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VEGETATION, INSECTS, MOLLUSCS AND STABLE ISOTOPES FROM LATE WÜRM DEPOSITS AT LOBSIGENSEE (SWISS PLATEAU). STUDIES IN THE LATE QUATERNARY OF LOBSIGENSEE 7.

by

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ABSTRACT

At a littoral site of Lobsigensee northwest of Bern pollen (including *Betula* pollen size measurements), plant macrofossils, Coleoptera, Trichoptera, Chironomidae, Ceratopogonidae, Mollusca, $\delta^{18}O$ and $\delta^{13}C$ from Late-Würm sediments were studied. In the clay of Oldest Dryas the expansion of *Betula nana* was recorded from the level where the first Coleoptera, Trichoptera and Mollusca occurred and a change in the chironomid fauna took place. The transition from Oldest Dryas to Bölling was sharply marked by the sediment (clay/lake marl transition), by vegetation (beginning of reforestation), by chironomid fauna (disappearance of cold stenothermic species) and by high mollusc frequencies; only a small rise of $\delta^{18}O$ in carbonate is recorded. During the Bölling a faunal shift among Coleoptera and Trichoptera suggests a rise of mean July temperature from 10-12°C to 14-16°C. No climatic cooling between Bölling and Alleröd was found. A Younger Dryas climatic cooling was indicated by pollen diagrams, by $\delta^{18}O$ and by a minimum among molluscs, but not by changes in the species composition of the insects. These data support the view that rising annual and summer temperatures favored a vegetational and faunal development reaching a major step around 13 300-13 000 B.P.; the only climatic reversal registered was the Younger Dryas.

A. INTRODUCTION

Multidisciplinary studies may provide complementary or contradictory results or both for the participating research workers, but they always challenge our traditional interpretations and our efforts to form an ecological synthesis. The tiny lake Lobsigensee (today 2 ha surface, 2,5 m maximum depth) is situated about 15 km northwest of Bern on the Swiss Plateau at 514 m asl. It is a primary reference site on the cross section Jura-Plateau-Alps of the Swiss contribution to the IGCP 158 b (LANG, 1983). Site 150 considered here is a littoral profile on a transect through the former and the modern lake (AMMANN, in prep.) This paper attempts a synthesis of studies carried out on this littoral material. Two pollen profiles, one from a core and one from an open pit, and some selected samples of plant macrofossils are discussed by AMMANN and TOBOLSKI (1983), *Betula* pollen size measurements by GAILLARD (1983), fossil assemblages of Coleoptera and Trichoptera by ELIAS and WILKINSON (1983), the Chironomidae and Ceratopogonidae by HOFMANN (1983), the molluscs by CHAIX (1983) and the stable isotopes by EICHER and SIEGENTHALER (1983). Sampling for the different methods is shown in Table 1

The basis of correlation between 150 a + b and 150 d + e is given by the local pollen assemblage zones (paz) L 1 to L 11. The pollen samples were usually taken at 1-5 cm intervals (in early Oldest Dryas at 5-20 cm) yielding a temporal resolution of 40-60 years between samples (but unknown in the Oldest Dryas). In the following we present the main ecological changes in their chronological sequence (Fig. 1).

B. RESULTS

1. THE OLDEST DRYAS

The date of the last retreat of the Rhone glacier from the studied area is not known but, it may have been between 18 000 and 15 000 B. P. The coarse sands and cobbles of this Würm till were reached in both the core and the pit.
L 1 = *Artemisia- Pinus* -paz is characterized by very low pollen concentrations and a large proportion of reworked pollen and spores; no algae, higher water plants, molluscs, or insects are found in the sandy clay of this periglacial lake. Just a few pioneers may have colonized the open ground after the ice retreat.
L 2 = *Artemisia- Helianthemum* -Cyperaceae-paz shows increasing pollen concentrations and increasing percentages of *Artemisia*, Chenopodiaceae, Cyperaceae, *Ephedra* and other NAP evoking a denser pattern of pioneers able to grow on still poorly developed soils. Algae (*Pedia-*

Table 1

Sampling at the littoral site 150 at Lobsigensee			
	150 a + b twin cores taken with a modified Livingstone piston sampler	150 c Livingstone core	150 d + e wall in an open pit (pollen profile 150e at 70cm from Livingstone core 150 a + b)
pollen	+	(+)	+
plant macrofossils	+		+
Betula pollen measurements	+		
Chironomidae & Ceratopogonidae	+		
Coleoptera & Trichoptera			+
Mollusca		(+)	+
stable isotopes	+		+

