

A study of the transport and deposition of oilseed rape (*Brassica napus* L.) pollen in east Fife, Scotland

Peter Cundill *

School of Geography and Geosciences, University of St. Andrews, Purdie Building, North Haugh, St. Andrews, Fife, KY16 9ST, UK

Received 17 November 1997; accepted 28 January 1998

Abstract

It has been suggested that there is a link between the relatively recent expansion in the farming of oilseed rape (*Brassica napus* L.) and an increase in the incidence of respiratory illness in eastern Scotland. However, there is limited evidence of the extent to which one possible cause of this increased illness, the pollen of oilseed rape, is disseminated from fields of this crop. The present study used sedimentation traps and a portable volumetric air sampler to study the transport of pollen from rape fields in Fife, and the results confirmed the widely held view that most of the pollen travels only a short distance from its source. In this case relatively low quantities of *Brassica* pollen were detected more than 200 m from fields of rape. This may have implications for the formulation of advice for those who appear to suffer from an allergic reaction to rape crops. © 1998 Elsevier Science Ireland Ltd. All rights reserved.

Keywords: Oilseed rape; Pollen; Dispersal; Deposition

1. Introduction

In the last 10 years concern has been expressed in eastern Scotland over an increase in the number of reported respiratory illnesses caused by allergic reaction during the spring and early summer. It seemed easy to conjecture that there was a link between this higher incidence of respiratory illness and an increase in the cultivation of oilseed rape (*Brassica napus* L.). Robinson (1988) has charted the spread of cultivation of this crop from southern-central England in the early 1970s through to the Scottish border by about 1979 and then through eastern Scotland, reaching maximum levels of cultivation by 1987. The history of cultivation of oilseed rape is similar in Fife as the rest of Scotland. Relatively few studies have been carried out on the link

between the growth of oilseed rape crops and allergic reactions in humans although investigations were carried out in 1989 (Cameron, 1989a,b, Cameron and Parratt, 1989) and further work is in progress at the present time (Parratt et al., 1995). It was assumed that the pollen of the oilseed rape crop produced the allergic reaction, but few studies have been conducted to demonstrate that oilseed rape pollen could travel sufficient distances from fields of the crop to affect people. Studies that have been carried out have taken place mainly in southern England (McCartney, 1990, McCartney and Lacey, 1991) and very few (Cameron, 1989b) discuss the situation in eastern Scotland.

The present study was undertaken to rectify this situation, although from the outset it was recognised that demonstrating the link between oilseed rape pollen and allergic reaction was the domain of medical scientists. The aim of the present study was to examine the transport and deposition of oilseed rape pollen from fields of the crop in a rural area.

