Jpn. J. Histor. Bot. Vol. 1 No. 2 p. 49−57 April 1993 植生史研究

Nobuo OOI*: A reconstruction of vegetation at Itai-Teragatani Site, Hyogo Prefecture, Japan, based on the spatial distribution of fossil pollen grains just below the Aira-Tn ash, about 24000 years ago

大井信夫*：兵庫県板井・寺ヶ谷遺跡における姶良 Tn 火山灰直下約 24000 年前の花粉化石の空間分布に基づく植生の復原

Abstract The frequency and spatial distribution of past plants at a small site were reconstructed from the spatial distribution of fossil pollen and spores in a local area. Samples were taken from peat of the Last Glacial just below the Aira-Tn ash at the Itai-Teragatani Site, Hyogo Prefecture, Japan. From the frequencies of 26 major pollen types at 29 points, maximum, minimum, average values and coefficients of variation (standard deviation/average) were obtained and the pollen types' distributions were mapped. Based on their abundance and coefficients of variation, pollen types could be classified into five groups: arboreal groups A-I, A-II and A-III and herbaceous groups H-I and H-II. A-I, A-II and H-I were local elements that had high coefficients of variation; whereas, A-III and H-II were regional elements that had low coefficients of variation. Based on the distribution patterns of the local pollen types (A-I, A-II and H-I), a distribution of the plants in a local area were reconstructed. The site was an open forest with *Picea*, *Salix*, *Betula*, *Fraxinus* and *Alnus* shrubs and local herbs such as *Lysichiton*, *Ranunculus*, *Gentiana*, etc.
Key Words: Pollen, Spatial distribution, Reconstruction of vegetation, The Last Glacial age

要　旨　一遺跡内における花粉化石の空間的分布を解析し植物の分布，配置の復原を試みた。試料は兵庫県板井・寺ヶ谷遺跡の姶良 Tn 火山灰直下の泥炭を 29 地点で採取した。26 の主要な花粉型の各地点の産出頻度の分布図を示し，その最大・最小・平均・変動係数（標準偏差／平均）を求めた。花粉型は産出頻度と変動係数に基づき，木本の A-I, A-II, A-III, 草本の H-I, H-II の 5 つのグループに分けられる。A-I, A-II, H-I は変動係数が高く，局地的な要素と考えられ，A-III, H-II は変動係数が低く，広域的な要素と考えられる。局地的な花粉型（A-I, A-II, H-I）の分布様式にもとづいて，遺跡内局所における親植物の分布を復原した。遺跡はトウヒ属・ヤナギ属・カバノキ属・トネリコ属・ハンノキ属の木本とミズバショウ属・キンポウゲ属・リンドウ属などの草本が生育する開けた林だった。
キーワード：花粉，空間分布，植生復原，最終氷期

Introduction

Although there are many studies that have reconstructed the distributions of past plants or vegetation, few have attempted to reconstruct their spatial distribution, This study aims to demonstrate that spatial analysis of pollen distribution can be used to reconstruct plant spatial distribution and estimate vegetation structure. To obtain the samples of the same time, samples were collected from the peat just below the Aira-Tn ash (MACHIDA & ARAI, 1976): a widespread tephra that is noted as a good time marker for the Last Glacial in Japan. Last glacial vegetation around the Itai-

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Teragatani study site has already been reconstructed from fossil pollen sequences, plant macrofossil sequences and fossil wood distributions (Ooi *et al.*, 1990). This study reconstruct the distribution of plant species in more detail, and furthers our knowledge of the plant spatial distribution.

Location, Samples and Methods

The Itai-Teragatani Site, an archaeological site of the Palaeolithic Age and Yayoi to Middle

