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SOME REFLECTIONS ON HAZEL (*CORYLUS AVELLANA* L.) ON ITS BOUNDARY IN FENNOSCANDIA DURING THE POST-GLACIAL

Refleksje nad występowaniem leszczyny (*Corylus avellana* L.) na granicy jej zasięgu w Fennoskandii w czasie postglacjału

ABSTRACT. Although the broad picture of hazel has long been known, one or two major details deserve further attention in the future. Firstly, despite its relatively early appearance in the Post-glacial plant succession, hazel does have certain climatic requirements, particularly regarding the setting of mature fruits. This leads on to the second point, which concerns the real distribution of hazel at the present-day. Thirdly, there is the question of its use as a palaeoclimatic indicator-species. The picture given by the distribution of the older macrofossil finds becomes modified when their chronological distribution is studied, and when they are compared with the picture given by contemporaneous local and regional pollen spectra. I suggest that the temperature decline (July mean), postulated by Andersson and later workers, is better attributed to a decline in the late summer temperatures (August—September). The "climatic optimum" occurred progressively later, northwards, and palaeotemperature estimates are better based on a variety of plant species and more precisely defined as to season and place.

INTRODUCTION

Quite a lot of information about the ecology, present-day and past distribution of hazel can be found in the literature (Hegi 1957; Kirchner, Loew & Schröter 1913; Hagerup 1942) and many people may consider that its palaeohistory is now well-known. However, the work done earlier on in the present century in Fennoscandia (Andersson 1902, 1909; Samuelsson 1915; von Post 1930, 1933) concerns finds of nuts and pollen, which were only dateable within very broad time-limits, and the results of ^{14}C-datings obtained during the past two decades have only been of pollen finds, which concerned variable horizons and pollen percentage values (Deacon 1974, for example). When the older results are reconsidered, certain paradoxes are found, which also affect the palaeoclimatic conclusions which have been drawn from the hazel data. Although the present short account only applies to hazel along its northern distributional boundary, the same reflections may well also apply to the altitudinal boundary of hazel in continental Europe (Hegi 1957, p. 194).

ECOLOGY

From the information available in the literature (see above, see also Waldén 1956), supplemented by personal observations, hazel has four phases in its life history during which the climatic conditions play a critical role, viz. a) the period May-October, during which the primordia for the following year are laid, b) the absolute air temperatures and humidity during March—May, when flowering and pollination take place, c) the mean air temperatures May—October, during which time the nuts form and ripen, and also the new shoots lengthen and the wood matures, d) the air temperatures at night in the autumn and early winter, which may kill-off, or cut-back, any or all shoots which have not matured properly. The main non-climatic factor is the degree of shade, which reduces the volume of flowering and fruiting, but not of vegetative survival.

For fresh establishment, or local replacement, it is also necessary that the ripe nuts be distributed and buried in soil or leafmould, and at least so deep that they are not killed by severe groundfrosts in the winter or spring (Hegi 1957, Hagerup 1942). Sufficient nuts must also be produced so that some survive predation by birds, voles and squirrels, although these, together with running-water, are also largely responsible for distributing the nuts.

For successful flowering and pollination the weather conditions in spring need to be relatively stable once the daytime air temperature has risen to $>10°C$ for more than an hour or two around midday. On three occasions now (Kvål, near Trondheim, C Norway; Igelsta, near Norrtälje, C Sweden; Kaltenberg, near Linz, E Austria) I have seen male catkins, which had opened during an unusually warm spell in spring, either set-back or entirely killed-off by a return to wintry conditions, with daytime temperatures around $+2°C$ and below zero at night. Since the female catkins usually open later than the male ones, such conditions may lead to poor pollination and minimal seed-setting later the same year. Similar observations have been made in Poland (Sokołowska 1962). Seed development is generally slow at first (Kirchner, Loew & Schröter 1913, p. 163), so that the critical months for ripening of the nuts are July—October. This accumulated warmth requirement explains why ripe hazelnuts can be gathered in S Europe in August, in C Europe generally in September, but in N Europe only in October, if at all (see later).

