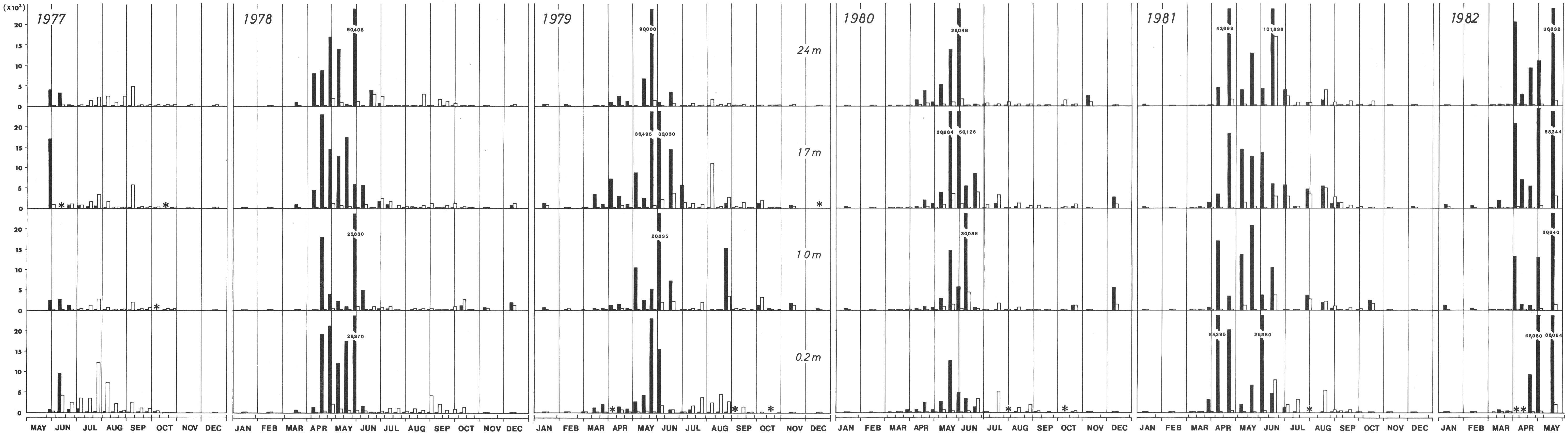

Fig. 5. Total amount of AP (shaded columns), grass and spores (white columns) per 100 cm² in each trap in each collection period.
* marks show the periods when samples were lost. Upper scales of the lowest part of the figure show the collection periods.

* marks and upper scales of the lowest part of the figure are used in Fig. 6~17 in the same sense as they are used in Fig. 5.

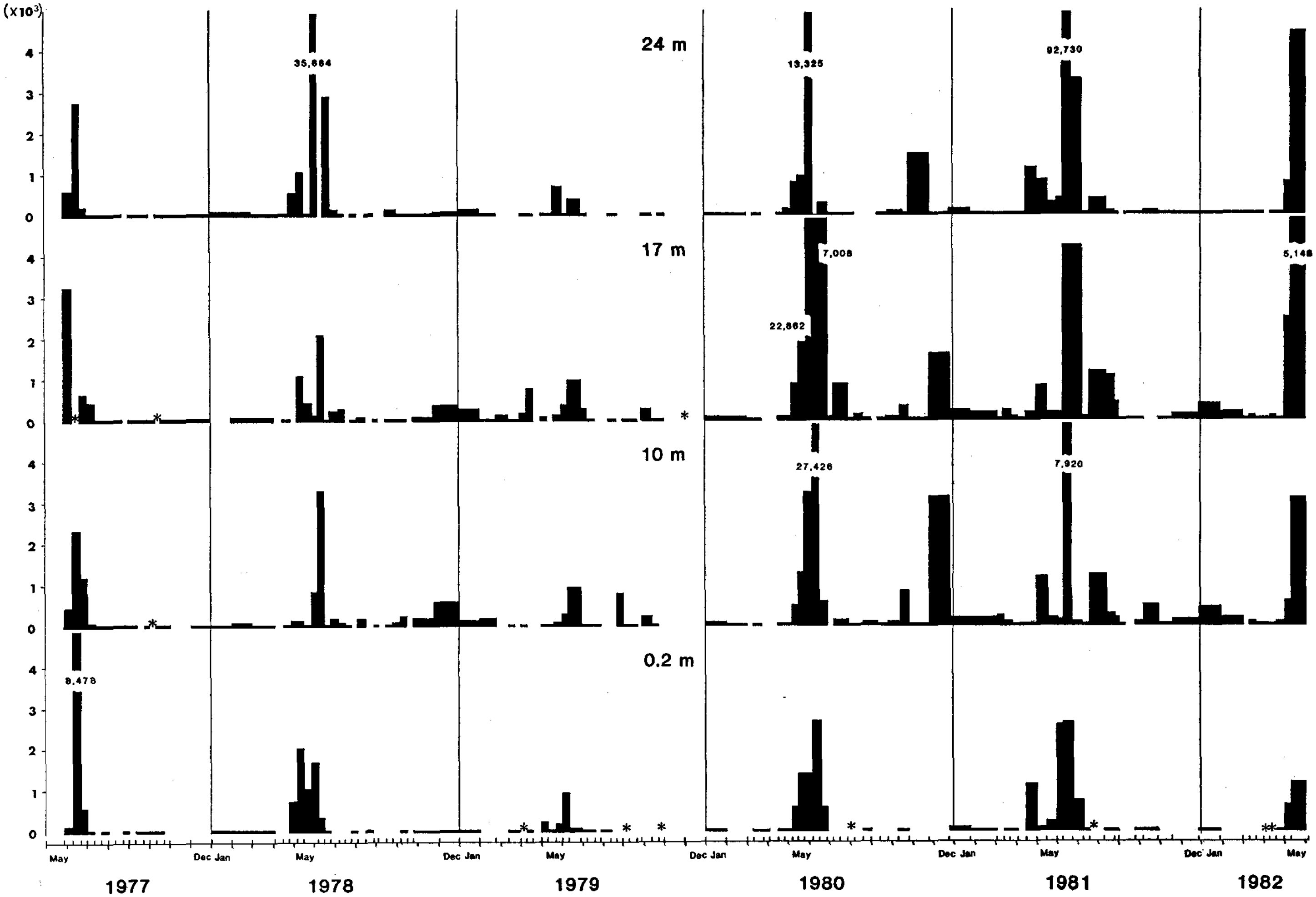

Fig. 6. Number of *Quercus* pollen per 100 cm² each collection period in each trap from 1977 to 1982.

Incidence of *Carpinus* pollen increased abruptly during the last ten days of May and decreased suddenly in the first ten days of June (Fig. 9). Maximum numbers of *Carpinus* pollen reached 35,703 or 34.2% of the total AP amount in the 0.2 m trap in 1978 (Table 5).

An increase in the incidence of *Ulmus* pollen was noted at the beginning of May, and it suddenly decreased at the end of May (Fig. 10). Maximum numbers of *Ulmus* pollen were 7,728, or 9.8% of the total AP amount, in the 10 m trap in 1979 (Table 6).

The pollen period of *Fraxinus* began in the middle of May (1981 and 1982), or in the first ten days of June (1978 and 1979), and dominant pollen incidence of *Fraxinus* continued for 10 to 30 days (Fig. 11). Maximum numbers of *Fraxinus* pollen were 4,058 in the 17 m trap in 1981, and they reached 4.6% for the AP total amount in the 10 m trap in 1981 (Table 7).

Incidence of *Acer* (Fig. 11), *Tilia* (Fig. 12) and *Salix* was low in spite of their abundant distribution in the forest. In addition, only a small amount of *Juglans* pollen was observed, agreeing with its scant distribution in the forest (Fig. 11). Incidence of *Corylus* pollen was low, except in 1981 (Fig. 12).