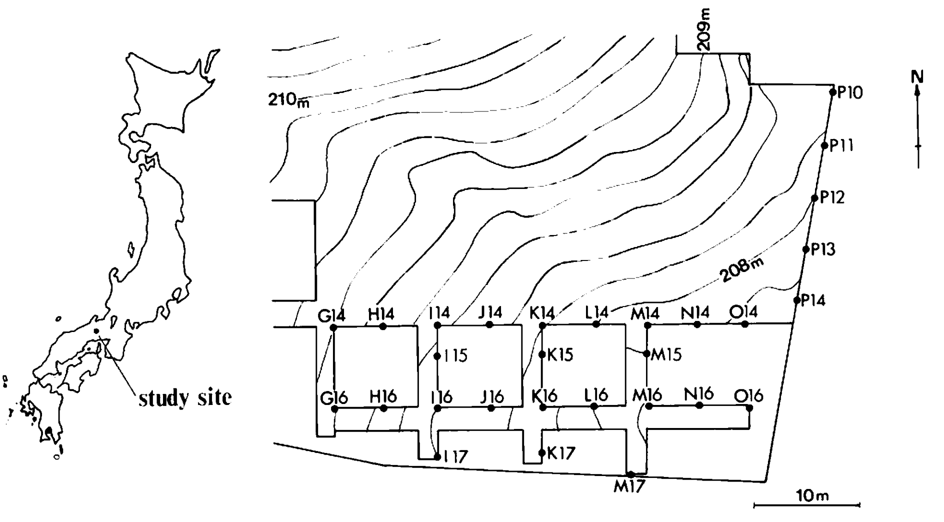

Fig. 1 Map of the Itai-Teragatani site
Black dots show sampling points. Contours show the level of the top of Aira-Tn ash.

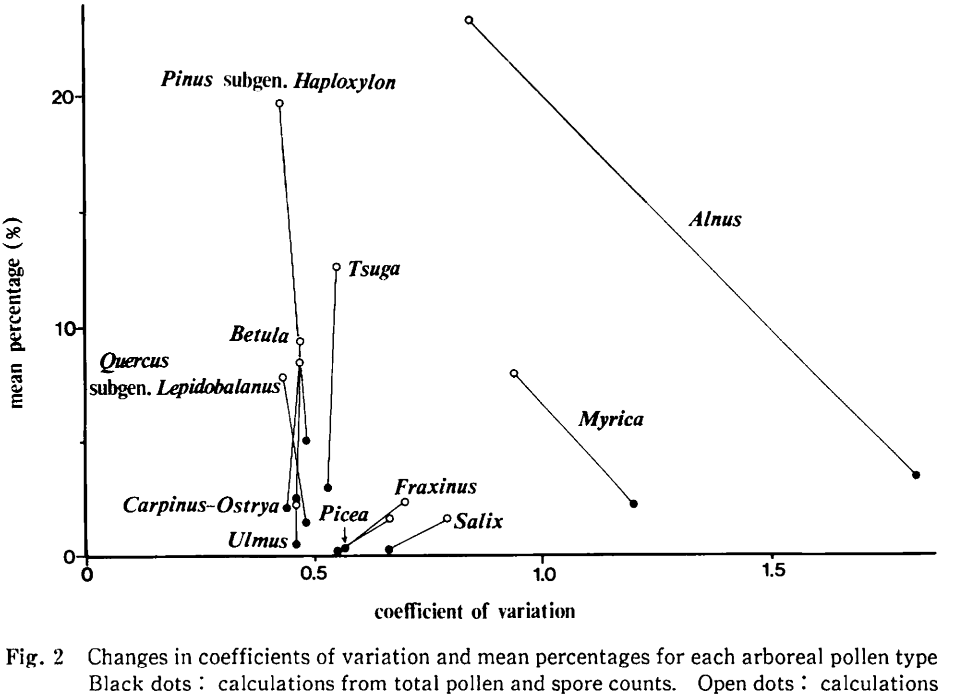

Fig. 2 Changes in coefficients of variation and mean percentages for each arboreal pollen type
Black dots : calculations from total pollen and spore counts. Open dots : calculations from total arboreal pollen counts. Values of same pollen types are connected.

Period, is located at lat. 35°05'53"N, long. 135°09'26"E on a terrace along the Miyata River. Peat sediment of the Last Glacial Age is distributed in the southern part of the site, and intercalates with the Aira-Tn ash. The radiocarbon date of the peat just below the Aira-Tn ash is 23600±200 years BP (KSU-938) (MIZUGUCHI, *et al.*, 1987).

Columnar samples of the peat a few millimeters in thickness were taken from just below the Aira-Tn ash at 29 points (Fig. 1) and were prepared for analysis. Contour lines of Fig. 1 show the altitude of the top of Aira-Tn ash. The thickness of Aira-Tn ash is about 20 cm at every point, therefore this map approximately represents the geomorphology just below the Aira-Tn ash. There was a channel which runs from the northwest to the southeast.