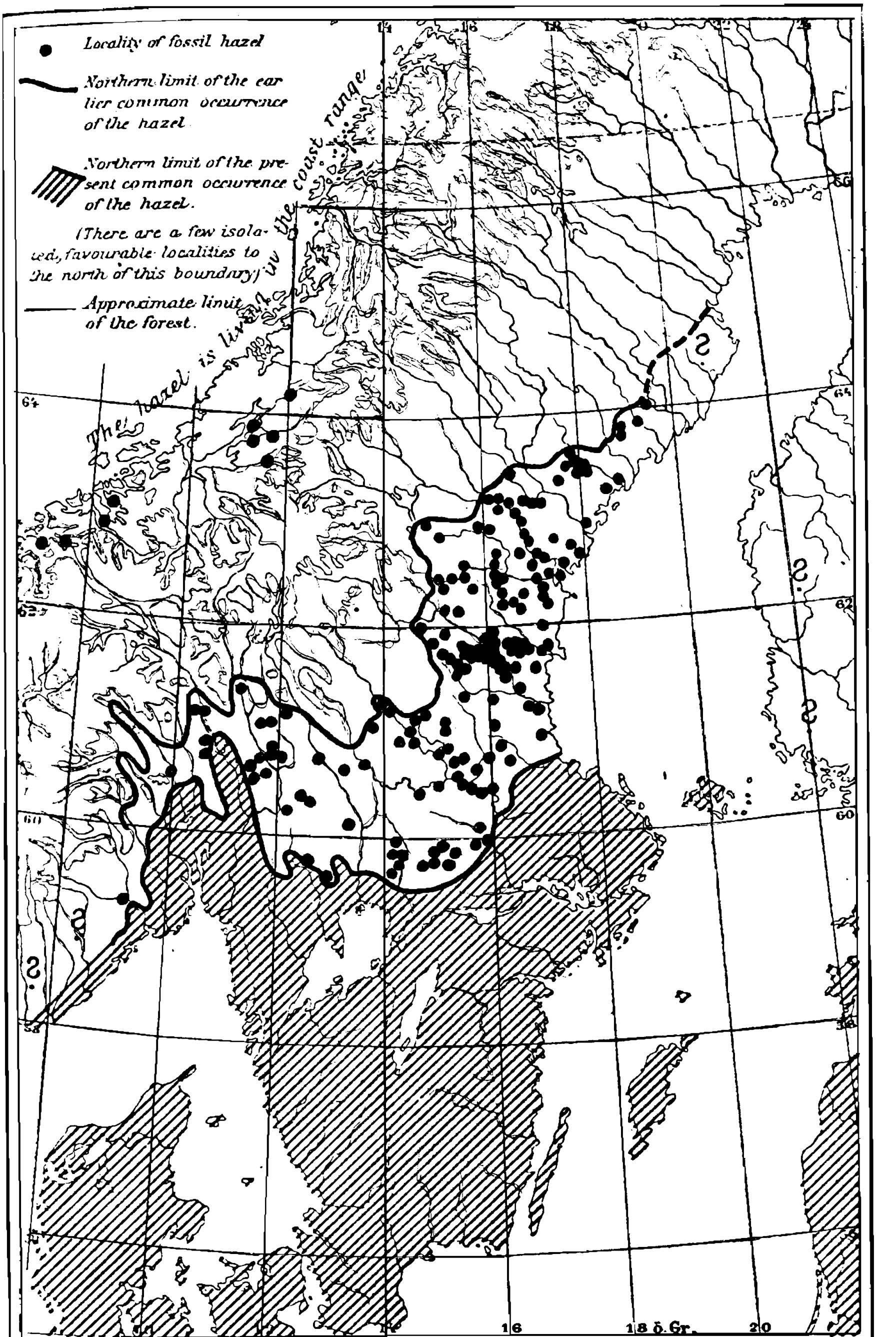

Fig. 1. Earlier and present distribution of the hazel in SE Scandinavia (from Andersson 1909)

