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Variations in pollen proportions of *Plantago lanceolata* and *P. major/media* at a Neolithic lake dwelling, Lake Chalain, France

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Abstract. Detailed pollen analytical investigations at a Neolithic lake dwelling site on Lake Chalain, Jura, France, show very characteristic variation in the *Plantago lanceolata* and *P. major/media* pollen curves in the period during which settlements are recorded (3030-2630 cal. B.C.). At first, *P. lanceolata* is the more important taxon but *P. major/media* representation gradually rises, to become the more important taxon in the uppermost settlement phase. After considering the present day ecology and phytosociology of the *Plantago* species in question, i.e. *P. lanceolata*, *P. major* and *P. media*, and the available archaeozoological and archaeological information, it is suggested that the changes in the representation of these two pollen taxa are the result of a change in the farming economy, at ca. 2800 cal. B.C., which involved a substantial rise in the numbers of domesticated grazing animals and more intensive land use.

Key words: Pollen analysis – *Plantago lanceolata* – *Plantago major/media* – Neolithic – Hunting-animal breeding equilibrium

Introduction

In eastern France, palynologists, particularly those working on archaeological sites, usually distinguish between *Plantago lanceolata* pollen, which is easy to identify to specific level and the pollen taxon *P. major/media*, which includes the pollen of two species that cannot be easily differentiated by optic phase contrast microscopy.

These two pollen taxa play an important role in the reconstruction of the anthropogenic activity from the pollen record. In palynological studies carried out on archaeological sites, *P. lanceolata* is normally regarded as an excellent anthropogenic indicator (Iversen 1949; Hicks 1971; Behre 1981, 1986, 1988) whereas *P. major/media* is often neglected. There are two main reasons for this: (1) some authors consider only *Plantago* pollen in general and make no distinction between the different taxa, and, (2) other authors make the distinction, but give detailed consideration to *P. lanceolata* only. They underestimate the palaeoecological significance of the *P. major/media* taxon mainly because it is often underrepresented. *P. major* and *P. media* may, of course, be part of the natural vegetation, e.g. river banks, to that the significance of the *P. major/media* pollen taxon as a cultural indicator may not be as clear as *P. lanceolata*.

Normally, it is only sites where palynomorphs are abundant and well preserved that provide suitable material for studying the significance of taxa which are normally not well represented in the pollen record. Lake Chalain, Jura, France, where archaeological research has been underway for many years has already been the subject of many palynological analyses (Fig. 1). A detailed analysis carried out in the centre of a palafittic village (station 2 AC) has yielded much information on the variation in *P. lanceolata* and *P. major/media* representation.

Ecology of *P. lanceolata*, *P. major* and *P. media*

Plantains, i.e. species of the genus *Plantago*, are hardy, hemicryptophyte plants of herbaceous communities and are represented by a large number of species. In France the major species are (excluding the Mediterranean region):
(1) *P. alpina* and *P. montana*, which are found in lawns, pastures and rocky areas in mountainous regions between 1200 and 2500 m altitude;
(2) *P. coronopus*, which is found in coastal areas; and
(3) *P. lanceolata*, *P. major* and *P. media*, which are found in all areas below approximately 2000 m altitude.

In the Lake Chalain region, the present day ecological and phytosociological characteristics of the last three mentioned species are summarized in Table 1. It can be seen that these species share a high light requirement and a preference for fertile soils. These species, however, show rather different responses to variations in soil moisture content and degree of trampling (Fig. 2).

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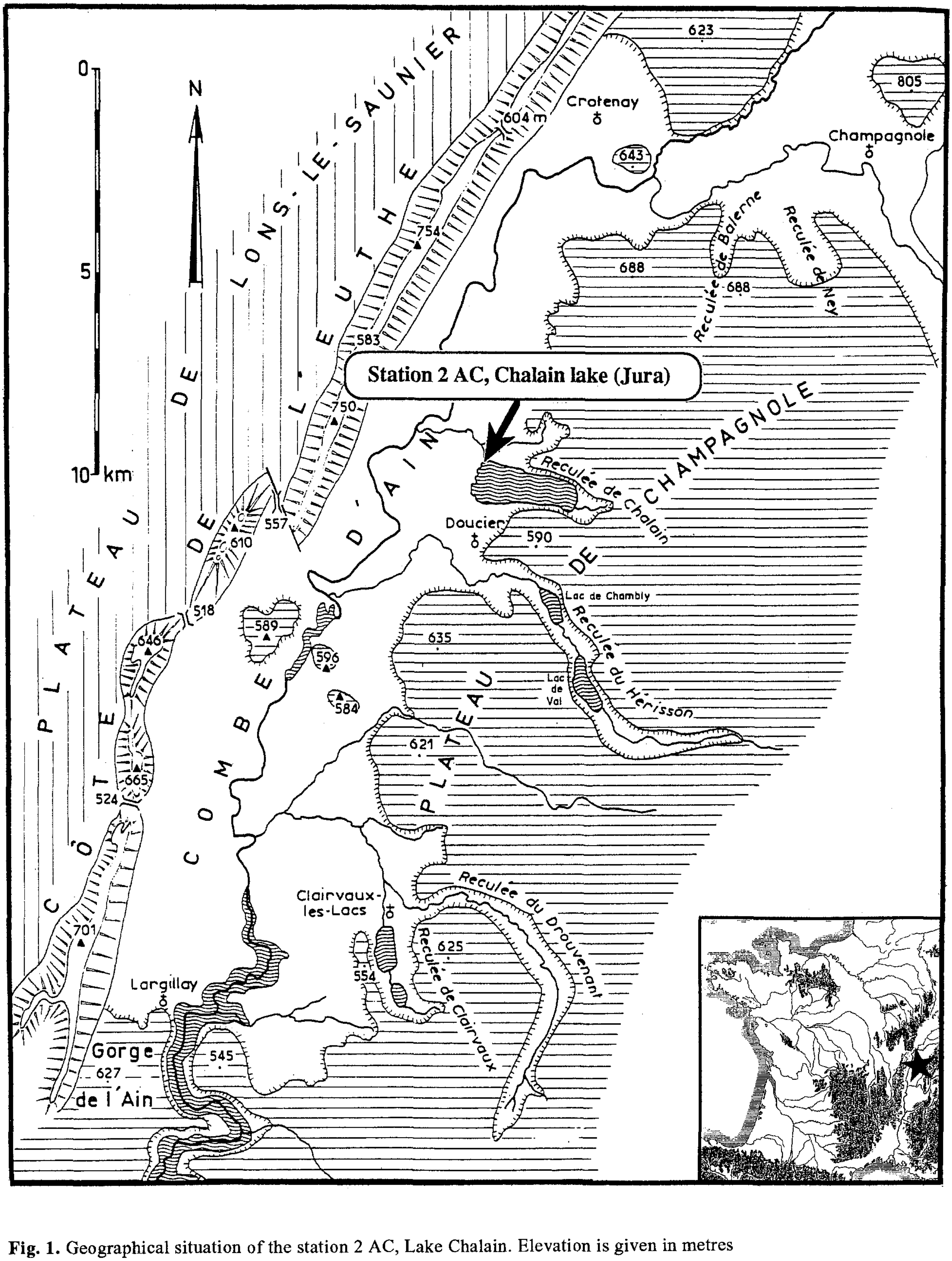