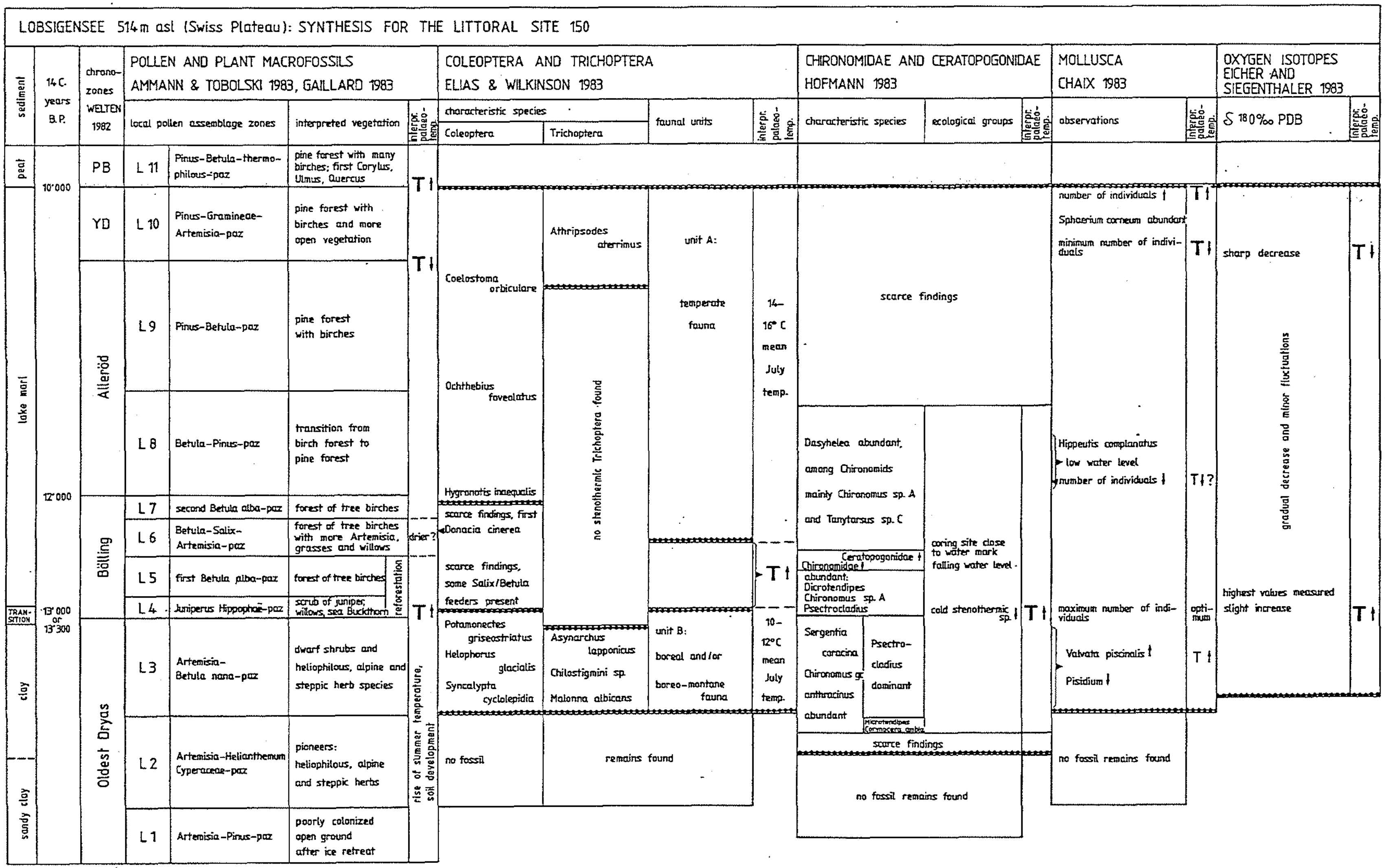

Fig. 1. Lobsigensee : review over the results of several methods applied to Late-Würm deposits.

strum.), higher waterplants (*Potamogeton* , *Coleogeton* , *Myriophyllum spicatum*) and, after the last level of inwashed sand, the first Chironomidae are found : *Microtendipes*, *Corynocera ambigua* and *C. oliveri* show their highest frequencies in the upper part of L 2, whereas *Sergentia coracina* and *Chironomus*. gr. *anthracinus* are abundant during the upper L 2 as well as during L 3.