* Tel.: +44 1334 463914; fax: +44 1334 463949; e-mail: gg@st-andrews.ac.uk

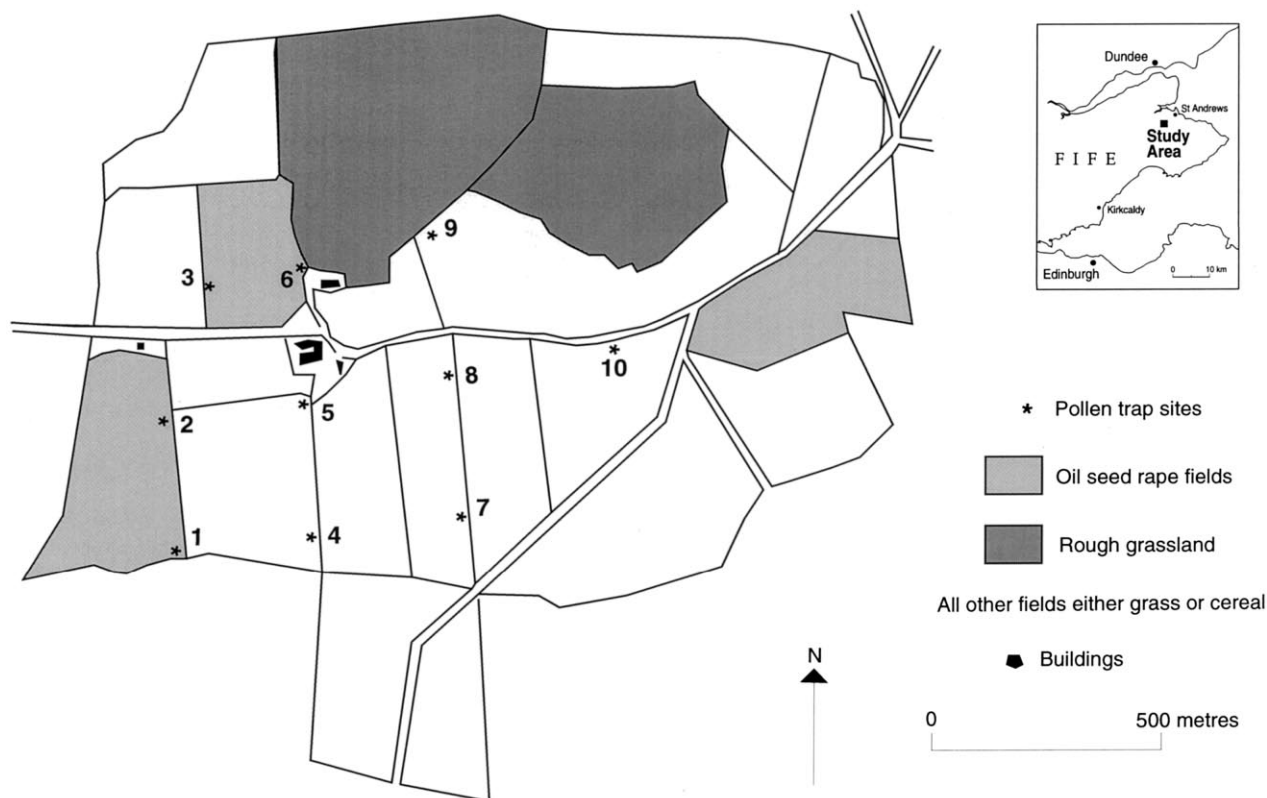


Fig. 1. The location of the study area within eastern Scotland and the distribution of sample sites and fields of oilseed rape at Drumcarro Farm, Fife in 1990.

2. Techniques

There are a number of problems associated with conducting field experiments which involve the capture of microscopic aerobiological particles. It is possible to use electrically powered static air samplers of the Burkard or Montezori type as McCartney (1990) demonstrated, but the cost of these together with their relative inflexibility (they need to be adjacent to an electricity source) has meant that invariably they are sited in few locations. This means that only a limited picture of pollen dispersal can be obtained. There are also portable battery powered air samplers such as the Burkard volumetric trap but these cannot be left unattended for more than two hours because of restrictions posed by battery life. They also sample relatively small quantities of air (10 l/min) but they are useful for taking 'spot' samples. Other methods of sampling modern pollen have been devised by palynologists interested in exploring the relationship between modern pollen and vegetation in order to assist the interpretation of fossil pollen records (Davis, 1963). The techniques adopted include collection of moss and surface lake mud samples (O'Sullivan, 1973, Caseldine, 1981, Boyd, 1986), but also a variety of sedimentation traps have been field tested (Flenley, 1972; Tauber, 1974; Cundill, 1986). Compared with air samplers, sedimentation

traps will only capture pollen which falls onto them over a relatively long period of time and they do not provide a record of atmospheric pollen content. Nevertheless sedimentation traps do have the advantages of being cheap, easy to sample and robust, and it is justifiable to use them to indicate the distances over which pollen is disseminated.