Fig. 1. Geographical situation of the station 2 AC, Lake Chalain. Elevation is given in metres

Table 1. The ecology and phytosociology of *Plantago lanceolata, P. major* and *P. media* in the Lake Chalain region today

	P. lanceolata	*P. media*	*P. major*
ECOLOGY	photophilous argillous or finely sandy soils, more or less wet, rich in nutrients but low in nitrogen	heliophilous argillous (and often calcareous) soils, dry during the summer (mesoxerophilous), usually rich in nutrients	heliophilous more or less wet soils, compacted and nitrogen-rich
HABITAT	**mowed meadows and pastures**	**calcareous mowed grasslands, trampled areas,** mesotrophic and basic nitogen-rich pastures	**over-trampled areas** (footpath, entrance to meadows, sides of roads) and pastures
PHYTOSOCIOLOGY	**Agrostio stoloniferae-Arrhenatheretea elatioris** (Tüxen 1937) Diagnostic species : *Trifolium repens, T. pratense* *Poa trivialis, P. pratensis* *Lolium perenne* *Bellis perennis* *Rumex acetosa* *Prunella vulgaris* *Leontodon autumnalis* *Taraxacum vulgaris* *Festuca pratensis* *Ranunculus acris* *Cynosurus cristatus* *Hypochaeris radicata* *Phleum pratense* *Cerastium fontanum*	**Mesobromion erecti** (Br. - Bl. and Moor. 1938) Diagnostic species : *Aceras anthropophorum* *Euphorbia brinttingeri* *Festuca ovina* *Gentianella ciliata, G. germanica* *Ophrys fuciflora, O. insectifera,* *Ophrys sphegodes* *Orchis purpurea* *Polygala amarella* *Thesium humifusum*	**Lolio perennis-Plantaginion majoris** (Sissingh1969) Diagnostic species : *Chamaemelum nobile* *Juncus tenuis* *Sagina procumbens*

It is always difficult to compare very precise present-day phytosociological data to pollen analytical results. Information from the latter can be expected to be complemented by macrofossil studies that are now in progress.

P. lanceolata, P. major and *P. media* in pollen analytical data

Pollen production in plantains is abundant. An anther of *P. lanceolata* produces between 15 700 and 29 500 pollen (Hyde and Williams 1945, see also Bassett and Crampton 1968). This high pollen production is a good adaptation to anemogamy.

The pollen of *P. lanceolata*, on the one hand, and *P. major* and *P. media*, on the other, can be distinguished mainly by the number and structure of the pores. *P. lanceolata* pollen has more than eight operculate pores with a distinct annulus while *P. major* and *P. media* have 4 to 9 non-operculate pores with granules but without a distinct annulus (Faegri and Iversen 1989). These two latter species cannot be easily distinguished using phase contrast microscopy. Thus, from the pollen analytical perspective, *P. major* and *P. media* are considered as a single taxon. On the basis of the present day behaviour of these species in the Lake Chalain region, this limitation, however, is not considered to be serious for the interpretation of the fossil record. As indicated in Fig. 2, both *P. major* and *P. media* are characteristic of areas with dry to moist soils and a good degree of trampling, whereas *P. lanceolata* is common in meadows and pastures.