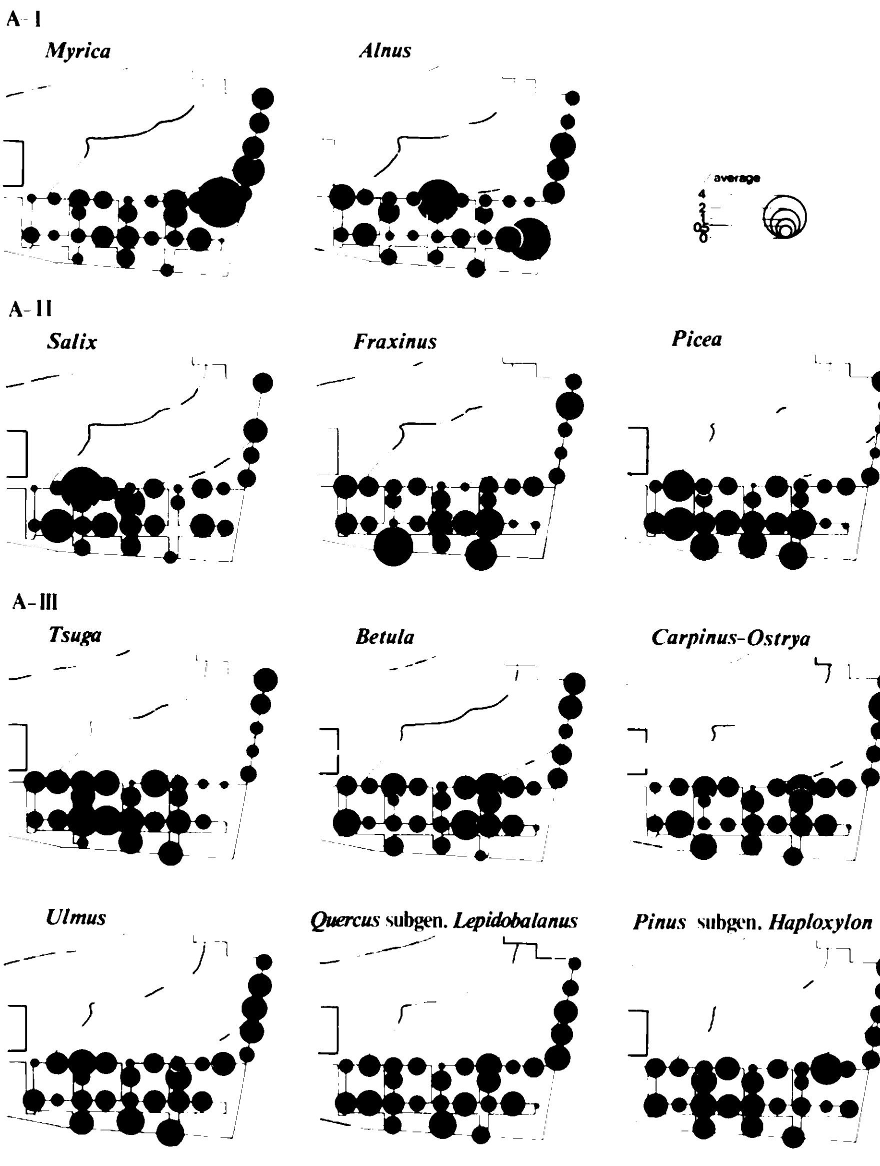

Fig. 3 Distribution of pollen grains of arboreal taxa
Circles are proportional representations of each taxa when compared to the total arboreal pollen count.

Pollen was extracted from the samples by the same methods as Ooi *et al.* (1990). Frequencies of each pollen and spore type at each point was calculated as percentage of the total pollen and spore counts. Percentages of each arboreal pollen to the total arboreal pollen were also calculated. A capital letter after the family name, for example, Ranunculaceae A type or Compositae subfam. Carduoideae L type indicates that the pollen type could be distinguished to the family or subfamily level but not to the genus level. Eleven arboreal pollen types whose average percentages exceeded 1.0 % of the total arboreal pollen counts and 16 nonarboreal pollen and spore types that were more than 0.5 % of the total counts were statistically analyzed. Other types were not analyzed because they are too scarce to have statistic significance.

Results

Figures 3 to 5 show the frequency distributions in percentages for each pollen type. Distribution maps of arboreal pollen types were drawn from percentages of the total arboreal counts.

Figure 2 shows the coefficients of variation and averages for each arboreal pollen type based both on total arboreal pollen counts and on total pollen and spore counts. It shows that arboreal pollen distribution patterns can be classified into three groups : A-I, A-II and A-III.

A-I : High frequencies and high coefficients of variation.