The conifer pollen collected originated from Cupressaceae, *Picea*, *Abies*, *Pinus*

Table 2. Percentages of pollen *Quercus* for the AP total amount and grain number per 100 cm² in each year and in each trap

Traps	1978		1979		1980		1981	
24 m	35.2 (%)	(40,791)	1.3 (%)	(1,461)	29.6 (%)	(17.211)	55.3 (%)	(99,444)
17 m	5.8	(5,250)	3.1	(3,867)	39.2	(41,439)	7.7	(13,845)
10 m	9.2	(5,768)	3.7	(2,944)	58.0	(37,716)	15.9	(12,866)
0.2 m	5.9	(6,128)	3.2	(1,712)	22.4	(6,954)	5.9	(7,689)

Table 3. Percentages of pollen *Betula* for the AP total amount and grain number per 100 cm² in each year and in each trap

Traps	1978		1979		1980		1981	
24 m	6.91 (%)	(7,995)	58.92 (%)	(63,507)	25.37 (%)	(14,726)	6.70 (%)	(12,063)
17 m	6.06	(5,492)	37.52	(45,866)	26.42	(27,927)	15.06	(13,740)
10 m	3.87	(2,417)	44.49	(35,258)	22.28	(14,482)	18.64	(15,061)
0.2 m	11.01	(11,505)	63.60	(34,467)	32.65	(10,134)	11.76	(15,378)

Table 4. Percentages of pollen *Alnus* for the AP total amount and grain number per 100 cm² in each year and in each trap

Traps	1978		1979		1980		1981	
24 m	10.4 (%)	(12,023)	3.9 (%)	(4,277)	4.3 (%)	(2,494)	16.4 (%)	(29,445)
17 m	15.8	(14,348)	5.0	(6,157)	4.3	(4,625)	24.5	(22,356)
10 m	19.1	(11,894)	3.6	(2,907)	3.9	(2,581)	29.5	(23,809)
0.2 m	14.2	(14,870)	6.1	(3,314)	5.9	(1,853)	62.8	(82,092)

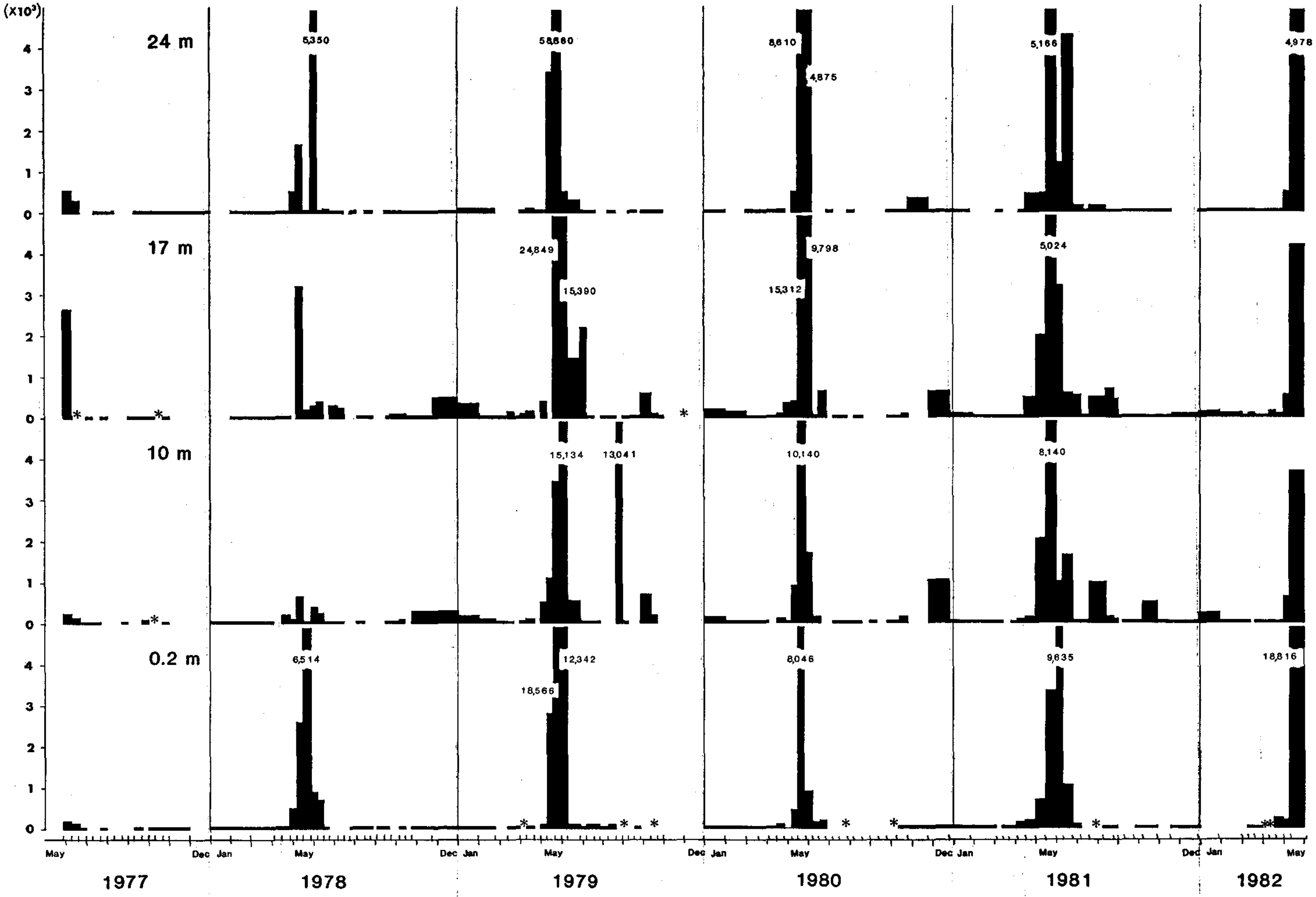

Fig. 7. Number of *Betula* pollen per 100 cm² in each collection period in each trap from 1977 to 1982.

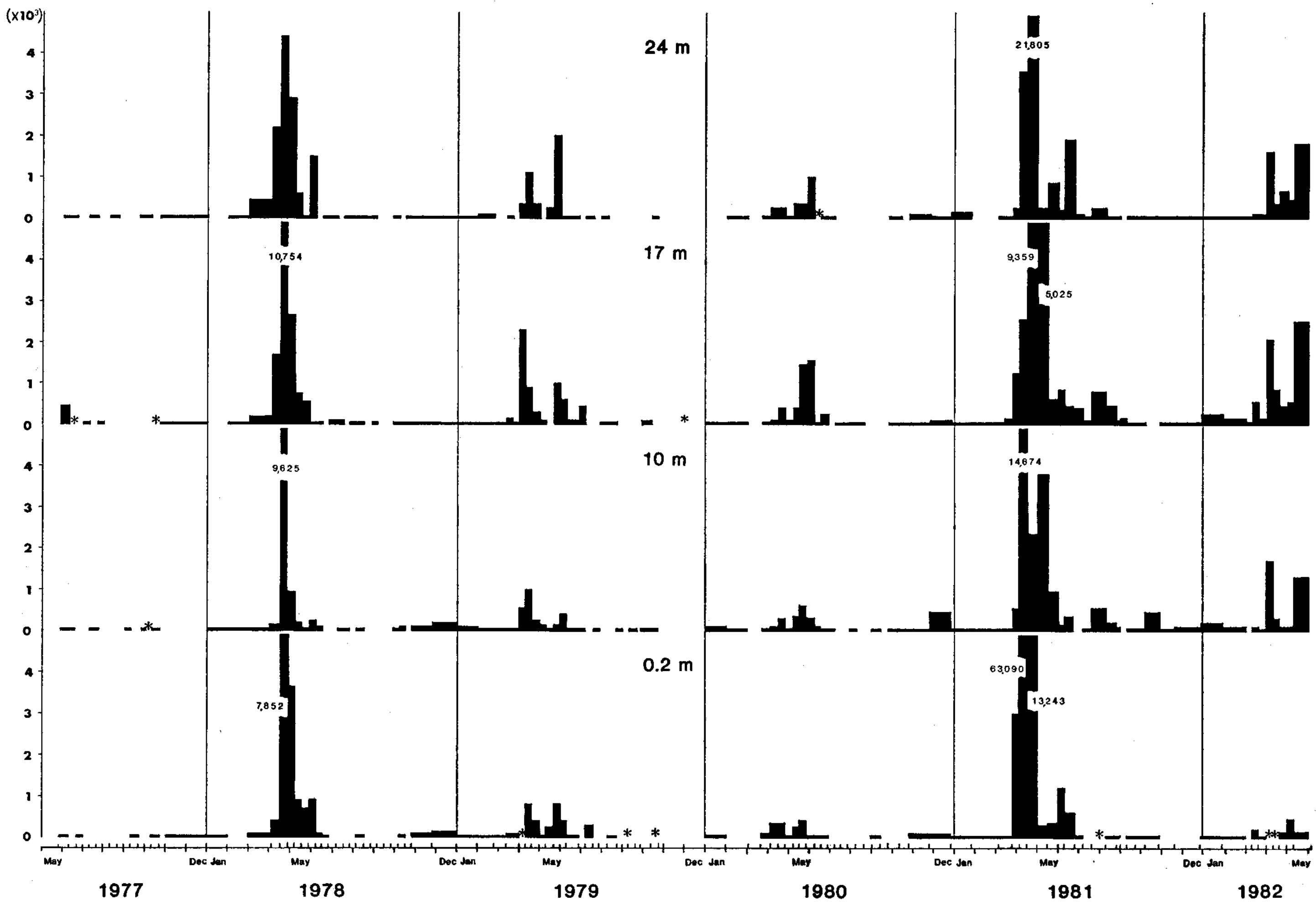

Fig. 8. Number of *Alnus* pollen per 100 cm² in each collection period in each trap from 1977 to 1982.