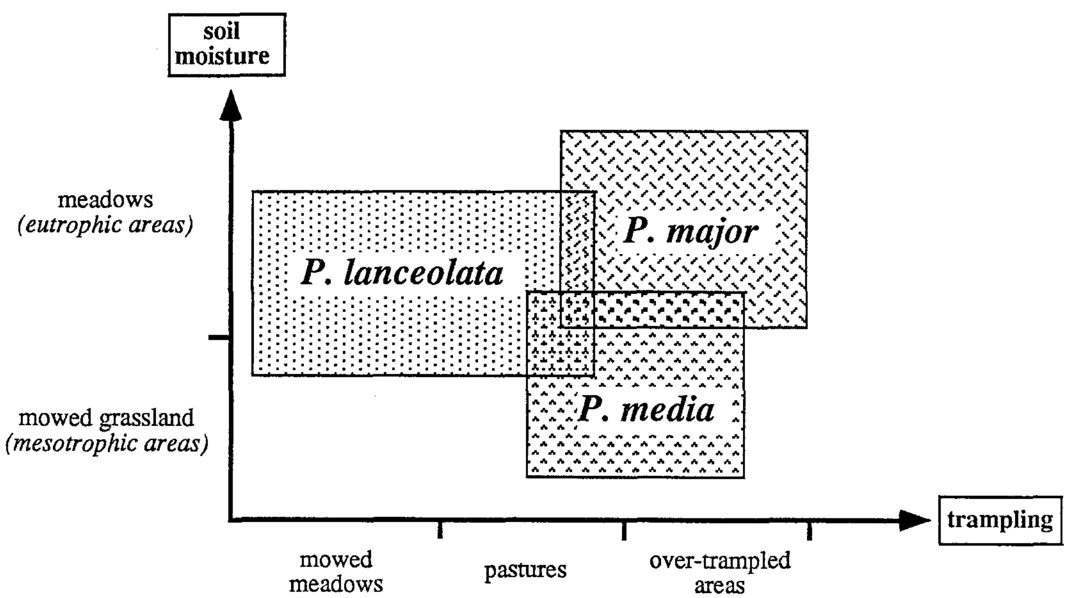


Fig. 2. Distribution pattern of *Plantago lanceolata, P. major* and *P. media* in relation to soil moisture content and degree of trampling in the Lake Chalain region today

It is generally agreed that the *Plantago* genus is an excellent anthropogenic indicator. Turner (1964) defined an arable/pastoral index in terms of number of *P. lanceolata* pollen as a percentage of *Plantago* + Compositae + Cerealia + Cruciferae + *Artemisia* + Chenopodiaceae. Values below 15% are considered to indicate predominantly arable activity whereas values in excess of 50% suggest pasture. Other authors have constructed different indices. It has been demonstrated by Behre (1981), however, that these indices can be misleading.

Many authors have demonstrated that *P. lanceolata*, on the one hand, and *P. major* and *P. media*, on the other, are associated with different and distinct land-use practices (Iversen 1949; Troels-Smith 1956; Behre 1981, 1986, 1988; Faegri and Iversen 1989). Behre (1981), using the results of Burrichter (1969), pointed out that *P. lanceolata* can play a significant role in the plant colonization of previously cultivated ground. Thus, it may be considered to be an indicator of fallow and a diagnostic species for some systems of crop rotation. Its abundance in pastures can indicate intensive grazing. *P. major* and *P. media*, on the other hand, are good indicators of the proximity of settlements and trampled ground.

Station 2 AC, Lake Chalain

At the end of the 19th century, this lake in the Jura region was known for the presence of piles beneath the water surface from former lake dwellings. The construction of a hydroelectric power station in 1904 brought about a fall of 3 m in the water level. Several archaeological sites were exposed as a result. In the meantime, these sites have been excavated and the artefacts recovered have been placed in both public and private collections (Roulière-Lambert 1985). Since the eighties, there has been a systematic excavation programme with particular attention being paid to those sites endangered by the extension of tourist facilities. This lake contains the remains of more than 50 villages dating from the beginning of the middle Neolithic until the end of the Bronze age (Pétrequin and Pétrequin 1988). Systematic research by different workers over recent years has