PRESENT-DAY DISTRIBUTION

The position of the northern limit for hazel depends upon whether plain occurrence is mapped, or whether account is taken of the ability of the stands to set ripe nuts relatively regularly (i.e. at least every third or fourth year see Kirchner, Loew & Schröter 913, p. 160). It is important to know, the criteria employed, in relation to the postulated correlations made with air temperature. A map which shows the changes in frequency of occurrence of hazel well is that for Finland given by Linkola (1938). The map for Fennoscandia reproduced by Fries (1963) also takes frequency of occurrence into account, as does that for N Sweden published by Pettersson (1956). Gunnar Andersson (1902, 1909) used a limit based on the "common occurrence" of hazel, while Helland (1912), for Norway, although publishing no map, used a limit based on those sites at which hazel "produces ripe nuts". Helland thereby deduced a tetraterm mean air temperature requirement (June—September) for hazel of 12·5° C, compared with Andersson's biterm mean value (August—September) of 12° C. Hintikka (1963), likewise, using sites for the common occurrence of hazel only, calculated the hazel limits to lie at +11° C (July mean) with a winter temperature (January mean) of +2° C, compared with a +17° C (July) with a winter (January) mean of −11° C. His map of the most favourable climatic regions for hazel in Fennoscandia at the present-day (op. cit. fig. 43), with a July mean range of 11·5° to 16·5° C and a January mean range of +2° to −8° C, slightly over-estimates the area within which hazel is able to reproduce regularly from seed, though well indicating the limits for vegetative survival, especially in micro-climatically favorable habitats.

Two 19th-century reports of hazel are interesting in this connection. From the inner part of Hjørundfjord (S Møre province, Norway) Grøvik (1975) describes how, after a series of catastrophic years for the local farmers, 1813 was both unusually warm and dry during the late spring and summer and "even hazel produced quite a quantity of nuts". Nowadays ripe nuts (and even seedlings) are only regularly produced in the favourable local climate of the mid-fjord districts around Modle. The second report concerns a locality in the inland part of northern central Sweden (Halåsberget, near Östersund in Jämtland). Jonsson (1956) reports that "hazelnuts were picked here 1848–1858, although no hazel grows there nowadays". This locality is typical of many of the present-day relict occurrences of hazel in N Sweden, a south-facing, micro-climatically, as well as pedologically and hydrologically, favourable boulder-strewn slope below a rockface (Swedish = sydberg), where, apart from its outpost nature (cf. Pettersson's map, op. cit.) hazel could be expected to occur or have occurred, also judging from the associated ground-flora and shrub species. The ultimate cause of its disappearance is here unknown. Sub-fossil hazelnuts have in fact been found at Kläppe, only a few kilometres from Halåsberget. Although hazel stools may be weakened by burning, browsing, or by cutting too frequently, either for posts or for winter fodder for sheep, they have exceedingly good powers of regeneration. An increase in woodland density, and shade, is unlikely to have occurred at this locality. A combination of factors, with a succession of two or three consecutive "frost-years" is perhaps more probable, here and elsewhere.

PAST DISTRIBUTION

Two points require mention. Firstly, the course and percentage values of the hazel pollen curves in pollen diagrams from sites near to the subfossil localities for hazelnuts north of the present-day northern limit for hazel.