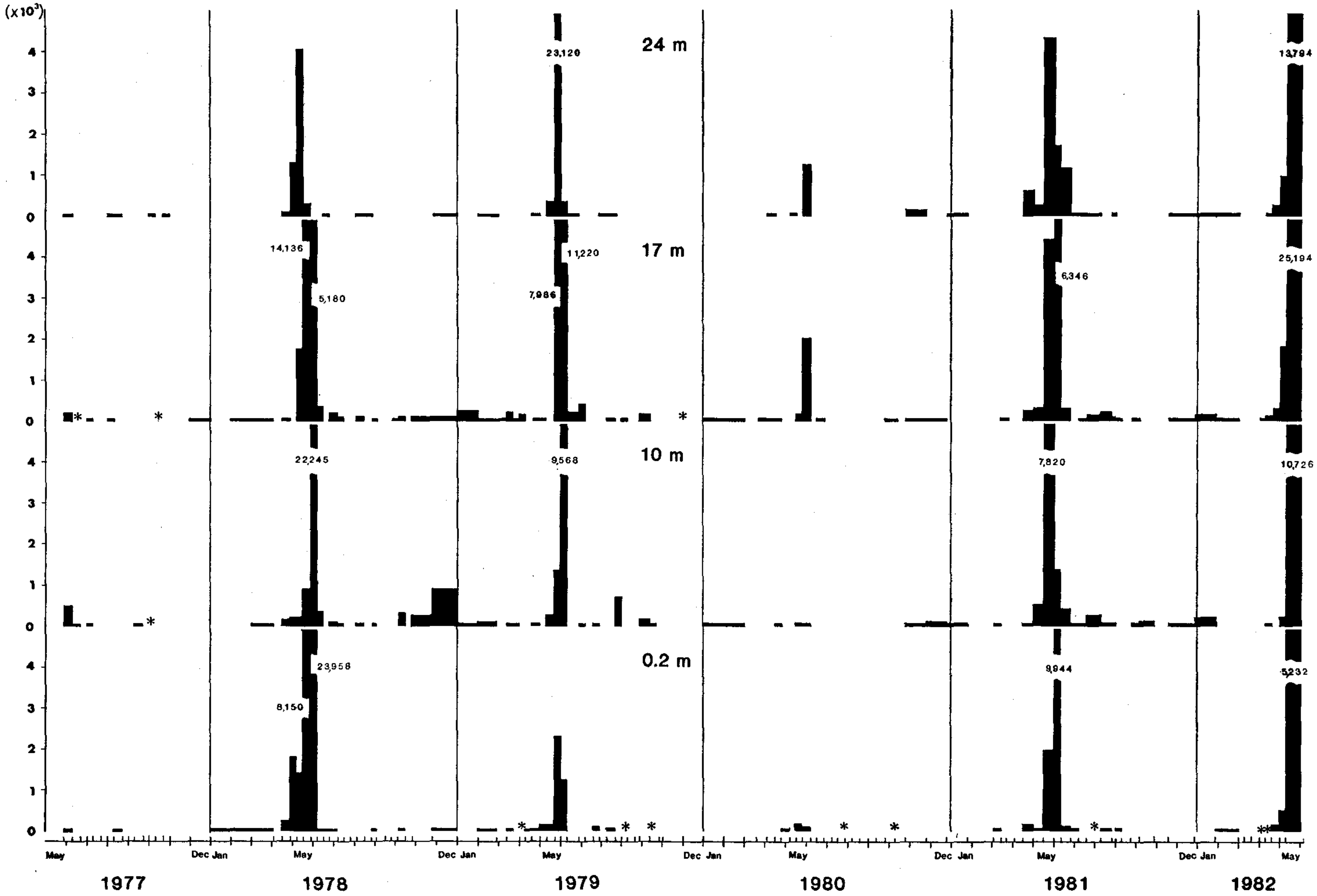

Fig. 9. Number of *Carpinus* pollen per 100 cm² in each collection period in each trap from 1977 to 1982.

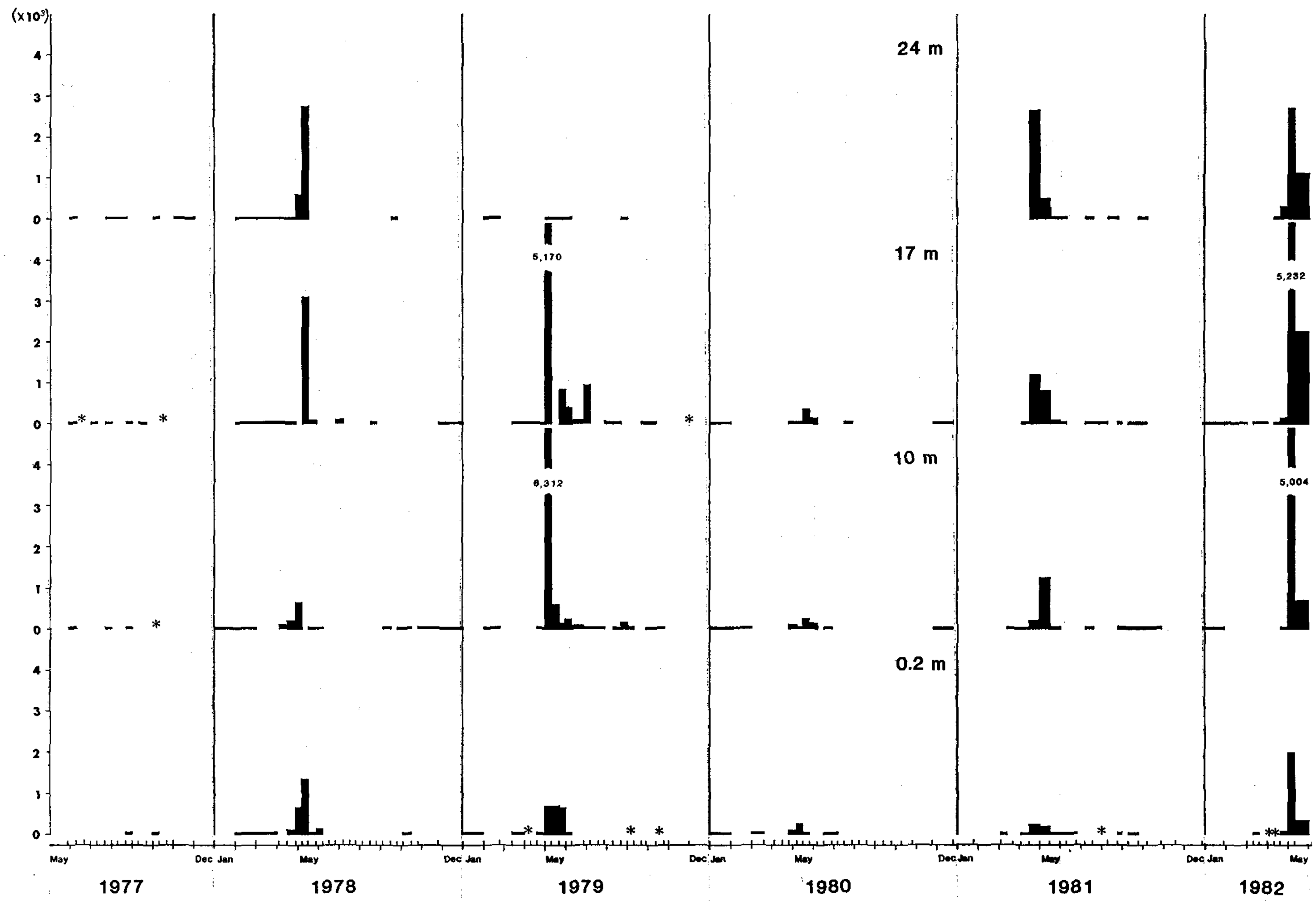

Fig. 10. Number of *Ulmus* pollen per 100 cm² in each collection period in each trap from 1977 to 1982.

Table 5. Percentages of pollen *Carpinus* for the AP total amount and grain number per 100 cm² in each year and in each trap

Traps	1978		1979		1980		1981	
24 m	5.3 (%)	(6,071)	22.2 (%)	(23,968)	2.5 (%)	(1,468)	4.5 (%)	(8,069)
17 m	24.5	(22,164)	17.0	(20,768)	2.2	(2,293)	13.2	(12,076)
10 m	40,7	(25,383)	15.6	(12,377)	0.4	(239)	13.1	(10,596)
0.2 m	34.2	(35,703)	7.6	(4,114)	0.9	(285)	9.4	(12,325)

Table 6. Percentages of pollen *Ulmus* for the AP total amount and grain number per 100 cm² in each year and in each trap

Traps	1978		1979		1980		1981	
24 m	3.0 (%)	(3,472)	2.8 (%)	(2,969)	1.1 (%)	(612)	1.8 (%)	(3,294)
17 m	3.8	(3,340)	6.3	(7,669)	0.7	(714)	2.3	(2,102)
10 m	5.3	(1,054)	9.8	(7,728)	0.8	(539)	2.0	(1,612)
0.2 m	2.2	(2,328)	3.9	(2,124)	1.7	(533)	0.5	(682)

Table 7. Percentages of pollen *Fraxinus* for the AP total amount and grain number per 100 cm² in each year and in each trap

Traps	1978		1979		1980		1981	
24 m	1.7 (%)	(2,026)	0.8 (%)	(877)	0.3 (%)	(196)	0.9 (%)	(1,768)
17 m	4.1	(3,682)	2.8	(3,473)	0.9	(1,034)	4.4	(4,058)
10 m	4.4	(2,770)	4.2	(3,324)	0.4	(281)	4.6	(3,697)
0.2 m	1.1	(1,155)	0.7	(398)	1.1	(347)	0.6	(840)

and *Taxus* trees planted in the surveyed forest. Incidence of Cupressaceae increased from April to March, especially in 1978 and 1982 (Fig. 13). Though *Picea* and *Abies* are distributed over a large area in the forest, the pollen incidence was infrequent, since they did not reach the flower stage (Fig. 14). Incidence of *Taxus* pollen in the 0.2 m trap in May, 1982 was abnormally dominant (Fig. 14), which was thought to be influenced by the stand of *Taxus* located near the trap. *Pinus* pollen occurred in a larger amount in the 17 m and 24 m traps than in the lower traps, especially in 1977 and 1980 (Fig. 15). Incidence of *Larix* pollen was low, except in 1982, in spite of the large number of mature *Larix* having a flower stage (Fig. 15).