2.1. The study

The area chosen for the present study is centred on Drumcarro farm, 7 km directly west of St. Andrews, Fife (Fig. 1). The sampling period commenced on Friday 13th April 1990 and ceased on Friday 22nd June 1990 (10 weeks in total). This time period extended from just before the commencement of oilseed rape flowering until the end of the flowering season. Two main techniques were employed. One used sedimentation traps which consisted of a standard 7.6 cm diameter flower pot with a layer of acetate wool held in the top by wire mesh (Cundill, 1986, 1991). The pot was then sunk into the ground so that the surface of the acetate wool was level with the surrounding ground surface. The acetate wool captures dry deposition of pollen on its surface and acts as a filter to pollen being carried through it on rain droplets during wet deposition (Cundill, 1986). The traps were located at ten sites

evenly spread across the area (Fig. 1). The sites were located at the edge of fields in order to facilitate their easy relocation during sampling and to avoid potential damage by farm vehicles spraying fungicide or fertilizer. In general, the sites were chosen at approximately the same distance apart and spread out sufficiently to identify in particular the eastward distribution of pollen from the two fields located at the western edge of the Drumcarro lands. Only three out of 100 samples could not be collected due to the removal of the acetate wool by birds or rodents, possibly for use as nesting material.

A second technique involved the use of a portable Burkard volumetric trap which draws air through a slit shaped orifice and any particles (including pollen and spores) are impacted on to a microscope slide which is smeared with sticky material to retain the particles. In the present study glycerol was used as the sticky material. The trap was operated at sites 2, 5, 8 and 10 while adjacent sedimentation traps were being sampled. At each of the sampling points the trap was allowed to operate for 15 min which resulted in 0.15 m³ of air being sampled. As soon as sampling was complete, the slide was removed from the trap and a 22 × 22 mm cover slip placed over the glycerol.

2.2. Laboratory analyses

The whole of the acetate wool sample from each of the 97 samples was dissolved in acetone and treated with 10% NaOH and acetolysis before being dehydrated with alcohol and mounting in silicon fluid (Faegri and Iversen, 1989; Moore et al., 1991). Samples prepared using this technique were clear of debris and pollen could be readily identified. A tablet (Stockmarr, 1972) containing 11267 ± 370 *Lycopodium* spores was added to each sample prior to chemical treatment and this allowed absolute pollen values to be calculated. The pollen sum adopted was 100 exotic *Lycopodium* and this permitted the counting of the same proportion of the total sample each time. In previous studies (Cundill, 1986, 1991) it was found to be necessary to use a total *Lycopodium* sum (rather than a sum based on, for example, total dry land pollen) because of the substantial variations in pollen deposition from month to month during the year. It was anticipated that the same problem would arise from week to week in the present study.

The slides collected from the Burkard volumetric trap were ready for immediate microscope examination. The whole of the cover slip was scanned systematically and all pollen recorded. A few unidentified pollen were encountered but in general the material was in a good state of preservation and easy to identify. Samples from both the sedimentation and Burkard traps were counted under a Nikon Sk-t microscope at a magnification × 600.

All the Brassicaceae identified in the present study are considered to have been derived from oilseed rape plants, although there are drawbacks with this assumption. Examination of the thirty different Brassicaceae species in the type slide collection at St. Andrews revealed that although there is considerable variation between the different species, it is difficult to distinguish oilseed rape pollen from several other Brassicaceae pollen types. This difficulty was recognised by Andrew (1984) who made few comments about distinguishing the pollen of different species of this family. Palynologists in general have made no attempt to separate pollen within the Brassicaceae family (Godwin, 1975; Moore et al., 1991). Potentially this creates a problem because many members of the Brassicaceae family flower at the same time as oilseed rape, so there is always the possibility that Brassicaceae pollen identified as oilseed rape may have originated from another species in the family. This problem is one which may affect sampling sites located some distance from fields of oilseed rape where there is an increased risk that at least some of the pollen has been derived from non oilseed rape sources. As long ago as 1943, in a study of eight sites around Britain, Hyde (1950) showed that Brassicaceae pollen was present at all of them, albeit at values of below 1% of total pollen. As Hyde's work was carried out prior to the expansion in the cultivation of oilseed rape, the Brassicaceae pollen he identifies was derived from plants such as charlock (Hyde, 1950). When dealing with sites in close proximity to rape fields it seems likely that the Brassicaceae pollen is from the crop whereas sites remote from rape fields may contain non-rape pollen.