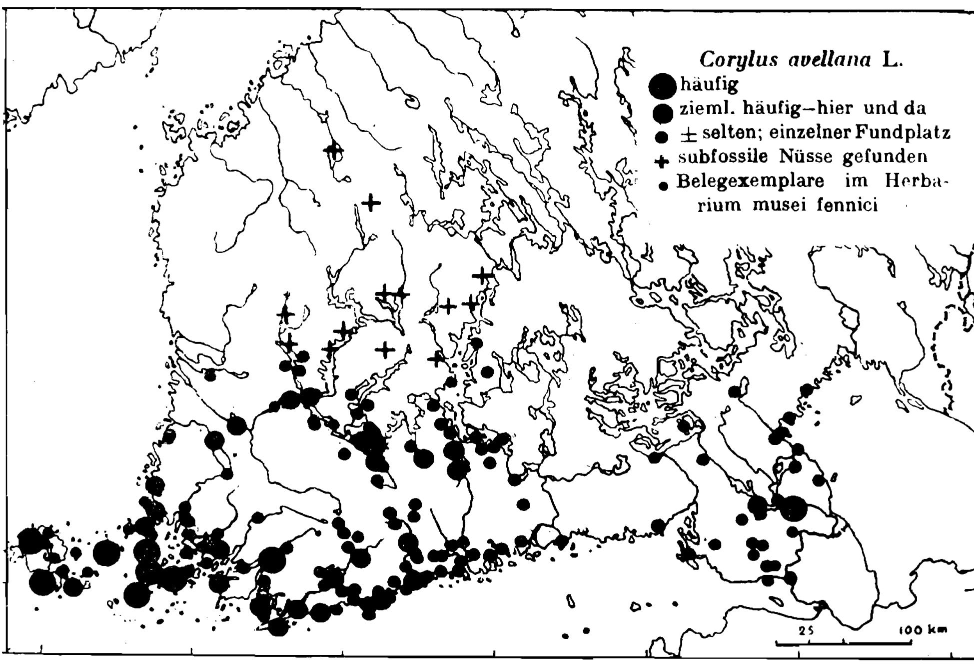

Fig. 2. Present-day and subfossil distribution of the hazel in Finland (Linkola 1938; the filled circles indicate frequency, the crosses indicate localities where subfossil hazelnuts have been found; see also Salmi 1968)

I have only checked on two areas, both in N Sweden, but I have no reason to suppose that similar results would not be obtained from an examination of Norwegian and Finnish sites (see Salmi 1963, for Finland). At all the sites investigated by G. Lundqvist (1963) in Gävleborgs Län, the coastal region just north of Gunnar Andersson's "common occurrence" limit (see maps in his 1902 or 1909 papers), the pollen values at all sites, during those periods in which the hazel curve is more or less continuous, range from 2 to 5 % only, excepting the southernmost sites (Jordbärsmossen and Bredmossen). At the former site hazel maintains 10% values only between 2590 and 1490 BC (^{14}C-datings). At the most inland site (Langsjömyren), even in the lower third of the diagram, no values are higher than 4% and the curve is discontinuous,

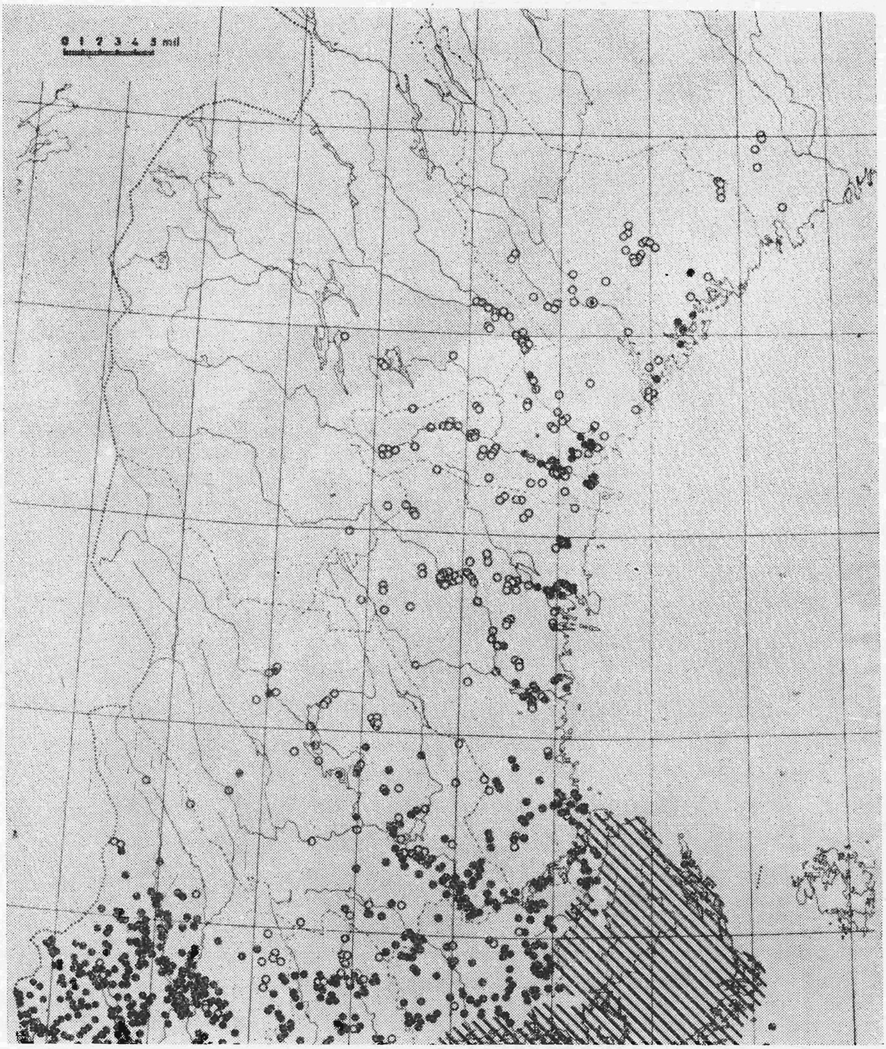

Fig. 3. The distribution of hazel along its northern boundary in Sweden (Pettersson 1956; the filled circles indicate small stands north of the area of common occurrences (hatched), the open circles indicate localities for subfossil hazelnuts, ringed filled circles indicate known 19th century localities from which hazel has now disappeared