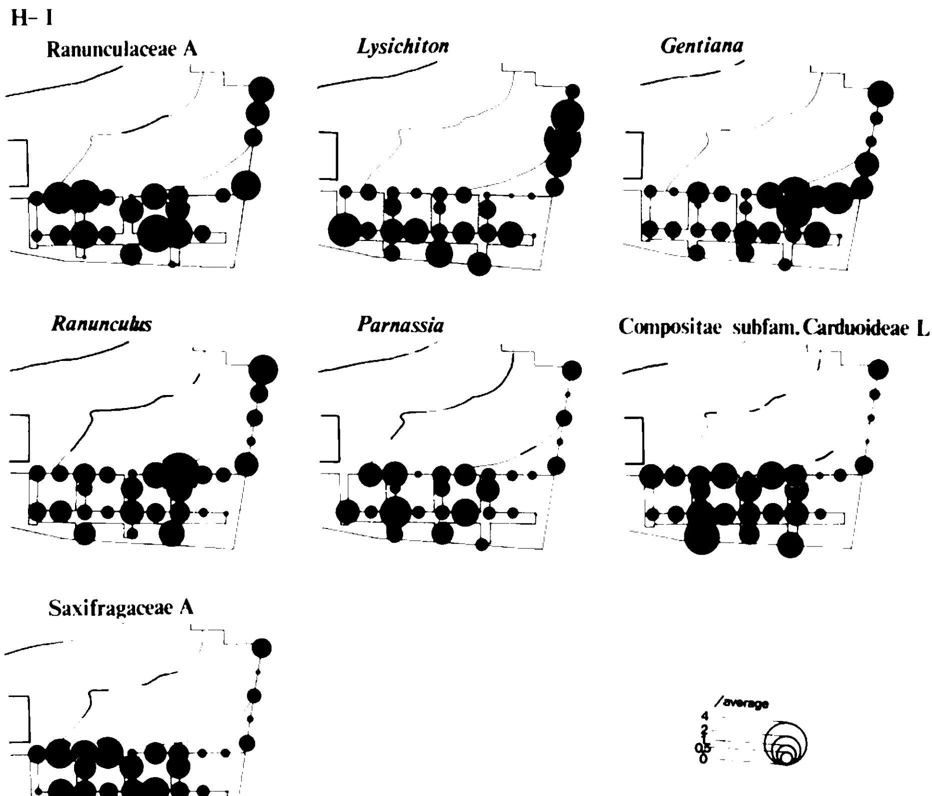

Fig. 4 Distribution of pollen types of herbaceous group H-I
Circles are proportional representations of each taxa when compared to the total arboreal pollen count.

Myrica and *Alnus* were included in this group. They had high coefficients of variation, 0.94 and 0.84 when calculated from the total arboreal pollen, and 1.20 and 1.81 when calculated from the total pollen and spores. Values were high at most of the points and extremely high at a few points : *Alnus* had more than twice the average percentage at K14 and O16 and *Myrica* at O14 (Fig. 3). *Myrica* and *Alnus* were often observed as a mass of pollen.

A-II : Low frequencies and high coefficients of variation.

This group consisted of *Salix*, *Fraxinus*, and *Picea*. Their coefficients of variation exceeded 0.6 when calculated from the total arboreal pollen, but decreased significantly when calculated from the total pollen and spores (Fig. 2). Average frequencies were from 0.3 to 0.5 %. The distribution maps show extreme abundance at several points, and the distribution of these points is somewhat clumped when compared with *Myrica* and *Alnus*. Distribution centers were I14 for *Salix*, I17 and M16 for *Fraxinus*, the western and southern sides for *Picea* (Fig. 3).

A-III : Low coefficients of variation.

Six pollen types were included in this group (Table 1). Coefficient of variation values was low, between 0.43 to 0.55, for all calculations. Distribution of *Tsuga* was concentrated along a southwestern line from G14 to K17 and a northeastern one at P10 (Fig. 3). Other pollen types had no clear distribution tendencies.