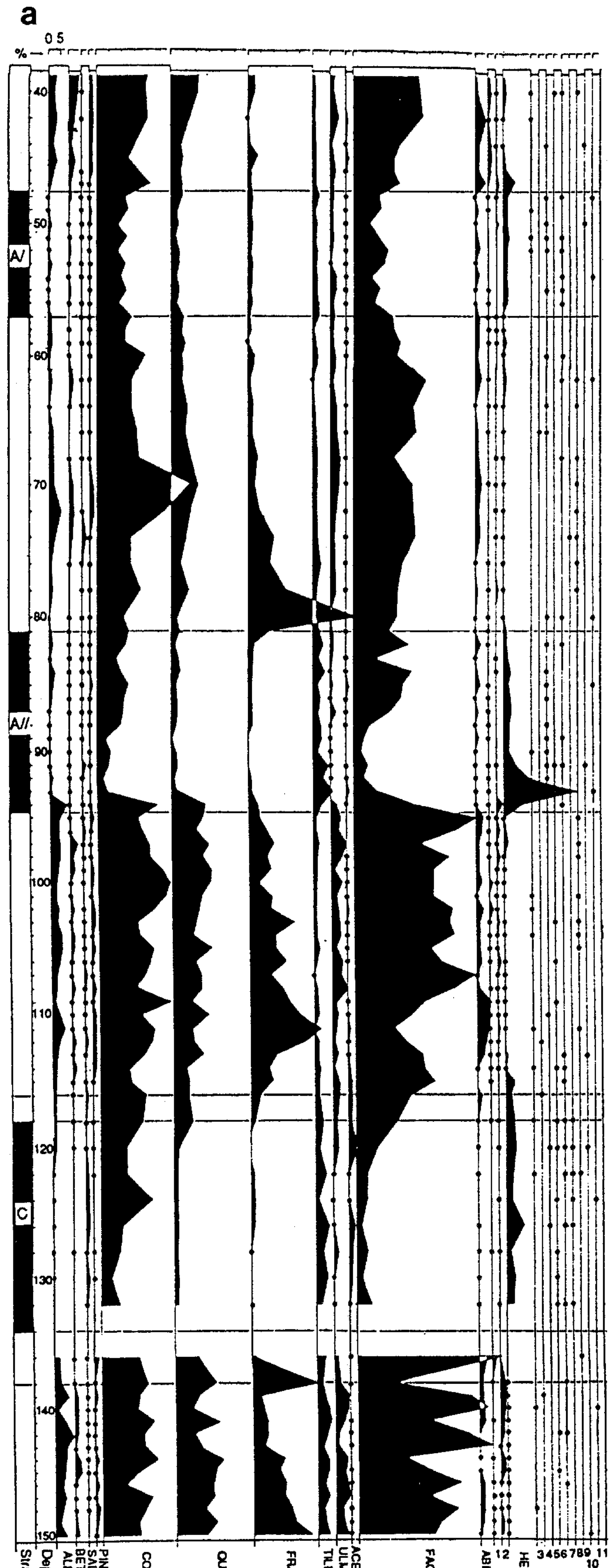
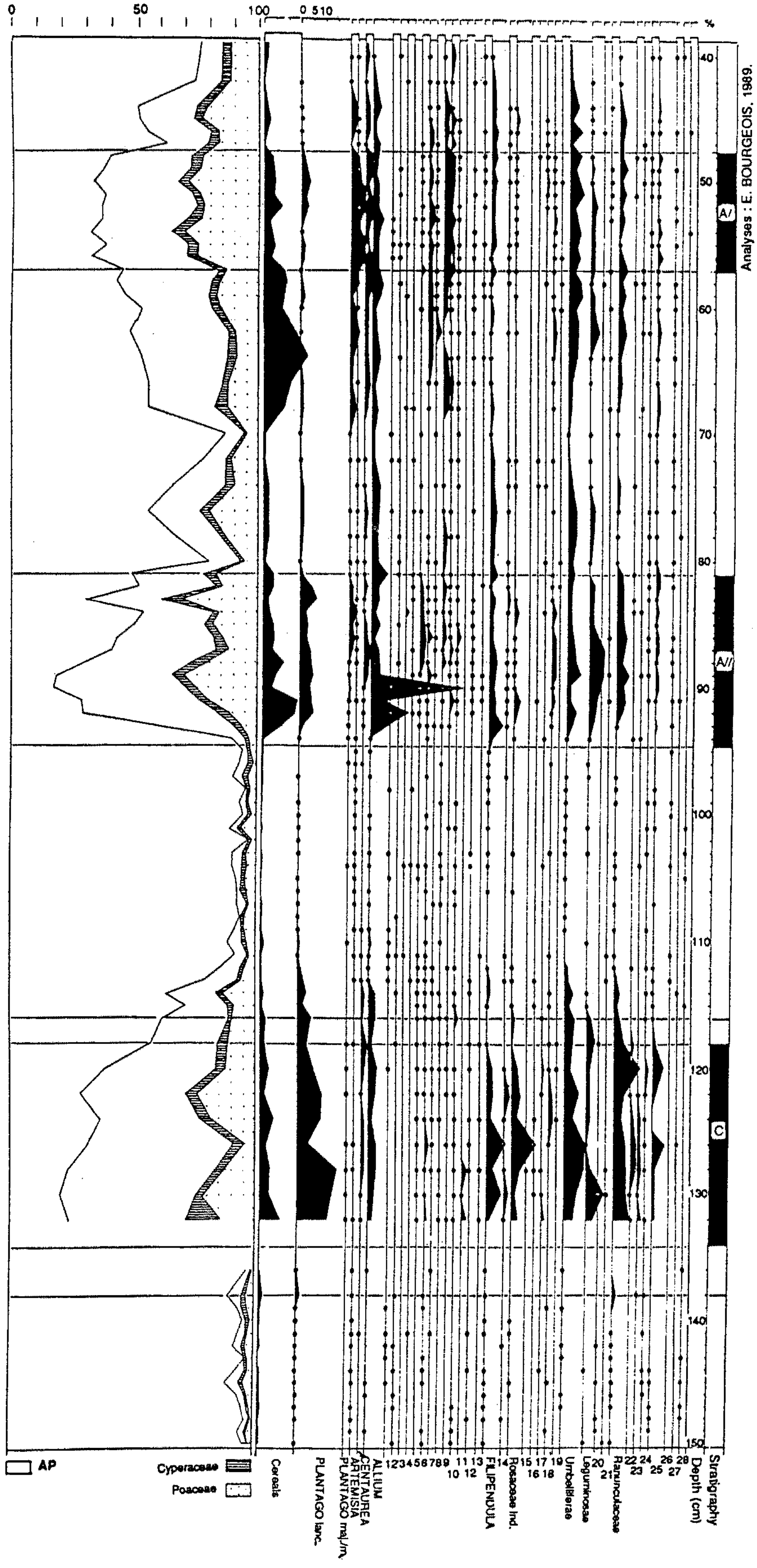