as it is higher up (see also von Post 1930, fig. 2). The second area comprises the sites in Jämtland investigated by J. Lundqvist (1969), an inland area with relatively few subfossil finds or present-day relict localities (see Jonsson 1956; Pettersson 1956). Here, in diagrams extending back to the "Atlantic" period (let us say around 4500 BC, from the ^{14}C-datings) no pollen values exceeding 2% were anywhere recorded, except at Stockbergsmyren, where 5% values were recorded in the latter half of the "Atlantic" period. At Hällåfloarna, the site nearest to Halåsberget and Kläppe, values of 2% were recorded during the "Atlantic" and "Sub-boreal" periods, thereafter sporadic traces only.

All in all it would appear that, even north of its present-day limit, hazel was by no means a generally distributed or very common tree or bush. In these more northern parts of Sweden, where the forests were never dense mixed-oak forests, but largely birch and pine, with some elm and lime very

Fig. 4. The areas in Fennoscandia in which, according to the temperature-coordinate calculations, hazel should have optimal conditions (heaviest shading) or progressively less suitable conditions (weaker shadings) climatically (Hintikka 1963)

locally on the coast or along the lower parts of the main river valleys, the hazel could also have been expected to produce fairly abundant pollen, where present, as in the open forests of the "Boreal" period further south. With the progressive isostatic recovery of the land the inland localities for hazel will also have become raised in altitude and increasingly further away from the coastline (by 100 m and 50 km respectively, in many cases) which may have been sufficient to reduce the mean summer temperature by 1°C or so?

The second point concerns the evidence from macrofossils. The main compilations of the finds of subfossil hazelnuts (leaves have only been found in undated tufa deposits so far as I know) have been made by Holmboe (1903) for Norway, Andersson (1902, 1904, 1909), Samuelsson (1915) and Pettersson (1956) for Sweden, and Linkola (1938) and Salmi (1963) for Finland. In no cases, unfortunately, do we possess any very precise dates for these finds, the more so since, in many cases, the pollen samples were taken several years after the nut finds were made. Although Salmi was unaware of the metachroneity of the horizons at which the pollen of the spruce markedly increases (Tallantire 1977), he remarked that this was likely and that all the nut finds were probably of "Sub-boreal" age in Finland (the only exception was site 7 where the pollen samples were taken some time after the nut find was made) and that most of Gunnar Andersson's nut finds were also "Sub-boreal" (judging from the peat depths for nut finds in C Norway reported by Holmboe, the same conclusion probably holds true there also). Salmi also pointed out the fact (unknown to me when I was checking on the Swedish pollen diagrams mentioned previously) that, even in layers containing fossil nuts, the hazel pollen frequencies "are often as low as 1–2 %".

We are thus faced with the paradox that, on the one hand, we do have definite evidence that hazel formerly grew north of its present-day limits of both frequent and sporadic occurrences; on the other hand that these subfossil localities restrict the conclusions which we may draw from them, since there is no evidence that hazel was ever common so far north, nor that it set ripe fruit except during the "Sub-boreal" period, to generalize rather widely. One point often overlooked is that most hazelnuts finds are made in Gyttja or Dy muds, or in Sedge peats or Schwemmtorf, never in *Sphagnum* peats, even when such were being formed in these areas prior to the "Sub-atlantic" period. Hazel may invade the later, drier, stages of alder carr *(Alnus glutinosa)*, but nowhere does it to my knowledge grow on peat substrates. Nevertheless, if nuts become incorporated in the marginal deposits of lakes or pools, then they are likely to have floated there, unless for reasons unknown they were deposited there by birds or small mammals. Even so, why do we have no semicontinuous finds of hazelnuts in these northern Fennoscandian regions, from the "Atlantic" period (say 4500 BC) onwards, as may be the case in some southern Swedish lakes?