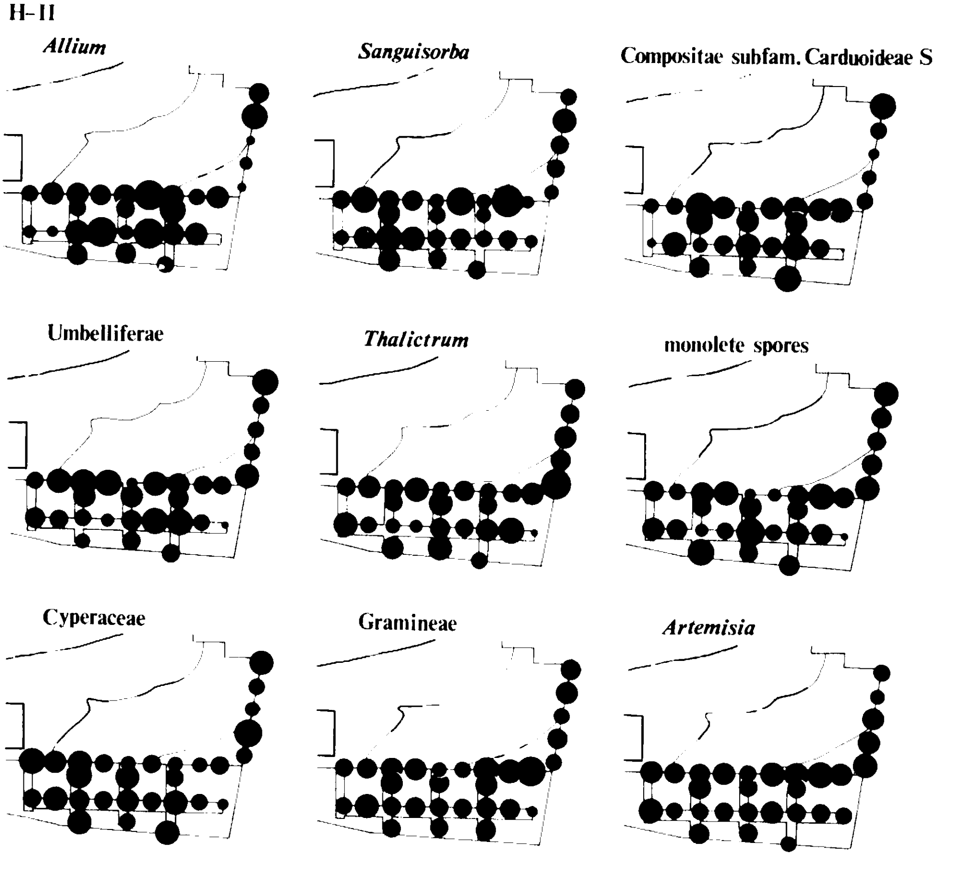

Fig. 5 Distribution of pollen types of herbaceous group H-II
Circles are proportional representations of each taxon when compared to the total arboreal pollen count.

Coefficient of variation values for herbaceous pollen ranged from 0.27 for *Artemisia* from 0.81 for Ranunculaceae A type (Table 1). There were no distinct boundaries for arboreal pollen types. However, based on coefficient of variation values, two groups could be distinguished : H-I and H-II. H-I : High coefficients of variation.

Table 1 Statistics for the distribution of pollen grains distribution of each taxon
Values were calculated from total pollen and spore counts. The values of arboreal pollen in the brackets were calculated from total arboreal pollen counts. MAX : maximum, MIN : minimum, AVG : average, STD : standard deviation, - : not observed, 0.0 : insignificant. Occurences of fossil woods and plant macrofossils were derived from Ooi *et al.* (1990). o : occurred just under the Aira-Tn ash. + : occurred in a different horizon of the peat layer of the site.