Fig. 3. a,b Percentage pollen diagram showing the main curves from Station 2 AC, Lake Chalain. In the stratigraphical column, white indicates lacustrine chalk (archaeologically sterile) and black indicates an archaeological layer which consists mainly of organic material (brown in colour; also known as *fumier lacustre*).
a. Main tree and shrub taxa; the numbered curves are as follows: *1, Picea*; *2, Taxus*; *3, Frangula*; *4, Ilex*; *5, Viscum*; *6, Viburnum*; *7, Sambucus*; *8, Prunus*; *9, Juniperus*; *10, Ligustrum*; *11, Vitis*.
b. Main herb taxa; the numbered curves are as follows: *1*, *Rumex*; *2*, Chenopodiaceae; *3*, Urticaceae; *4*, *Papaver*; *5*, Boraginaceae; *6*, Tubuliflorae; *7*, *Carduus*-type; *8*, Liguliflorae; *9*, Campanulaceae; *10*, Caryophyllaceae; *11*, Caryophyllaceae-type, *Spergula*; *12*, Cruciferae; *13*, Dipsacaceae; *14*, *Potentilla*; *15*, Gentianaceae; *16*, *Helianthemum*; *17*, *Hypericum*; *18*, Labiatae; *19*, *Linum*; *20*, *Polygala*; *21*, *Polygonum bistorta/viviparum*; *22*, Saxifragaceae; *23*, Scrophulariaceae; *24*, Rubiaceae; *25*, Liliaceae; *26*, *Nuphar*; *27*, *Nymphaea*; *28*, *Typha latifolia*

b


0
50
100
0 5 10
%
AP
Cyperaceae
Poaceae
Cereals
PLANTAGO lanc.
PLANTAGO maj./m.
ARTEMISIA
CENTAUREA
ALLIUM
FILIPENDULA
Rosaceae ind.
Umbelliferae
Leguminosae
Ranunculaceae
Depth (cm)
Stratigraphy
A/
A//
C
Analyses : E. BOURGEOIS, 1989.

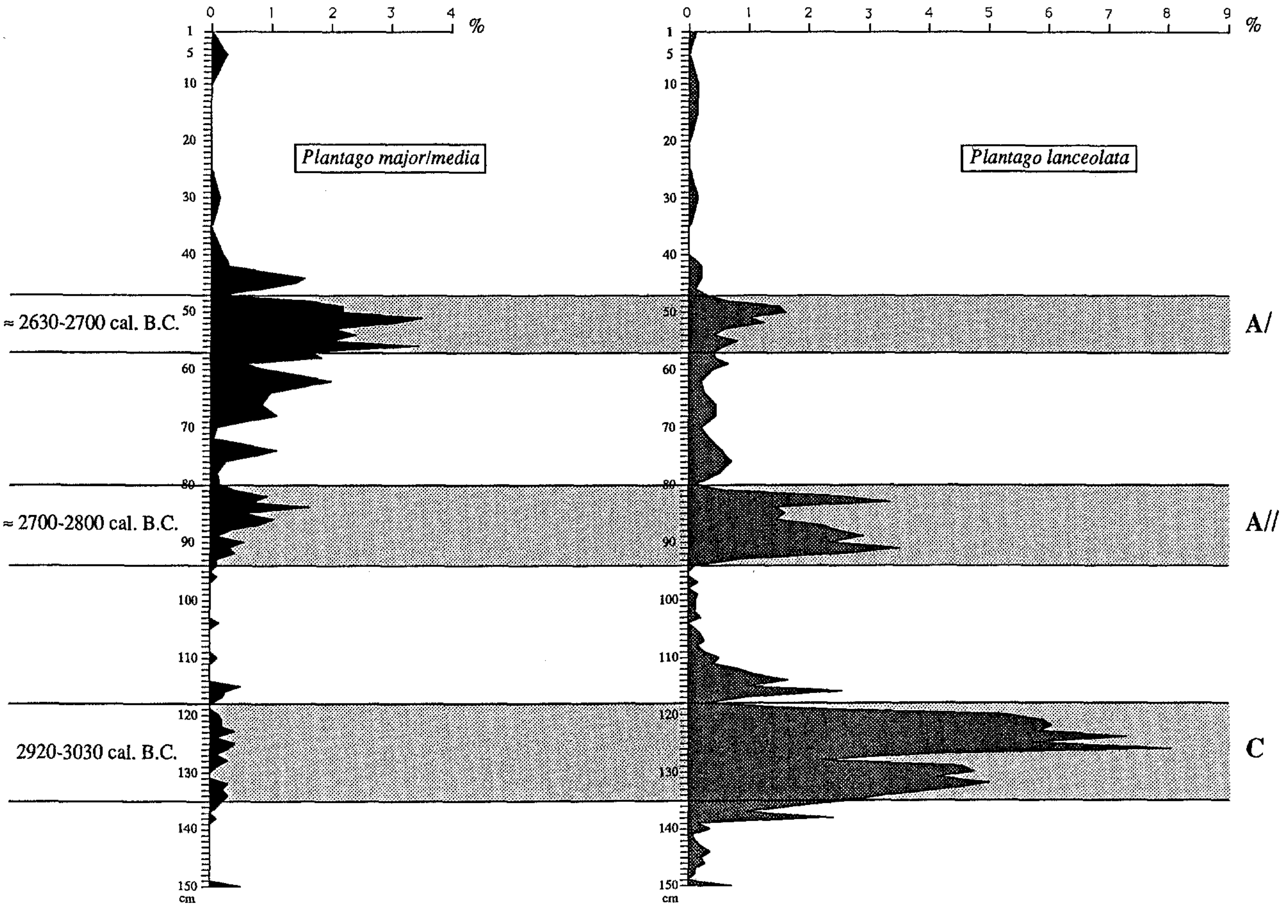


Fig. 4. Variation in the representation of *P. lanceolata* and *P. major/media* as a percentage of total pollen in the profile from Station 2 AC, Lake Chalain. Samples analysed: 107; average number of pollen counted per sample: 560; maximum and minimum counts: 1158 and 248, respectively

provided much new palynological data (Magny and Richard 1988; Richard 1983, 1985, 1991, 1993; Bourgeois 1989).