IV. Refloatation

Certain amounts of pollen and spores were found after the flower period. These appeared to be due to refloatation of pollen and spores which had been dispersed in the flower period (TAUBER, 1967). In the surveyed forest, the refloatation period of AP was from August until February, and that of grass pollen and spores was from November until April in each year. During these periods, high refloatation occurred especially in November and December every year. There is

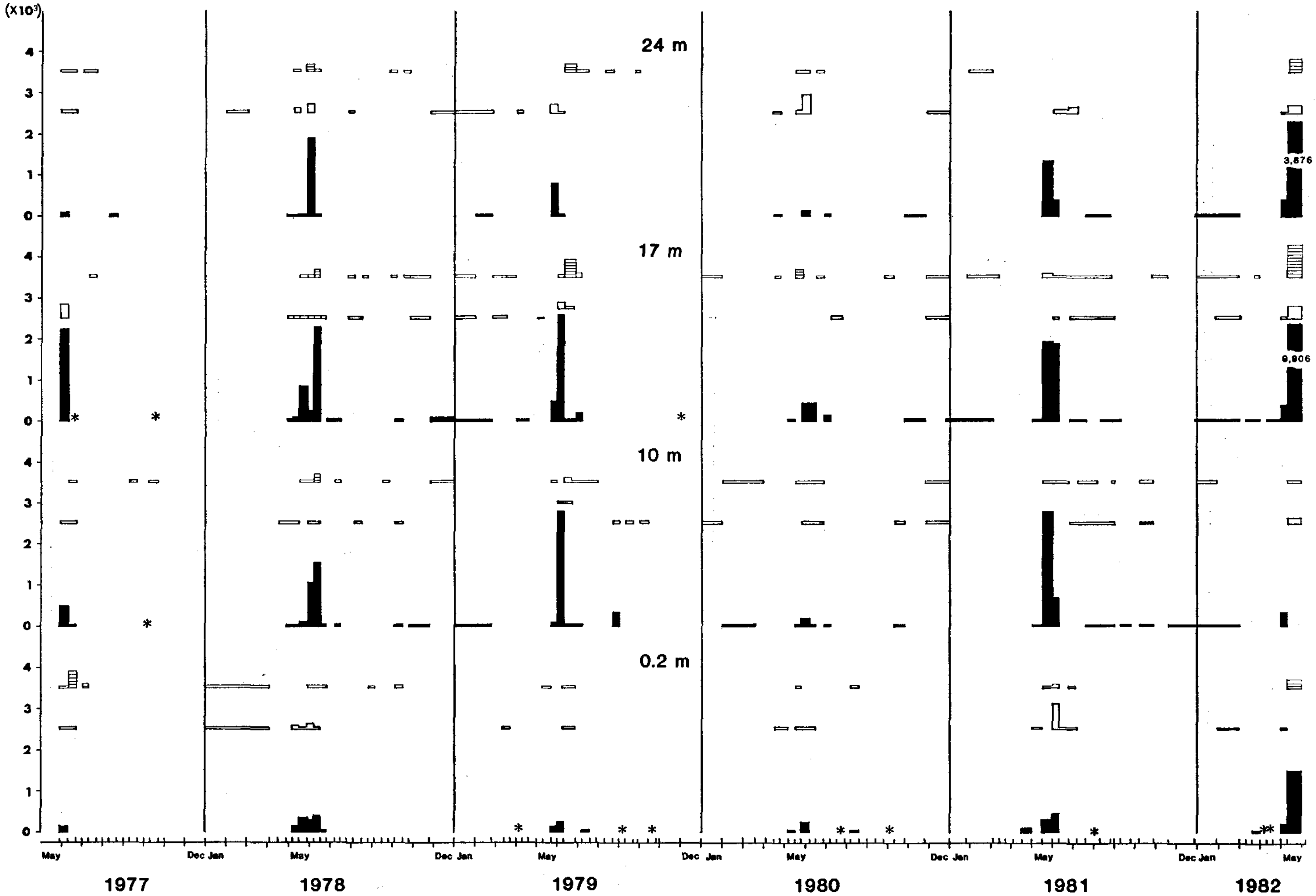

Fig. 11. Each pollen number of *Fraxinus*, *Juglans* and *Acer* per 100 cm² in each collection period in each trap from 1977 to 1982.

Fraxinus *Juglans* *Acer*

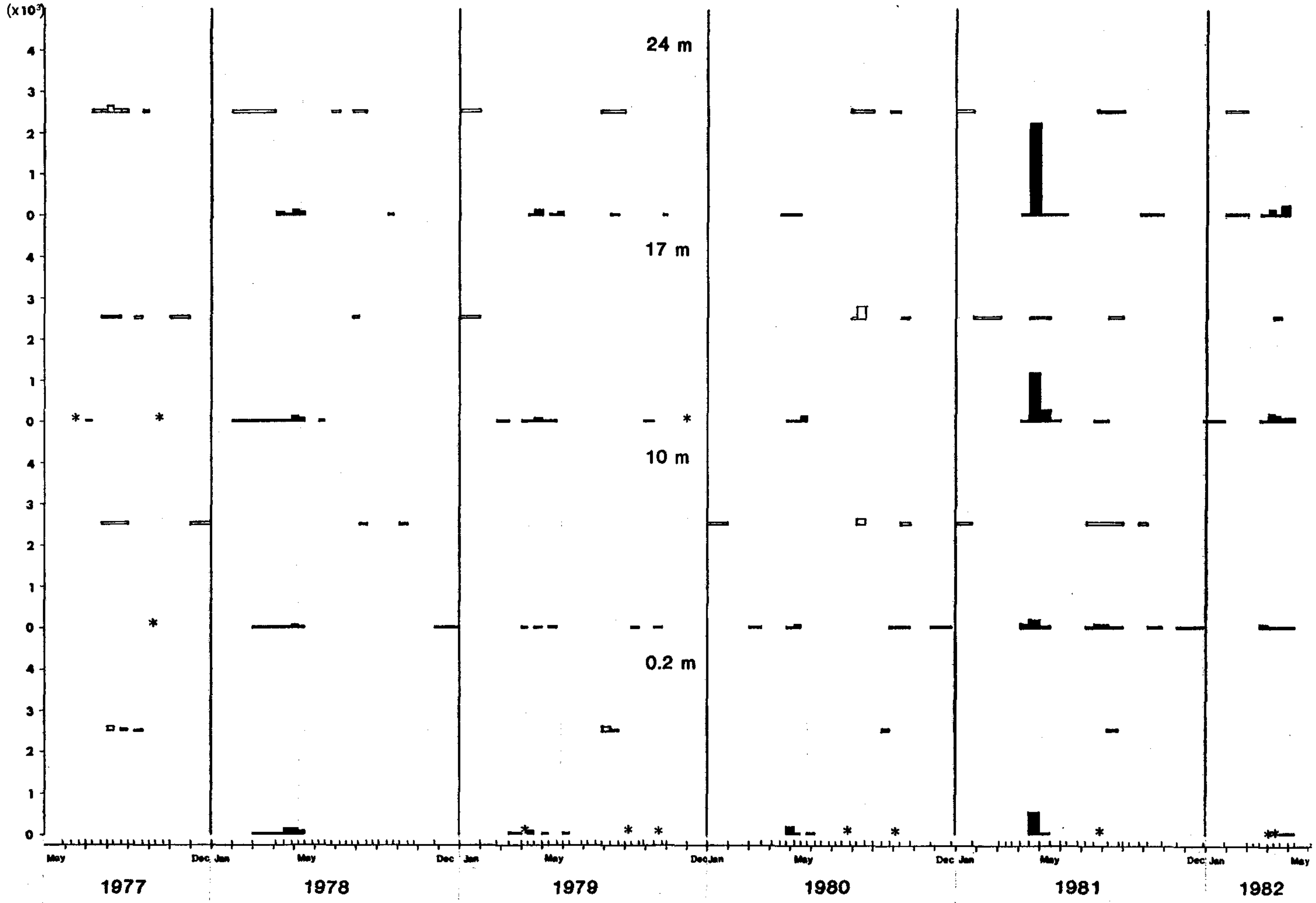

Fig. 12. Each pollen number of *Tilia* and *Corylus* per 100 cm² in each collection perriod in each trap from 1977 to 1982.
Corylus *Tilia*