3. Results and discussion

The results from the present study provide a great deal of detailed information: 32 different pollen taxa were recorded in the study together with a few types which could not be identified mainly because they were severely damaged. The full range of taxa are listed in Table 1 together with the sites where they were recorded. All the pollen could have been derived from plants growing within about 1 km distance from Drumcarro and therefore there is no obvious long distance wind transported pollen. As the study is dealing with oil seed rape pollen and its distribution, no further discussion will be made of the other 31 pollen taxa.

There are problems in trying to display the Brassicaceae results in terms of diagrams because of the wide range of values between sites and variations in values from week to week. However, an attempt has been made to produce a set of distribution maps for the pollen deposited in the sedimentation traps (Fig. 2). The volumetric trap data has been expressed in graphical form (Fig. 3).

Table 1
List of pollen taxa identified in pollen trap air and sediment samples from Drumcarro together with the sites at which they were identified

Betula	1	2	3	4	5	6	7	8	9	10
Pinus	1	2	3	4	5	6	7	8	9	10
Ulmus		2					7			
Quercus		2	3		5		7	8	9	10
Alnus				4					9	10
Picea	1	2	3	4	5	6	7	8	9	10
Fraxinus	1	2					7	8	9	10
Acer	1								9	
Fagus		2		4	5	6	7	8	9	10
Carpinus			3							
Coryloid	1		3							10
Salix										10
Ilex						6				
Calluna								8		
Poaceae	1	2	3	4	5	6	7	8	9	10
Cerealia	1	2	3	4		6	7	8	9	10
Cyperaceae	1	2	3			6	7	8	9	
Caryophyllaceae										
Scleranthus	1	2			5	6				
Dianthus	1									
Stellaria	1				5					
Lactuceae		2			5		7			10
Brassicaceae	1	2	3	4	5	6	7	8	9	10
Apiaceae			3							
Plantago lanceolata		2	3	4		6		8		
Potentilla			3							
Filipendula								8		
Rosaceae undifferentiated					5					
Polygonum					5					10
Rumex acetosa				4	5					
Labiatae				4						
Scrophularaceae					5					
Urtica		2						8		10

The distribution maps demonstrate very low values during the first 2 weeks of sampling but this is followed by a rapid build up in pollen output during weeks 3 and 4 culminating in the peak of pollen from the field adjacent to traps 1 and 2 in the week ending on the 11th May. The rape field adjacent to sites 3 and 6 seems to have reached a peak of flowering during the week ending 18th May, probably reflecting factors such as later sowing of the crop. Brassicaceae pollen values during weeks 6, 7 and 8 (ending on 25th May, 1st June and 8th June, respectively) remain at similar levels. After this there is a dramatic decline, although oilseed rape had not completely finished flowering during the 10th week of sampling because values had only dropped to the equivalent of week 3 (the results may be misleading because the values are for the whole week and by the Friday very few rape plants were in flower). The pattern evident in the maps of pollen distribution seems to reflect a later flowering of the field adjacent to sites 3 and 6. In general the rape pollen appears to be distributed from the fields in an easterly direction probably in response to the predomi-

nantly westerly windflow. This is surprising because there were frequent easterly winds during the time of sampling. The inefficiency of easterly winds in transporting rape pollen from fields is emphasised by the fact that site 10, although only just over 200 m to the west of a field of rape, records pollen values in excess of 10 pollen cm² on only one occasion, whereas site 9 about the same distance to the east of an oilseed rape field has values in excess of 10 pollen cm² on 4 weeks and has a maximum value of 40 pollen cm² for the week ending 11th May. In general though the values of rape pollen decline rapidly away from the edge of the fields of the crop and are mostly very low at distances of more than 200 m from the crop.