I suggest that the explanation lies in the summer warmth requirement for the production of ripe nuts, mentioned earlier. The hazel may have colonised these subfossil localities (i.e. the nearby slopes) during the "Atlantic" period, when they lay nearer the coastline at that time and lower in altitude, but that they then maintained themselves more or less vegetatively, as do the relict stands today, and that prolific nut production had to await the "climatic optimum of the north", which did not occur until the "Sub-boreal" period and was primarily connected with a rise in the mean temperatures of the late summer and autumn months (July—September or even August—October). In fact, if one reads carefully and fully, Gunnar Andersson in 1902 pointed out this conclusion also, since he there specifically mentioned an August—

September mean temperature of 12° C. The latitudinal delay in the attainment of the post-glacial "thermal maximum" is akin to the similar delay northwards in the climatic amelioration of the 1920—1940 AD period, documented by the meteorologists. The previously postulated increase in the July mean temperature for the period ca 5000–3000 BC, of ca 2·4° C, which was Andersson's conclusion from a comparison of the fossil and present-day hazel limits and the isotherm maps (although he spoke only of "the summer temperature reduction from the climatic optimum") needs reconsideration. It may be true, but the hazel data alone are insufficient. What is required is a careful compilation of data for 1) well-dated finds of 2) pollen and macrofossils of 3) plants whose ecological requirements in all parts of their geographical ranges are properly known. Otherwise botanists do a disservice to palaeoclimatologists by presenting them with data which are too imprecise to bear the burden of generalisation.

AFTERTHOUGHT

One final word, on the so-called "soil factor" in relation to the growth of hazel. Like many plants near their northern limits (e.g. *Pteridium aquilinum*) hazel grows hereabouts in localities usually receiving a good mineral nutrient supply, from the ground-water or calcareous morainic soil (Waldén 1956). During the relatively mild autumn last year (1978), especially during October, it was interesting to observe near Stockholm how long the earthworms remained active and how much more of the leaf-fall was converted to mull (buried at least) compared with the situation seen in more normal autumns there recently. Where the recycling of soil nutrients is delayed, due to a slower rate of breakdown of plant detritus by the soil fauna, on account of lower air temperatures and a shortening of the metabolic period, perhaps a compensation is necessary, from the primary store of soil nutrients. Plants with relatively high nutrient requirements will then, near to their northern limits become restricted to such favourable habitats. Basically, however, this is still the operation of a climatic factor, viz. relatively high and stable mean air temperatures in autumn, since a week or two of "premature" winter in September seems to lead to a cessation of activity by the larger members of the soil fauna. This activity is not then renewed by a week or two of "Indian Summer" conditions during October.

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STRESZCZENIE

REFLEKSJE NAD WYSTĘPOWANIEM LESZCZYNY (*CORYLUS AVELLANA* L.) NA GRANICY JEJ ZASIĘGU W FENNOSKANDII W CZASIE POSTGLACJAŁU

Chociaż ogólny obraz występowania leszczyny jest znany od dawna, to jednak niektóre szczegóły zasługują na dalszą uwagę w przyszłości. Po pierwsze, pomimo stosunkowo wczesnego pojawienia się w postglacjalnej sukcesji roślin, leszczyna ma pewne wymagania klimatyczne, szczególnie w okresie wytwarzania dojrzałych owoców. To łączy się z drugim punktem — rzeczywistym rozmieszczeniem leszczyny obecnie. Po trzecie, nasuwa się pytanie, czy można zastosować leszczynę jako paleoklimatyczny gatunek wskaźnikowy. Obraz, jaki uzyskujemy na podstawie rozmieszczenia starszych znalezisk makro-

szczątków, ulega modyfikacji, gdy studiuje się chronologię ich występowania i gdy porównuje się te znaleziska z obrazem, jaki przedstawiają współczesne im lokalne i regionalne spektra pyłkowe. Autor sugeruje, że spadek temperatury (średniej lipca) postulowany przez Anderssona i późniejszych autorów, należy raczej przypisać obniżeniu temperatur późnego lata (sierpień—wrzesień). „Optimum klimatyczne" występowało stopniowo coraz później w miarę posuwania się na północ, a oceny paleotemperatur należy raczej opierać na rozmaitych gatunkach roślin i definiować je bardziej precyzyjnie, jeżeli chodzi o porę roku i miejsce.