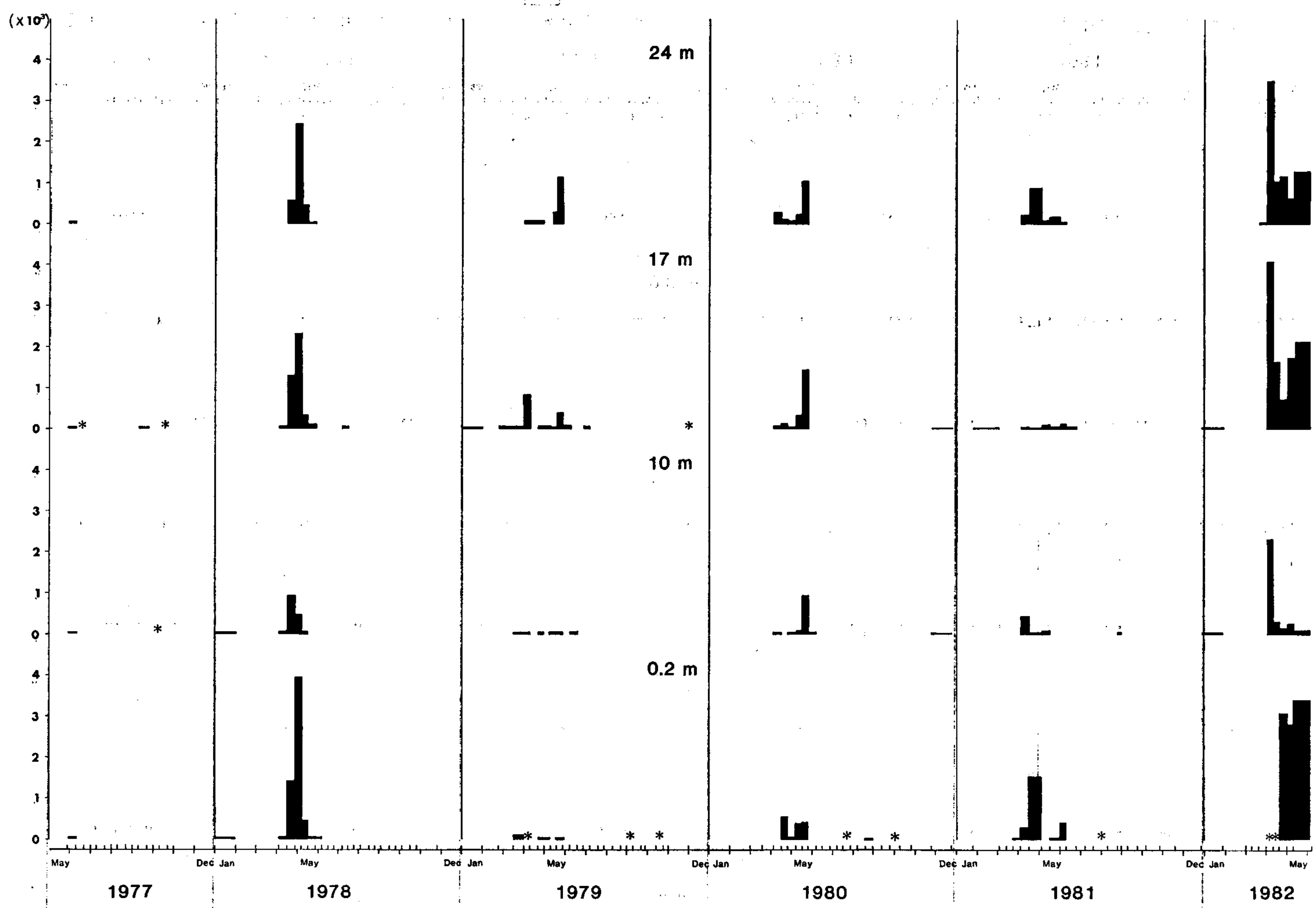

Fig. 13. Number of pollen Cupressaceae per 100 cm² in each collection period in each trap from 1977 to 1982.

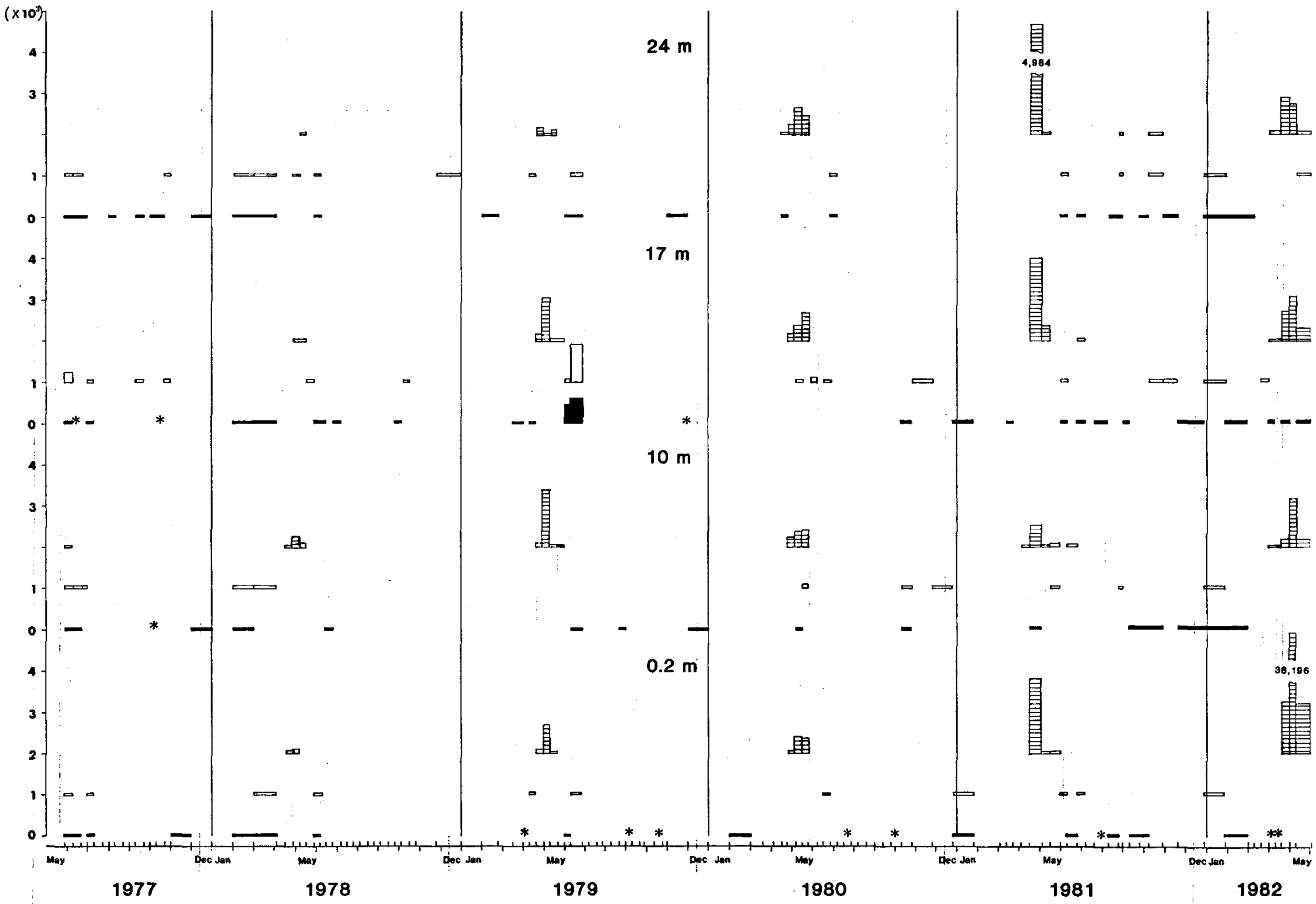

Fig. 14. Each pollen number of *Picea*, *Abies* and *Taxus* per 100 cm² in each collection period in each trap from 1977 to 1982.