Station 2 AC is located on the north-west side of the lake (Fig. 1). Here there is a super-imposition of several villages that date from the beginning of the middle Neolithic until the second half of the late Neolithic. A 12-cm-diameter core, 150 cm long, was taken at the centre of this station and covers the whole Subboreal period (3700-850 cal. B.C.). It contains evidence for three periods of human settlement stratified in the archaeologically sterile lacustrine chalk layers. Details of the levels relating to these periods are as follows:

(1) level A/: this spans the interval ca. 2700-2630 cal. B.C. It does not correspond to a settlement at the sampling site but rather to a nearby village;

(2) level A//: this corresponds to a settlement of 20 to 25 dwellings occupied between ca. 2800-2700 (at the latest) cal. B.C.

(3) level C: this corresponds to about 12 dwellings that span the interval 3030-2920 cal. B.C.

The three layers were formed almost exclusively as a result of anthropogenic activity; they contain non-carbonized organic material with archaeological and other material, including wood, refuse, excrements, etc.

A detailed palynological analysis of this core (Bourgeois 1989; Fig. 3) and, in particular, results of analyses of 2-mm-thick slices, which give a continuous record over the interval represented by level C, provide a detailed picture of the changes in vegetation during this period of human settlement (Richard 1991, 1993). This comparative study of the changing frequencies of *P. lanceolata* and *P. major/media* pollen was facilitated by sediments that were particularly rich in pollen; the lacustrine chalk can contain up to 100,000 pollen per gram of wet sediment.

In Figs. 4, 5, pollen percentage and concentration values [determined using the volumetric method of Cour (1974)], of *P. lanceolata* and *P. major/media* are presented. Before level C, i.e. the first archaeological horizon, *P. major/media* is rare and *P. lanceolata* is not particularly well represented. These records probably reflect activity

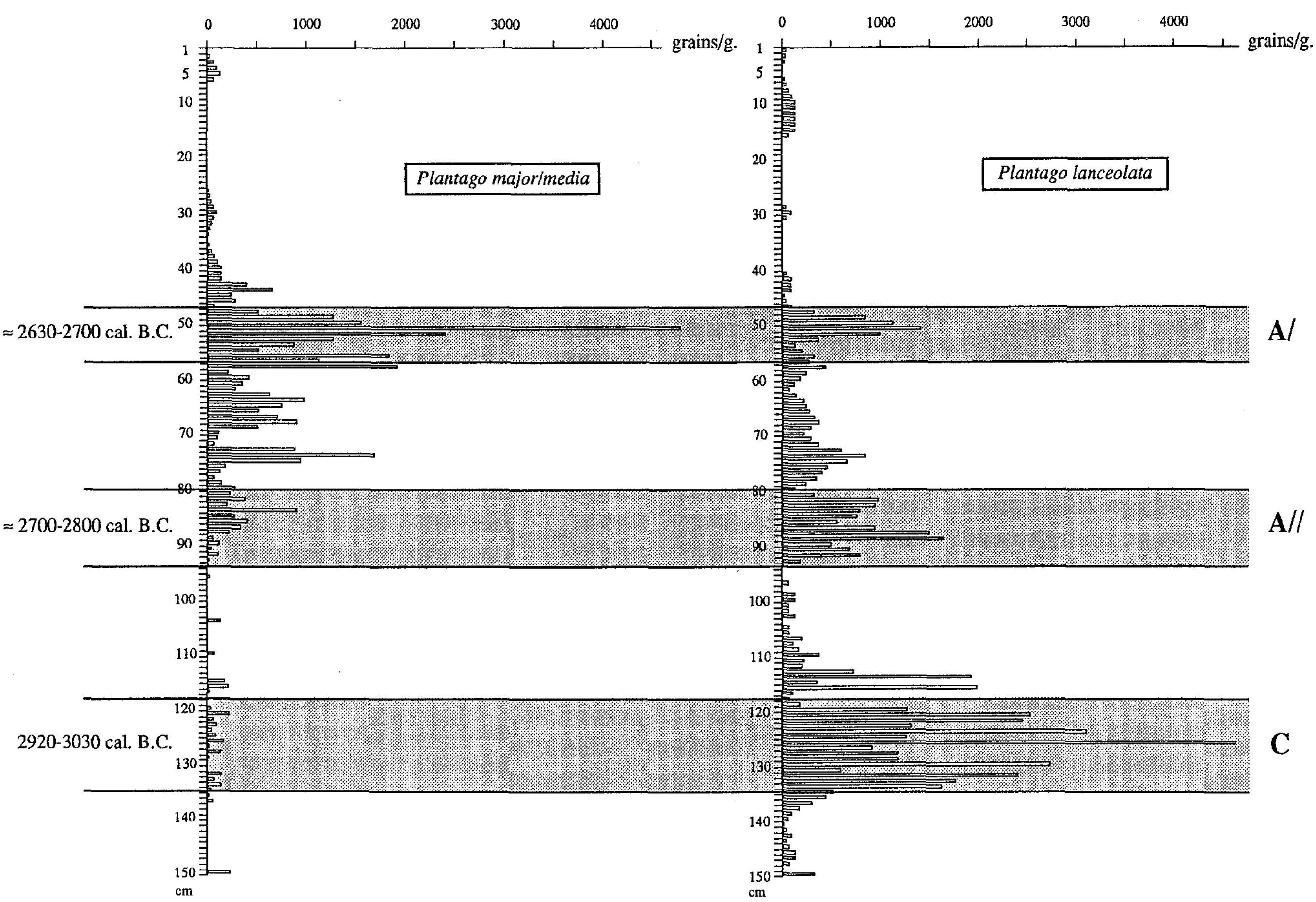


Fig. 5. Variation in pollen concentration of *P. lanceolata* and *P. major/media* in the pollen profile from Station 2 AC, Lake Chalain

associated with earlier settlements located elsewhere in the lake basin (e.g. station 3, where settlement began at ca. 3200 cal. B.C.).