The volumetric air sampler does not produce results which are directly comparable with the sedimentation traps because (a) they are samples of air rather than the pollen sedimented out on to the surface of the ground and (b) they are short 15-min samples unlike the sediment traps which record 7 days of continuous pollen deposition. The volumetric trap records highest values on the 4th and 25th May compared with the

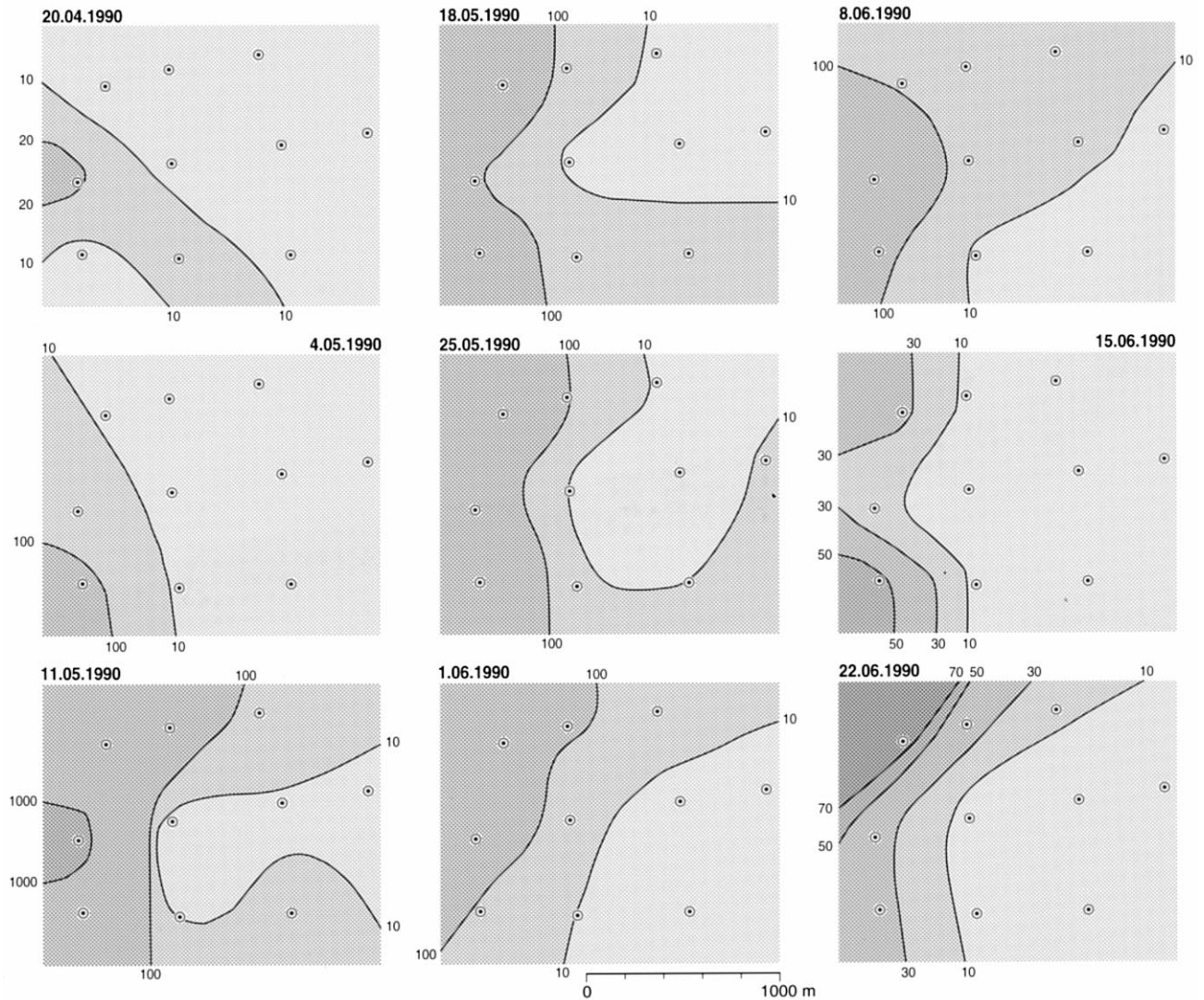


Fig. 2. Brassicaceae pollen distribution in sedimentation traps at Drumcarro Farm for each week during the oilseed rape flowering season in 1990. Pollen trap locations are indicated by an open circle with a dot and the values are numbers of Brassicaceae pollen cm^2 week. No map is shown for week 2 (27th April) because values were uniformly below 10 Brassicaceae cm^2 for that week.

sedimentation traps which have highest values in the week ending the 11th May. Nevertheless, the volumetric sampler does show similar trends: there is a rapid increase in pollen after the first 2 weeks and a return to low levels in the 9th and 10th weeks of sampling, and site 2 has the highest individual values (except for the 8th June when all values were very low). There is also a rapid decline in values away from the oilseed rape fields, although site 5 records the same value as site 2 on the 11th May and 8th June.