Picea *Abies* *Taxus*

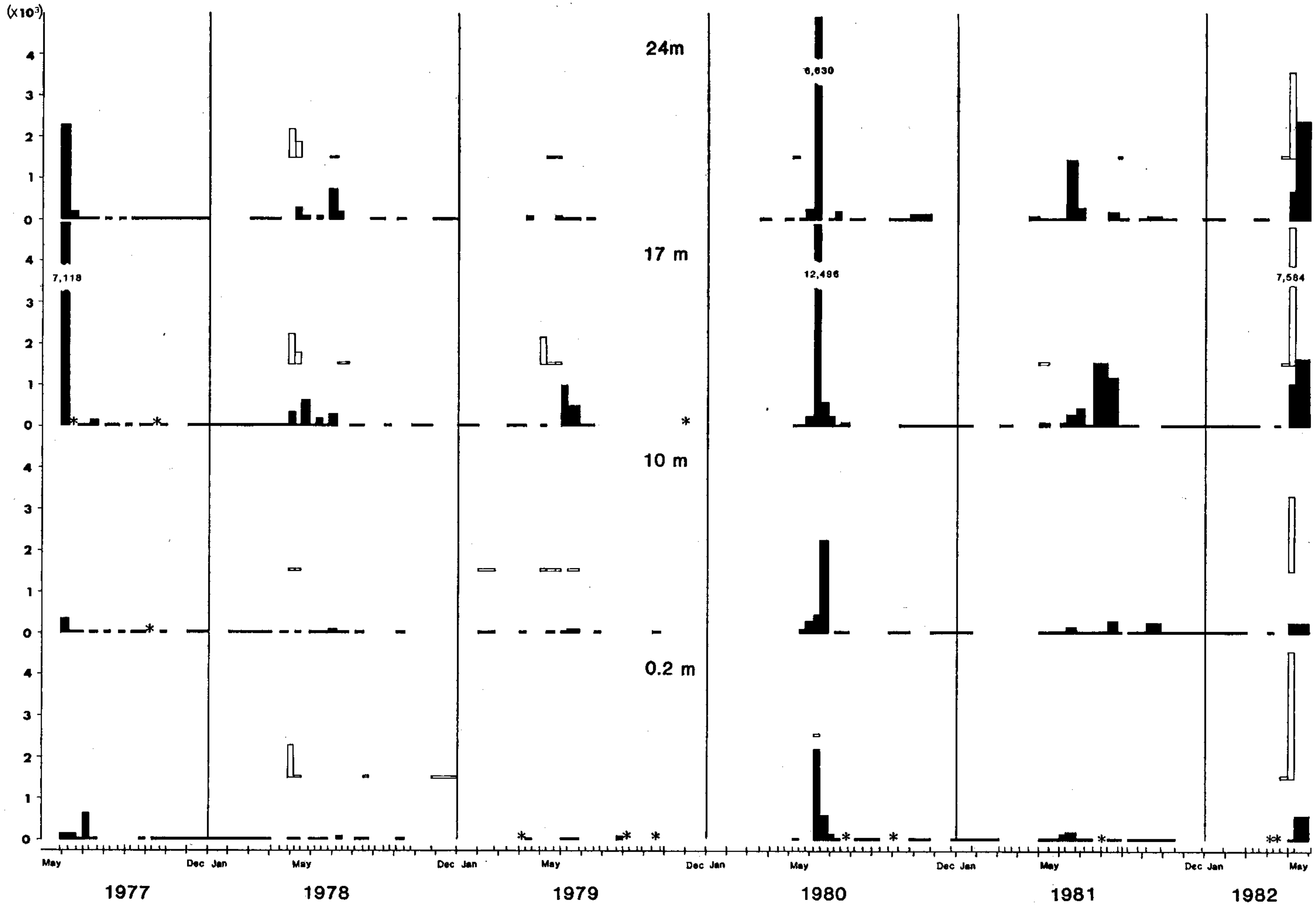

Fig. 15. Each pollen number of *Pinus* and *Larix* per 100 cm² in each collection period in each trap from 1977 to 1982.
Pinus *Larix*

Table 8. Refloatation number of each taxon per 100 cm² in 0.2 m trap collected in each winter time, from November until February

Taxon	1977~1978	1978~1979	1979~1980	1980~1981	1981~1982
Picea	5		10	9	10
Abies			13		
Pinus	16			62	60
Cupressaceae	5				
Larix		28			
Cryptomeria	6	60	13		10
Quercus	18	110	13	96	18
Betula	80	146	43	101	7
Alnus	20	285	26	24	16
Ulmus	3	31	13		
Carpinus	4	95			10
Fagus	6				
Acer	4				
Juglans	5				10
Phellodendron	2				10
Rhus				45	
Araliaceae	8				
Euonymus	3				
AP total	185	755	131	337	151
Rosaceae		12		15	
Chloranthaceae		28			
Sanguisorba	1				
Caryophyllaceae	2				
Epilobium	4				
Polygonum	3	28			
Caltha	3				
Rumex		20			
Labiatae			13		
Carduoideae	2	64	15	15	
Cichorioideae				38	
Artemisia	27	198	21	51	10
Chenopodium	2	102			
Tricolporate	21	86	15		
Tricolpate				9	20
Gramineae	22	67	47	94	20
NAP total	87	605	111	222	50
Polypodiaceae	63	120	15	31	37
Osmunda	4	40			
Lycopodium	84	160	90	22	
Spore total	151	320	105	53	37

Table 9. Refloatation number of each taxon per 100 cm² in 10 m trap collected in each winter time, from November until February

Taxon	1977~1978	1978~1979	1979~1980	1980~1981	1981~1982
Picea	7	34	10	22	18
Abies				8	20
Pinus	16	548		22	56
Cupressaceae	5			43	20
Larix		36			
Cryptomeria		190	63	72	44
Tsuga		17			
Taxus					16
Quercus	94	1,164	139	8,678	811
Betula	30	290	169	1,152	346
Alnus	7	436	147	500	395
Ulmus	3	43	49	22	20
Carpinus	4	98	66	94	180
Fagus	6	9		8	
Acer	4	17	5	43	10
Juglans	5		13	22	
Phellodendron	4				10
Rhus				86	10
Araliaceae	4	57		10	18
Ligustrum				22	8
Salix				108	10
Morus				43	
Corylus		34		22	
Celtis			5		
Maackia		9			
Eleagnus			5		
Fraxinus		88	5		126
Populus		12		22	28
Ostrya		130		15	
Sorbus		34			
AP total	189	3,246	676	6,014	2,146
Daphne		12			
Rumex		12	39	5	
Artemisia	28	878	444	516	152
Carduoideae		34	54	94	18
Chenopodium		24	59	81	
Labiatae			13		
Umbelliferae			156		
Rumex				108	
Polygonum					58

Taxon	1977～1978	1978～1979	1979～1980	1980～1981	1981～1982
Sanguisorba					5
Leguminosae		34			
Thalictrum		9			
Liliaceae					5
Urtica				65	
Reynoutria	5				
Corydalis			12		
Typha		10			
Fagopyrum		9			
Rosaceae		43		8	10
Tricolporate	16	230	140	86	33
Tricolpate		60	26		36
Gramineae	16	256	139	594	70
Cyperaceae		50	26	22	25
NAP total	65	1,661	1,108	1,579	412
Lycopoduim		102	424	65	30
Equisetum		12			
Polypodiaceae	14	230	78	145	63
Osmunda					5
Sphagnum		34			5
Spore total	14	378	502	210	103

Table 10. Refloatation number of each taxon per 100^2 cm in 17 m trap collected in each winter time, from November until February

Taxon	1977～1978	1978～1979	1979～1980	1980～1981	1981～1982
Picea	9			32	27
Abies				5	8
Pinus	21	31		48	87
Cupressaceae		25		80	8
Cryptomeria	10	195	47	39	34
Quercus	62	795	288	2,126	772
Betula	6	912	367	770	407
Alnus	12	114	64	159	420
Ulmus	2	27	32	18	60
Carpinus	6	585	48	23	31
Fagus		46		18	48
Acer		37	8	26	31
Juglans		58		18	5
Castanea		27			
Rhus	4			18	8

Taxon	1977～1978	1978～1979	1979～1980	1980～1981	1981～1982
Araliaceae		12		18	
Ligustrum		27			
Salix		38		26	15
Corylus	2				16
Celtis	2		16		
Maackia				18	
Cornus			30		
Styrax		17			
Populus		25	18		15
Fraxinus		144		15	44
Tilia	3	25		15	
Cercidiphyllum					5
Aesculus					8
AP total	139	3,140	918	3,472	2,049
Carduoideae	4	51	9	14	24
Cichorioideae		6		7	
Artemisia	27	696	203	321	214
Labiatae			17		
Umbelliferae			8		
Rumex	2		17	97	8
Polygonum				61	92
Sanguisorba			9	23	7
Leguminosae	6			7	
Thalictrum		25	6		
Plantago	4	6			
Campanula		25			
Urtica				36	
Corydalis		125			
Chenopodium	11	118	8	61	26
Tricolporate	69	222	111	48	29
Tricolpate	6	56	15	14	62
Gramineae	18	291	39	355	213
Cyperaceae		54	6		29
NAP total	149	1,675	465	1,141	712
Polypodiaceae	22	149	88	95	83
Osmunda	9				20
Lycopodium	24	167	384	36	48
Sphagnum					10
Spore total	55	316	472	131	161

Table 11. Refloatation number of each taxon per 100 cm² in 24 m trap collected in each winter time, from November until February

Taxon	1977~1978	1978~1979	1979~1980	1980~1981	1981~1982
Picea	29	49			19
Abies	9	21			
Pinus	39			144	25
Cryptomeria	11	136		63	
Quercus	116	291	29	1,617	121
Betula	49	191	20	440	95
Alnus	27	185	9	250	126
Ulmus	11	12		18	
Carpinus		102		180	38
Fagus	6	12			24
Acer				6	
Juglans	3	70		7	
Tilia	3	26		9	8
Araliaceae	3				
Fraxinus		23		18	16
Hydrangea	7			63	3
Salix				9	8
Celtis		26		18	
Corylus					8
AP total	331	1,144	58	2,842	391
Rumex				90	3
Artemisia	80	517	94	218	80
Carduoideae	8	50		49	15
Chenopodium	5	50	7	18	15
Umbelliferae		12			
Lysichiton					8
Sedum			7		
Thalictrum		12			
Leguminosae				18	
Corydalis		182			
Utricularia				18	
Typha	6				6
Tricolporate	27		24	180	18
Tricolpate	3	73		18	38
Gramineae	106	87	55	175	71
Cyperaceae	3	69			23
NAP total	238	1,052	187	784	277
Lycopodium	183	139	346	43	110
Polypodiaceae	140	126	51	90	104
Spore total	323	265	397	133	214