Where the first traces of organic matter are recorded in the lacustrine chalk, *P. lanceolata* representation increases. In much of level C, exceptionally high values are recorded; percentage values are at or exceed 6% and there are frequently more than 2000 grains/g. In this same layer, *P. major/media* representation remains low, i.e. less than 1%.

In the lacustrine chalk, between levels C and A//, *P. lanceolata* exceeds 1% in the lower third of this interval. In the upper two thirds, the percentage values decline. The concentration values show a similar pattern. The cause of these variations is most probably twofold: changes in the intensity of human activity in the area about the settlement (certainly the most important) and fluctuations in the lake level. In support of the latter, sedimentological analyses carried out on the lacustrine chalk show that, between levels C and A//, there was a progressive increase in the lake level, the increase being initially slow and later becoming more marked (Magny 1991).

At level A// there is a return to the high values of *P. lanceolata*. *P. major/media* is scarce in the lower third of this level, but it reaches relatively high values in the upper part (higher than in level C). The last centimetres of level A// are marked, as is the case for level C, by a sudden drop in the values of both taxa.

The archaeologically sterile lacustrine chalk between levels A// and A/ is not characterized, as previously, by an almost complete absence of *Plantago*. On the contrary, *P. lanceolata* values show relatively little variation, while *P. major/media* shows marked peaks in both percentage and concentration (especially high concentration values in sample 75; also 68 and 64). Furthermore, *P. major/media* is now better represented than *P. lanceolata*. It appears that human settlement was uninterrupted in the area during the interval between the two settlement levels. This is not surprising in view of the evidence for continuous settlement, over the interval in question, at the nearby stations 2 and 3-5.

In level A/, we see the continued replacement of *P. lanceolata* by *P. major/media*. *P. major/media* reaches particularly high values (e.g. samples 51 and 52) whereas there is only a moderate increase in the representation of *P. lanceolata*. Apart from the lowermost few centimetres, the uppermost lacustrine chalk has low representation of both taxa.

During the period under consideration, it is obvious that there was a substantial shift in the relative importance of *P.*