group	pollen type	MAX	MIN	AVG	STD	STD/AVG	wood	macrofossil
	[arboreal pollen]							
A-I	*Myrica*	14.8	0.3	2.2	2.6	1.20		
		[43.2]	[0.3]	[8.0]	[7.6]	[0.94]		
	Alnus	75.8	1.6	8.7	15.9	1.81	o	o
		[90.4]	[7.1]	[23.1]	[19.6]	[0.84]		
A-II	*Salix*	0.7	-	0.3	0.2	0.66	+	
		[4.1]	[-]	[1.1]	[0.8]	[0.79]		
	Fraxinus	1.4	0.1	0.5	0.3	0.56	o	
		[7.9]	[0.5]	[2.3]	[1.6]	[0.70]		
	Picea	0.8	0.1	0.4	0.2	0.55	o	+
		[4.2]	[0.1]	[1.7]	[1.1]	[0.86]		
A-III	*Tsuga*	6.7	0.3	3.0	1.6	0.53		
		[28.0]	[0.3]	[12.6]	[7.0]	[0.55]		
	Betula	5.7	0.8	2.4	1.1	0.46	o	o
		[20.2]	[1.4]	[9.4]	[4.4]	[0.47]		
	Carpinus-Ostrya	4.3	0.5	2.1	0.9	0.44		
		[16.5]	[0.6]	[8.5]	[4.0]	[0.47]		
	Ulmus	1.1	0.0	0.5	0.2	0.46		
		[3.7]	[0.0]	[2.2]	[1.0]	[0.46]		
	Quercus	3.2	0.4	1.5	0.7	0.48		
	subgen. *Lepidobalanus*	[11.2]	[0.5]	[5.9]	[2.6]	[0.43]		
	Pinus	14.9	1.9	5.0	2.4	0.48		+
	subgen. *Haploxylon*	[43.1]	[3.8]	[19.7]	[8.5]	[0.43]		
	[nonarboreal pollen]							
H-I	Ranunculaceae A	1.9	-	0.6	0.5	0.81		
	Lysichiton	35.3	0.9	11.5	8.5	0.74		
	Gentiana	1.7	0.0	0.5	0.4	0.73		
	Ranunculus	3.9	0.0	1.1	0.7	0.69		
	Parnassia	1.7	-	0.7	0.5	0.67		
	Compositae							
	subfam. Carduoideae L	7.2	-	2.4	1.6	0.65		
	Saxifragaceae A	16.2	0.2	7.2	4.6	0.63	o (*Hydrangea*)	
H-II	*Allium*	1.8	-	0.9	0.4	0.50		
	Sanguisorba	9.8	1.9	4.4	2.0	0.44		
	Compositae							
	subfam. Carduoideae S	6.3	0.1	3.7	1.6	0.43		
	Umbelliferae	6.0	0.6	3.7	1.5	0.40		o
	Thalictrum	3.1	0.3	1.4	0.5	0.36		
	Cyperaceae	23.5	5.7	13.3	4.5	0.33		o
	Gramineae	21.0	3.2	10.9	3.4	0.30		
	Artemisia	4.0	1.4	2.5	0.7	0.27		
	[fern spores]							
	monolete spores	9.1	1.0	5.3	1.8	0.34		

Seven pollen types were included in this group and their coefficients of variation were more than 0.63. Their distributions varied greatly (Fig. 4). Ranunculaceae A type was concentrated near H14, I14 and L16 ; *Lysichiton* type from G16 to K17 or L16 and from P11 to P13 ; and *Gentiana* and *Ranunculus* types around K14 and K15. The distribution of *Parnassia* type was scattered ; whereas, Compositae subfam. Carduoideae L and Saxifragaceae A types were more widely distributed. Carduoideae L type was around the center of the southern part, and Saxifragaceae A type around the western part.

H-II : Low coefficients of variation.

This group consisted of *Allium*, *Sanguisorba*, Compositae subfam. Carduoideae S, Umbelliferae, *Thalictrum*, Cyperaceae, Gramineae and *Artemisia* types and monolete spores (Table 1). Their coefficients of variation values were less than 0.50. They were distributed evenly at every point (Fig. 5).

Discussion

Pollen concentration is generally higher near its source and decrease rapidly as the distance from the source increases (JANSSEN, 1966). When differences between pollen abundances at two relatively close points are measured at equal intervals, they decrease as measurements are taken further from the pollen source. This suggests that pollen type frequencies close the their source are more variable. Plant groups at the site might consequently have high variances, especially if they were not distributed