Table 12. Refloatation percectages of AP from August until February for the AP total amount in each trap and in each year

Year	0.2 m	10 m	17 m	24 m
1978～1979	1.18 (%)	9.52 (%)	5.00 (%)	1.69 (%)
1979～1980	1.36	22.23	2.00	3.09
1980～1981	3.31	11.90	4.77	5.76
1981～1982	0.59	9.30	11.77	1.58

Table 13. Refloatation percentages of grass pollen and spores from November until April for the total amount of grass pollen and spores in each trap and in each year

Year	0.2 m	10 m	17 m	24 m
1978～1971	8.81 (%)	21.88 (%)	11.48 (%)	10.72 (%)
1979～1980	4.57	31.70	5.16	16.30
1980～1981	13.58	7.15	7.79	24.89
1981～1982	3.15	7.04	9.23	5.05

small amount of snow fall in Tomakomai area in these two months.

Tables 8, 9, 10 and 11 show the grain numbers per 100 cm^2 of pollen and spores collected in the winter time, from 1 November until 1 March. Snow deposited in the traps was also collected. Trees which had dispersed pollen in a large amount during their flower period such as *Quercus, Betula, Alnus, Carpinus* and *Pinus* had high refloatation percentages. In addition to those, *Cryptomeria,* which was located at a considerable distance from the above trees, revealed a comparatively high percentage of pollen. Besides these taxa, 33 AP taxa were found in refloatation. Percentages of AP refloatation of each trap during 1 August to 1 March for the total amount of Ap were between 0.59～22.23% (Table 12).

As to the undergrowth, refloatation of *Artemisia,* Gramineae and *Lycopodium* was comparatively high. Refloatation percentages of grass pollen and spores of each trap from 1 November to 1 May were between 3.15～31.70 (Table 13). Besides these 3 taxa, 34 taxa of grass pollen and fern spores were found to be in refloatation.

V. Wind transport

Pollen of *Cryptomeria, Tsuga, Sciadopitys, Fagus, Aesculus* and *Castanea* collected were not distributed in the surveyed area. Since these taxa are not planted in the forest, they were probably transported by the wind from outside the forest.

Cryptomeria are not naturally distributed in Hokkaido. However, *Cryptomeria* forests have been planted in Oshima Peninsula (Fig. 1). The nearest planted forest of *Cryptomeria* is located about 60 km southwest of Tomakomai near Muroran (Fig. 1). Therefore, the *Cryptomeria* pollen collected were most likely transported by the wind from a distance of at least 60 km. The amount of *Cryptomeria* varied remarkably every year (Fig. 16). Especially in 1978, it increased to a large amount. The percentage of this pollen among the AP total of each trap was between 1.25 and 20.15 per year. Mean of 4 years of each trap was between 5.20 and 8.42% (Table 14).

Fagus are also not naturally distributed around the surveyed area. The present northernmost limit of *Fagus* distribution is the Kuromatsunai Lowland (Fig. 1), about 100 km west of Tomakomai. *Fagus* pollen were thus transported by the wind from a distance of at least 100 km. The percentage of *Fagus* pollen found in each trap was 0.01～3.91 per year. Mean of 4 years of each trap was 0.7～1.2% (Fig. 17, Table 15). NAKAMURA (1967) calculated the amount of *Fagus* transported by the wind from *Fagus* percentages in fossil pollen assemblages of Holocene sediments. According to him, the percentage of *Fagus* pollen transported by the wind was 3.1 at Tomakomai.

The northernmost limit of *Tsuga* distribution is located at Mt. Hakkoda-san (Fig. 1), about 230 km south of the surveyed area. Amount of transported *Tsuga* pollen among the AP total was 0～0.06% per year in each trap (Fig. 17, Table 16). Mean of 4 years of each trap was between 0 and 0.01%. According to NAKAMURA (1967), the precentage of *Tsuga* pollen transported during the Holocene period was 0.08 near Tomakomai.

Sciadopitys pollen originating from about 700 km south of the survey site occurred in the 10 m trap during the middle ten days of May, 1980. Its percentage of the AP total amount per year was calculated as 0.03. Mean value of 4 years was 0.007%. Percentages of each of these transported pollen were lower than those calculated from Holocene sediments by NAKAMURA (1967).

Amount of wind transport is strongly influenced by the prevailing westerlies (NAKAMURA, 1967). Therefore, in the present study, the location of the surveyed area and its position in relation to the source of pollen is an important point. As

Table 14. Percentrages of pollen *Cryptomeria* for the AP total amount and grain number per 100 cm² in each year and in each trap

Traps	1978		1979		1980		1981		1978～1981
24 m	12.72 (%)	(14,713)	1.92 (%)	(2,078)	4.40 (%)	(2,557)	2.31 (%)	(4,157)	5.33 (%)
17 m	20.15	(18,248)	7.01	(8,569)	1.89	(2,003)	2.11	(1,928)	7.79
10 m	14.26	(8,900)	2.83	(2,243)	1.32	(859)	2.43	(1,970)	5.20
0.2 m	18.03	(18,847)	6.84	(3,708)	7.58	(2,352)	1.25	(1,637)	8.42

Table 15. Percentages of pollen *Fagus* for the AP total amount and grain number per 100 cm² in each year and in each trap

Traps	1978		1979		1980		1981		1978～1981
24 m	1.44 (%)	(1,666)	0.01 (%)	(12)	0.57 (%)	(335)	0.85 (%)	(1,545)	0.71 (%)
17 m	1.34	(1,219)	0.08	(109)	0.85	(908)	2.45	(2,593)	1.18
10 m	0.40	(247)	0.04	(33)	0.60	(392)	3.91	(2,545)	1.23
0.2 m	2.15	(2,249)	0.11	(61)	1.34	(417)	1.12	(1,473)	1.18

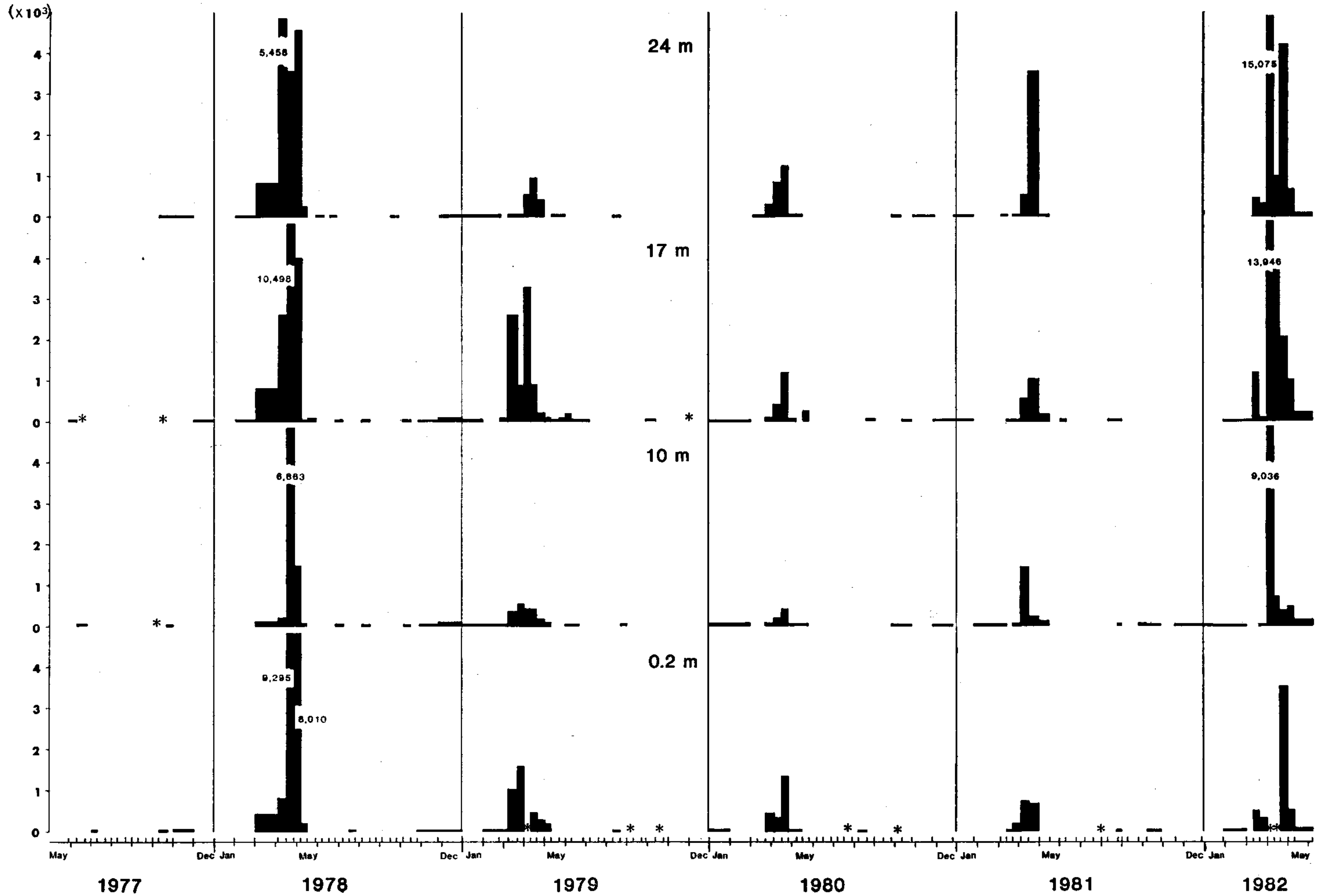

Fig. 16. Number of pollen *Cryptomeria* per 100 cm² in each collection period in each trap from 1977 to 1982.