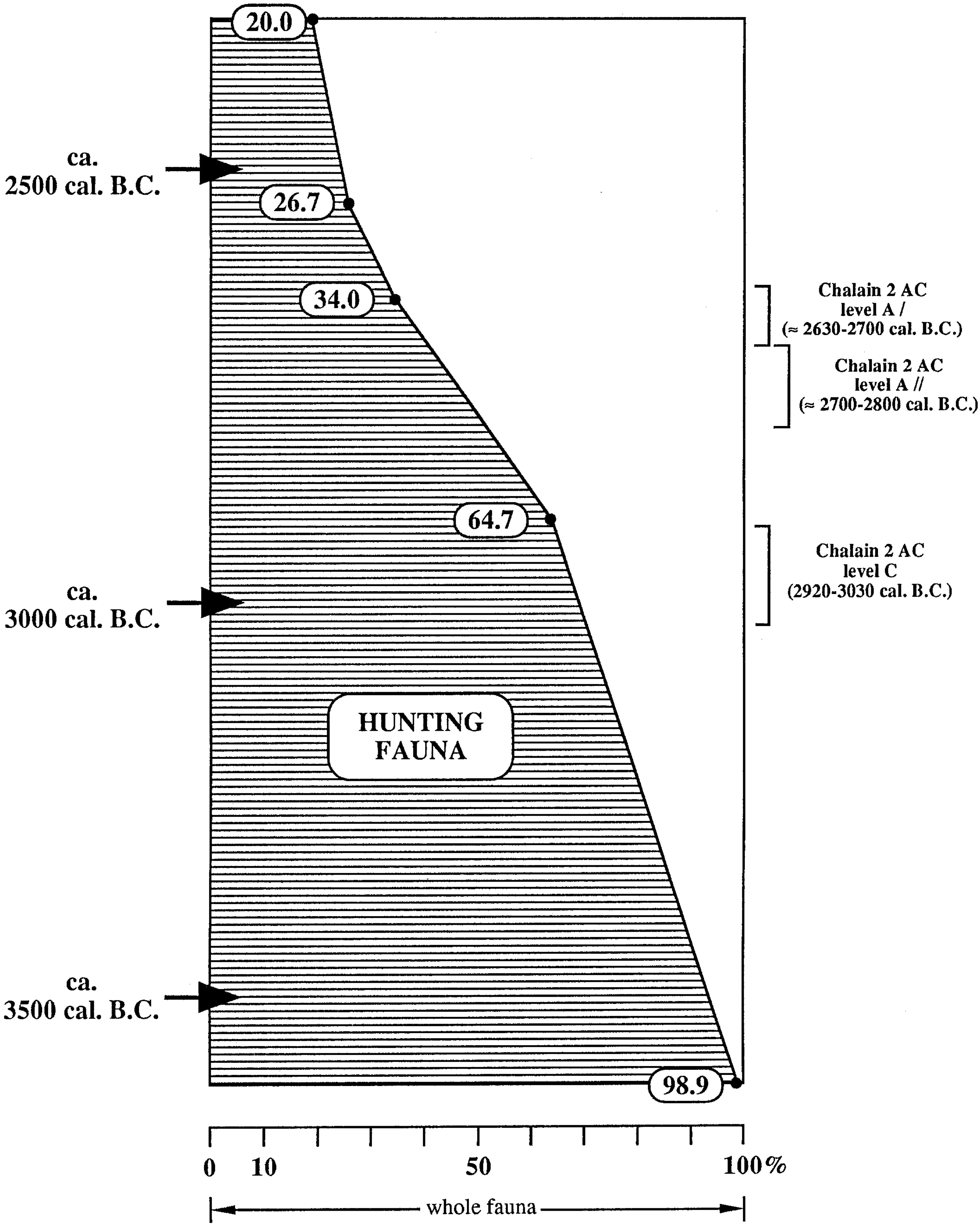


Fig. 6. Faunal remains of hunted animals as a percentage of all faunal remains at the sites of Chalain and Clairvaux. The number of individual animals (hunted) is also given (source: Pétrequin 1986, 1989; Pétrequin and Pétrequin 1988; determinations of faunal remains: RM Arbogast and MH Chenevoy)

lanceolata as against *P. major* and/or *P. media*. Large changes are also recorded in other curves, specially in arboreal pollen (AP) percentage representation (Figs. 3a, b). Between layers C and A//, i.e. in the archaeologically sterile lacustrine chalk, AP values of ca. 90-95% of total pollen sum are recorded, while between layers A// and A/, AP is ca. 60-70% and Cereal representation is high. These changes can be explained in terms of the proliferation of settlements around Lake Chalain which resulted in a major transformation of the vegetation and landscape.

With respect to the other pollen curves, the two types of sediments (lacustrine chalk and archaeological layers) give very different results. The lacustrine chalk, archaeologically sterile, is dominated by AP (except between layers A// and A/ when there were certainly settlements nearby). The archaeological layers, produced mainly by anthropogenic activity, are dominated by pollen brought in with plants gathered by humans (*Hedera*, cereals, Poaceae, *Allium*, etc.) and generally by pollen of non arboreal species. It is the classic situation that is repeatedly found in lake dwelling sites.

From hunting to breeding

In the Lake Chalain region today, *P. lanceolata* prefers mowed meadows whereas *P. major* and *P. media* are characteristic of trampled or over-trampled areas (Fig. 2). It would thus appear unlikely that these species grew in the settlement itself because of the nature of the soil and the frequent flooding. It is more likely that they grew in open areas close to the settlement. Also, the demographic pressure must have increased between levels C and A// as the number of dwellings doubled and land utilization was accordingly intensified.

The information from the archaeozoological studies carried out at the excavation sites on Lake Chalain lake and on the nearby Lake Clairvaux (Pétrequin et al. 1986, 1989) is also pertinent. It shows that there was a substantial decrease in the number of game animals and an increase in domesticated animals between 3000 and 2500 cal. B.C. (Fig. 6). This suggests a change, during the Neolithic, from an economy based on hunting to one based on animal breeding.

Weighing up the evidence, the shift in importance from *P. lanceolata* to *P. major/media* pollen representation is best explained as follows: between levels C and A//, substantial areas of meadows, pastures or fallow lands came under a different management regime so that they were subject to trampling or over-trampling. This may have come about as a result of a considerable increase in the number of cattle which would also have led to an increase in deforested areas. At the same time, the abandoned cultivated areas were now without a specific purpose in a primitive fallow system and were transformed into pastures. These changes favoured *P. major* and/or *P. media*, which is more resistant to trampling, to the detriment of *P. lanceolata*.

Conclusion

It has been often shown, particularly in the lake dwellings of the Jura (Richard 1985, 1991, 1993), that most of the pollen in the settlement horizons was brought to the site with plants gathered by people, as food either for themselves or their livestock, or to be used in building. The pollen analytical results in such situations depend largely on the sedimentation rate at the point where coring was carried out. The same number of samples may cover a period of a few days if the sedimentation is high, or months, years and even several decades, if it is low. Our perception of vegetation change will be affected accordingly. In addition, pollen produced by forests, meadows and cultivated areas are diluted by the large amount of pollen brought in with plants gathered in the adjoining environment, and also that produced by the lake-shore vegetation (Lundström-Baudais 1983; Behre and Jacomet 1991; Richard 1991). Caution must therefore be exercised in interpreting the results.

The Lake Chalain site appears to be quite exceptional in the context of the type of analyses under consideration here. A comparison with other French and Swiss lake dwelling sites has never clearly shown this particular relationship in the these two *Plantago* pollen taxa. It also illustrates the importance of precise sampling for this type of site. Obviously, a detailed study of present-day pollen production, dispersal, preservation, etc. in the *Plantago* species involved would also prove useful. However, using ecological arguments, and bearing in mind the archaeozoological and archaeoecological evidence, the data from station 2 AC, Lake Chalain, it may be concluded that:

1. the *P. major/media* rather than the *P. lanceolata* curve expands as a result of an increase in the domesticated grazing animal population, which is the opposite to the widely accepted view; and,
2. the opposite course followed by the curves of these two taxa may be explained by developments, at about 2800 cal. B.C., in the Neolithic agricultural system that involved a different equilibrium between arable farming, hunting and stock rearing.

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