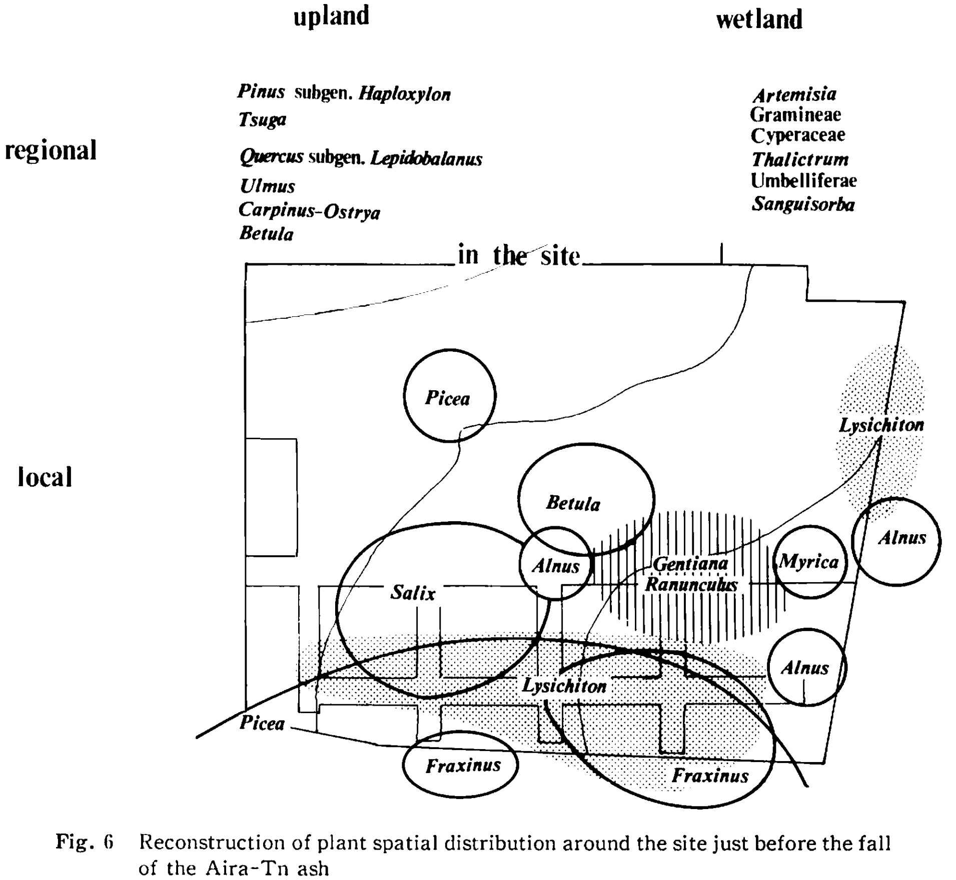

Fig. 6 Reconstruction of plant spatial distribution around the site just before the fall of the Aira-Tn ash

equally at the site. These groups are called autochthonous groups or more conventionally local elements. On the other hand, pollen frequency of plants from outside the sites would have low variances. These groups are referred to as allochthonous groups or regional elements. In the Kakuda Basin in northern Japan, YONEBAYASHI (1988) distinguished local and regional elements by their coefficients of variation. This method of analysis can be applied to this study, although the extent of the study areas differ. YONEBAYASHI (1988) investigated differences between sites in the basin, whereas differences at the site were investigated in this study.

Thus, it is possible to concluded that the groups A-III and H-II which had low coefficients of variation between the sampling points were regional elements. On the other hand, groups A-I and H-I which had high coefficients of variation were clearly local elements as was group A-II whose coefficients of variation become high when caluculated from total arboreal pollen. The pollen distribution of the local groups, H-I, A-I and A-II, indicates the distribution of the plants at the site. For example, *Lysichiton* lived in the south and east (Fig. 4 and 6). *Gentiana* and *Ranunculus* were concentratedly near point M14 ; whereas, *Parnassia* had a scattered distribution (Fig. 4 and 6). The distibution of *Alnus* pollen suggests that they were near points K14 and O16 (Fig. 3 and 6). *Myrica* was distributed near point O14, and *Salix*, *Fraxinus* and *Picea* shared their habitats in the southern part of the site (Fig. 3 and 6).

From the vertical sequences of fossil pollen and plant macrofossils and fossil wood distribution of 4 horizons at the study site, OOI *et al.* (1990) reconstructed two types of vegetation : wetland and upland. Wetland vegetation was distributed near or on peaty sediments, and upland vegetation was distributed in the mountains around the wetland. On the uplands, there were forests that consisted mainly of *Pinus* subgen. *Haploxylon* and *Quercus* subgen. *Lepidobalanus*. In the wetlands, there were stands of *Betula* and *Alnus* in grassland consisting of Cyperaceae, Gramineae, *Lysichiton*, *Thalictrum*, *Sanguisorba*, Umbelliferae and Compositae. Going from the wet lands to the uplands, *Alnus*, *Betula* and *Picea* trees could be found in the order listed here.