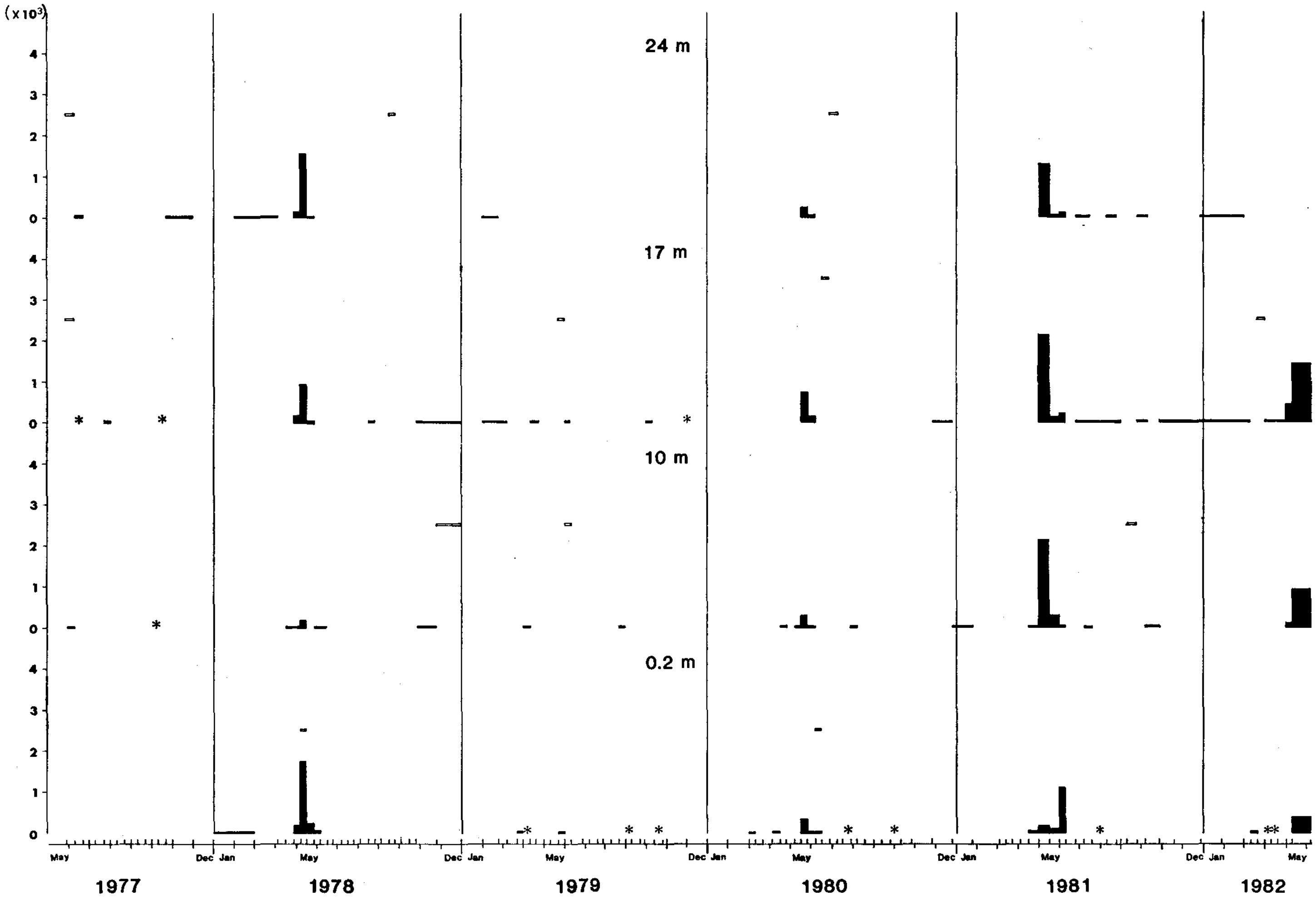

Fig. 17. Each pollen number of *Fagus* and *Tsuga* per 100 cm^2 in each collection period in each trap from 1977 to 1982.
Fagus *Tsuga*

Table 16. Percentages of pollen *Tsuga* for the AP total amount and grain number per 100 cm² in each year and in each trap

Traps	1978		1979		1980		1981	1978～1981
24 m	0.01 (%)	(17)	0.00 (%)		0.00 (%)		0.00 (%)	0.00 (%)
17 m	0.00		0.03	(33)	0.00		0.00	0.00
10 m	0.03	(17)	0.03	(23)	0.00		0.00	0.01
0.2 m	0.01	(12)	0.00		0.06	(19)	0.00	0.01

Tomakomai is located east of the present distribution area of *Fagus* and *Cryptomeria*, the amount of pollen transported by the wind is expected to be larger than that found in other areas.

Conclusion

A large part of each pollen incidence was found during the flower period of each pollen taxa. Generally, AP incidence increased abruptly in March, followed by a sudden decrease in May. Especially, there was a high incidence of *Quercus*, *Betula*, *Alnus*, *Carpinus* and *Fraxinus* pollen. During the flower period, there was generally a larger amount of AP observed above the trunk level than the ground level.

Incidence of grass pollen and spores occurred from May until October at a lower percent than that of trees.

Refloatation of *Quercus*, *Betula*, *Alnus*, *Carpinus* and *Pinus* occurred at comparatively high percentages. Amount of refloated AP of the total AP per year was 0.59～22.23% in each trap.

As to undergrowth, refloatation of *Artemisia*, Gramineae and *Lycopodium* occurred at a comparatively high rate. Amount of refloated undergrowth was 3.15～31.70% for the total of undergrowth pollen and spores per year in each trap.

Percentages of *Cryptomeria* pollen transported from 60 km distance by the wind were 5.2～8.4 of the AP total amount per 4 years in each trap. *Fagus* pollen transported from about 100 km distance showed percentages of 0.71～1.23 for the AP total amount per 4 years in each trap. The percentages of *Tsuga* pollen transported from 230 km distance among the AP total amount were 0～0.06 per 4 years in each trap. These values provide some clues as to distribution of these taxa in geological ages from fossil pollen assemblages.

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要　　約

花粉堆積のメカニズムを明らかにする目的で，1977 年から 1982 年まで，北海道大学農学部附属苫小牧地方演習林内で空中花粉の採取を行った。トラップは，林内の地上より 0.2 m, 10 m, 17 m, 24 m の 4 カ所に設置した。トラップの交換は，開花期間は 10 日ごと，その他の期間は 30 日ごとに行い，その間にトラップに落下した花粉・胞子を同定して taxa ごとに落下数を求めた。

花粉・胞子の落下数は，高さによりまた年により著しく変化に富むが，樹木花粉は，3～7 月の開花期に，樹木花粉の年間落下総数の 80% 以上が落下した。草本花粉・胞子は，5～10 月の開花期に 68% 以上の落下が認められた。樹木では，*Quercus, Carpinus, Betula, Alnus, Fraxinus* 花粉の落下が著しく多く認められた。

開花期以外の期間に再浮遊する taxa は，樹木で 39，草本で 37 taxa に及んだ。中でも，樹木では *Quercus, Betula, Alnus, Carpinus* などの開花期に落下の多かった taxa と *Pinus* が多く，草本では *Artemisia*, Gramineae, *Lycopodium* が多かった。時期的には，降雪の少ない 11 月と 12 月に特に多く認められた。

風による遠距離飛来花粉については，本林より少なくとも 60 km 西の室蘭周辺の植栽林より飛来したとみられる *Cryptomeria* の花粉が 4 つのトラップの 4 年間の平均値の最大が，落下した樹木花数総数の 8.4% に達した。約 100 km 西方の分布北限地の黒松内低地帯より飛来した *Fagus* 花粉は，1.23% に達し，約 230 km 南の分布北限地より飛来したとみられる *Tsuga* 花粉は，0.06% であった。花粉が偏西風にのって運ばれる場合のあることを考慮すると，苫小牧は，*Fagus* と *Cryptomeria* の分布地域の東に位置することから，花粉の飛来率は他地域におけるそれよりも高いことが推定されるものの，化石花粉群集から古植生を復元する際の一つの目安となろう。