The pattern of rapid decline away from the edge of the crop is a feature already reported by McCartney (1990) and McCartney and Lacey (1991) in studies at Rothamstead and this mirrors results from other kinds of modern pollen studies where it has been found that

values decline rapidly as distance increases from the source of the pollen (Turner, 1964; Tinsley and Smith, 1974). Therefore, it follows that concentrations of oilseed rape pollen in the regional pollen rain should be low and this is confirmed by measurements of Brassicaceae pollen taken with the volumetric trap at sites 5, 8 and 10. These sites are over 200 m from the nearest field of oilseed rape and in only four samples out of 40 does Brassicaceae pollen exceed 50 pollen m^3 . Such atmospheric concentrations may not be sufficient to induce an allergic reaction; for example, Knox (1979) reports that in London an atmospheric concentration of 50 Poaceae pollen m^3 is required to induce an allergic reaction. However, the impact on allergy sufferers of particular concentrations of Brassicaceae pollen

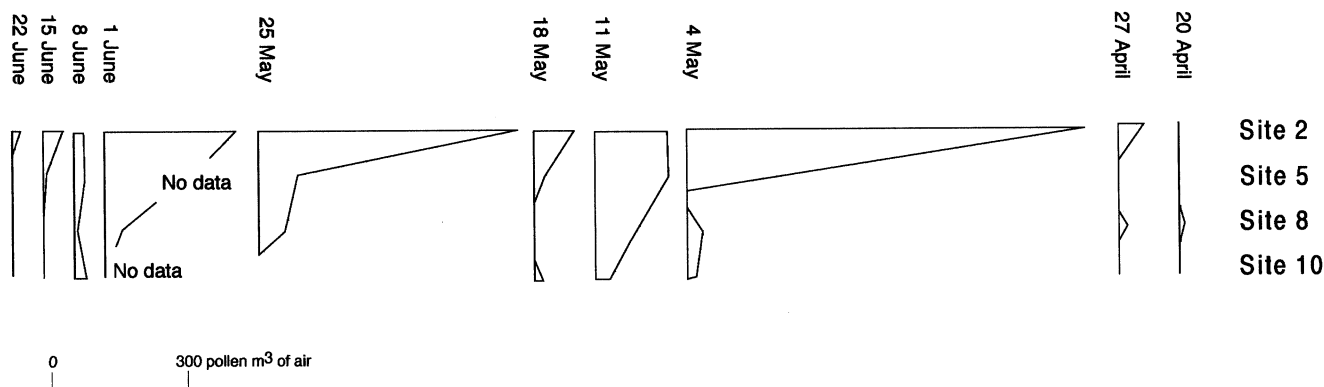


Fig. 3. The values of Brassicaceae pollen collected in a Burkard portable volumetric trap at four sites at Drumcarro Farm during the oilseed rape flowering season in 1990.

is not clear and the threshold at which a reaction is induced may not be the same as Poaceae.

4. Conclusions

The present study demonstrates that large quantities of oilseed rape pollen are released into the atmosphere of eastern Scotland particularly during May. This dispels the belief held for many years that because Brassicaceae plants are entomophilous they do not release significant amounts of pollen into the atmosphere (Hyde, 1950). However, because of factors such as the low release height of the pollen, it rapidly sediments out of the atmosphere away from the edge of a field of the crop. This feature is clearly demonstrated by both the methods of pollen sampling used in the present study. Nevertheless, some of the Brassicaceae pollen does enter the regional pollen rain although the significance of this to allergy sufferers is not yet medically demonstrated. At the present time, and in terms of the pollen only (allergic reaction may be produced by other airborne substances released by oilseed rape crops such as fungal spores or aromatic vapours) it appears that allergy sufferers may be less likely to suffer a reaction if they do not approach within 200 m of an oilseed rape field. This is not necessarily easy to achieve in some areas of lowland eastern Scotland where large numbers of fields of the crop are found in close proximity to one another.