A comparison of the reconstruction by OOI *et al.* (1990) with the present study highlights the advantages and problems of spatial analysis. Herbaceous taxa can distinguish local and regional elements by spatial analysis, and the habitats of local elements can be reconstructed from pollen distribution. For arboreal taxa, local elements correspond with wetland vegetation and regional elements with upland vegetation. Distribution of *Alnus* wood coincided well with the distribution of the pollen, although *Picea* and *Fraxinus* wood had relatively different distributions. This may have resulted from difference in sampling methods. Fossil woods were correcting whole of the northern parts and trench walls at the southern parts of the site ; whereas pollen samples were collected from trench walls at the southern parts of the site. A problem in using spatial analysis can be seen from the habitat of *Betula*. There were erect *Betula* stumps that provide evidence of their presence at the site, but *Betula* had a relatively low pollen distribution variance. Also Cyperaceae whose macrofossils were common had a relatively low variance. One possible explanation is that they were common during the age investigated, but large quantities of pollen from outside the sites covered the local distribution. In addition, for Cyperaceae many species occupied various habitats, and thus, they had a relatively constant distribution at the site.

In conclusion, we can estimate the distribution of plants just before the fall of the Aira-Tn ash (Fig. 6). The site was an open forest of *Picea*, *Salix*, *Betula*, *Fraxinus*, *Alnus* and *Myrica* trees and shrubs. In the understory, herbaceous plants such as, *Lysichiton*, *Ranunculus*, *Gentiana*, *Parnassia* and some Compositae shared the habitat. Other dominant herbaceous taxa, such as, Cyperaceae, Gramineae, Umbelliferae, *Sanguisorba*, *Artemisia*, and *Thalictrum* were widely distributed in wetland. *Pinus* subgen. *Haploxylon*, *Tsuga*, *Quercus* subgen. *Lepidobalanus*, *Ulmus*, and *Carpinus-Ostrya* were dominant in uplands.

Spatial analysis of pollen is an excellent method for estimating plant distribution. It is difficult to determine plant distribution only from a one point analysis and spatial pollen analysis provides good information on the spatial distribution of fossil wood and plant macrofossils. A multidisciplinary study of various fossil parts, for example pollen, wood, leaf and seeds yields good information. Spatial analysis, however, provides further information for understanding past vegetation.

Acknowledgements

I am grateful to Prof. Shohei KOKAWA, Chiyoda Junior College, and Dr. Sei-ichiro TSUJI, Osaka City University, for their continuous advice and encouragement throughout this study. Thanks are also due to Dr. Mutsuhiko MINAKI, University of Marketing and Distribution Science, Mr. Toshio FUJII, Museum of Human Activity and Nature, Hyogo Prefecture, and Miss Kiyoko KUWAHARA, Osaka City University, for help with field surveys and sampling. My special thanks go to the Educational Board of Hyogo Prefecture for permission to use the site and publish the results.

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(Accepted on February 18, 1993)

書評（新刊紹介）：環境庁環境保健部保健調査室．1993．花粉症の原因となる花粉の形態学的観測法． 128 pp. 公害研究対策センター．

本書は現在社会問題化している花粉症の原因となる花粉の形態学的観測法を，花粉症に詳しい斉藤洋三氏を班長とし，幾瀬マサ氏らを班員とする研究班を組織して取りまとめたものである。基礎編－観測システムと花粉の同定法と，技術編－観測の実技と花粉症花粉の臨床的意義の２部から構成されている。

本書は花粉症治療に携わる地域で活動する保健医療機関を対象としているため，花粉症の原因となっいる花粉を正確に把握し，地域に情報提供するために，日本で実施されている先進的な花粉観測システムを概括し，花粉観測実施の手引きとなる手法について，例えば標準的な機器，観測地点の選び方などの意見がまとめられている。飛散する花粉の形態学的観察に関する研究者の業績の紹介，図版と写真を添えた解説は，実用的な手引き書として利用価値が高いものである。

空中花粉の観測サンプリング方法や測定方法など，研究者によってまちまちであるが，スギ花粉を主体とした花粉観測システムが，全国的に統一されつつあり，スギ花粉前線図などの作成など花粉症予防の面で役立っている。空中花粉の測定は，花粉分析の基礎的研究としての花粉の動態研究の一部としても重要であるので，空中花粉サンプリング捕集法の実際などを知る上で，本書は役立つであろう。また，花粉の開花時期や開化時間，飛散数，飛散距離などを測定する際の参考ともなるであろう。また，日本の主な空中花粉 57 種についての検索表が，幾瀬の花粉型模型図をもとにして作成されているが，あくまでも花粉症治療に携わる者のための検索表であって，検索の根拠は，花粉の形態だけでなく，飛散期間や周辺の植生などを考慮して作成されたユニークなものとなっている。（松下まり子）