Acknowledgements

I am grateful to the Lohoar family at Drumcarro Farm for allowing access to their land, to Professor Bruce Proudfoot for commenting on an early draft of this paper and to Graeme Sandeman for constructing Fig. 2.

References

- Andrew R. A Practical Pollen Guide to the British Flora. Cambridge: Quaternary Research Association Technical Guide 1:1984;139
- Boyd WE. The role of mosses in modern pollen analysis: the influence of moss morphology on pollen entrapment. *Pollen Spores* 1986;28:243–56.
- Cameron LA. Oil Seed Rape: Are we sure? Angus District Council:Environmental Health Service Report. 1989a.
- Cameron LA. Oil seed rape: a potential threat to hay fever sufferers? In: Davies RR, editor. *Pollen in Close Up*. London:Franklin Scientific Projects, 1989b:25–27.
- Cameron LA, Parratt D. Oil seed rape population study. Angus District Council Environmental Health Service Report, 1989.
- Caseldine C. Surface pollen studies across Bankhead Moss, Fife, Scotland. *J Biogeogr* 1981;8:7–25.
- Cundill PR. A new design of pollen trap for modern pollen studies. *J Biogeogr* 1986;13:83–98.
- Cundill PR. Comparisons of moss polster and pollen trap data: a pilot study. *Grana* 1991;30:301–8.
- Davis MB. On the theory of pollen analysis. *Am J Sci* 1963;261:897–912.
- Fægri K, Iversen J. Textbook of Pollen Analysis, 4th ed. In: Faegri K, Kaland PE, Krzywinski K, editors. London:Wiley, 1989.
- Flenley J. The use of modern pollen rain samples in the study of the vegetational history of tropical regions. In: Birks HJB, West RG, editors. *Quaternary Plant Ecology*, 14th Symp Br Ecological Society, Oxford: Blackwell, Oxford, 1972:131–141.
- Godwin H. History of the British Flora, 2nd edn. London: Cambridge University Press, 1975.
- Hyde HA. Studies in atmospheric pollen. Pollen deposition in Britain; Part 1, the influence of situation and weather. *New Phytol* 1950;49:398–406.
- Knox RB. Pollen and Allergy. Studies in Biology. London: Edward Arnold, 1979:107.
- McCartney HA. The dispersal of plant pathogen spores and pollen from oilseed rape crops. *Aerobiologia* 1990;6:147–52.
- McCartney HA, Lacey ME. Wind dispersal of pollen from crops of oilseed rape (*Brassica napus* L.). *J Aerosol Sci* 1991;22:467–77.
- Moore PD, Webb JA, Collinson ME. An Illustrated Guide to Pollen Analysis, 2nd edn. London: Hodder and Stoughton, 1991.
- O'Sullivan PE. Contemporary pollen studies in a native Scots pine ecosystem. *Oikos* 1973;24:143–50.
- Parratt D, Macfarlane WH, Thomson G, Cameron LA, Butcher RD. Evidence that oilseed rape (*Brassica napus* ssp. *oleifera*) causes respiratory illness in rural dwellers. *Scot Med J* 1995;40:74–6.

- Robinson GM. Agricultural Change: Geographical Studies of British Agriculture. Edinburgh: North British Publishing, 1988.
- Stockmarr J. Tablets with spores used in absolute pollen analysis. *Pollen Spores* 1972;13:615–21.
- Tauber H. A static non-overload pollen collector. *New Phytol* 1974;73:359–69.
- Tinsley H, Smith RT. Surface pollen studies across a woodland/heath transition and their application to the interpretation of pollen diagrams. *New Phytol* 1974;73:547–65.
- Turner J. Surface samples from Ayrshire, Scotland. *Pollen Spores* 1964;6:583–92.