L 3 = ***Artemisia - Betula nana*** -paz : In the open vegetation formed by a high diversity of herb species (NAP-types ⩾ 20) the dwarf shrubs *Betula nana* and *Salix* spp. are well established. Shrubs like *Hippophaë*, and *Juniperus* occurred as well as some tree birches (according to macrofossils and *Betula* pollen size measurements). Synchronous with this transition L 2/L 3, defined by the expansion of *Betula nana* , the first Coleoptera, Trichoptera and Mollusca are found. The beetles *Potamonectes griseostriatus*, *Helophorus glacialis* and *Syncalypta cyclolepidia* and the caddisflies *Asynarchus* cf. *lapponicus*, *Molanna albicans* and the Chilostigmini species belong to a boreal or boreo-montane faune indicating mean July temperatures of 10-12°C. The first molluscs are *Pisidium nitidum* , *P. subtruncatum* and *Pisidium* not identifiable to species, together with *Valvata piscinalis* and *Radix ovata* . Later in this pollen zone also *Pisidium casertanum* , *P. milium* and *P. obtusale* have been identified. Most species of this genus are well adapted to water cold and/or poor in $CaCO_3$ and some are pioneers after deglaciation. The same is true for *Radix ovata* (CHAIX, 1983).

2. THE BÖLLING

The chronozone Bölling (about 13 000 to 12 000 B.P.) comprehends the pollen zones dominated by *Juniperus* and *Betula* ; in the pollen diagram it extends from the rise of *Juniperus* to the rise of *Pinus*. Its beginning, the transition from L 3 to L 4 , is the strongest marked horizon in the whole profile for several of the parameters studied at Lobsigensee :

- the sediment shows a transition from clay (blue-gray) to lake marl (white-yellowish) i.e a sharp increase in carbonates.
- reforestation introduced by *Juniperus* and *Hippophaë* commences (and pollen concentrations rise rapidly).
- among *Betula* species the proportion of dwarf birch decreases, the proportion of tree-birches increases, a shift suggested by macrofossil analysis and pollen size measurements.
- among the Chironomidae the cold stenothermic species disappear.
- among the molluscs a maximum in numbers of individuals is found.
- among the Coleoptera and Trichoptera the cold stenothermic species decrease.

L 4 = ***Juniperus - Hippophaë*** -paz is a record of the first woodland vegetation when juniper, willows and Sea Buckthorn formed at least patches of scrub in the open vegetation. The expanding tree-birches belonged to several species (GAILLARD, 1983). In the lake the inwash of clay was virtually stopped and instead the precipitation of carbonates was strongly promoted. Among the Chironomidae the cold stenothermic species have disappeared. Fossils of *Salix*- and *Betula*,- feeding leaf beetles were found in the pollen zones L 4 and L 5. During the end of L 3 and the beginning of L 4 a maximum number of molluscs was recorded (447 specimen in 200 cm^3), a number only surpassed by the upper most sample at the transition from Younger Dryas to Preboreal. All of these changes may be interpreted as indicating a rapidly warming climate (mainly summer temperature). In contrast to other localities in Central Europe (EICHER and SIEGENTHALER, 1976; EICHER *et al.*, 1981) $\delta^{18}O$ measured in samples of lake marl as well as in shells of *Valvata piscinalis* do not show a substantial change at the beginning of Bölling. Since results from several other sites clearly indicate that mean $\delta^{18}O$ in precipitation did increase markedly at that time in Central Europe, this must be due to some local effects, e.g. changing water regime in Lobsigensee. In early Bölling (paz L 4 and L 5) the highest $\delta^{18}O$ values of the whole profile are observed, similarly as in other profiles. After that, $\delta^{18}O$ gradually decreases, with minor fluctuations, until paz 9 (late Alleröd). $\delta^{13}C$ was also measured besides $\delta^{18}O$. It is generally observed to vary parallel to $\delta^{18}O$ in Lobsigensee as well as in Gerzensee (EICHER and SIEGENTHALER, 1983).

In L 5 = **first *Betula alba*** -paz tree-birches formed a dense forest (NAP decrease in percentages and concentrations). Macrofossil analysis and pollen size measurements suggest that several birch species were involved (*Betula pubescens* , *B. tortuosa*, *B. pendula*). At the transition from L 4 to L 5 a rather unique sample with the dominant Chironomidae *Dicrotendipes*, *Psectrocladius* and *Chironomus* termed sp. A was found (HOFMANN, 1983). Diversity and number of individuals among Chironomidae decrease rapidly.

During L 6 = ***Betula Salix - Artemisia*** -paz a slight depression in the birch curve can be compared with what was often correlated with the Older Dryas, but no indications of a cooling climate can be detected in the pollen diagrams (AMMANN and TOBOLSKI, 1983; GAILLARD, 1981; WELTEN, 1982). Therefore we agree with WELTEN (1982) who postulated a pollen zone called the Bölling-complex, including minor fluctuations and lasting from about 13 000 to 12 000 B.P. as the chronozone Bölling does (WELTEN 1982 incorporates the period of 12 000 to 11 800 B.P. into the Alleröd). It is during L 6 that the first temperate Coleoptera occur, *Donacia cinerea* . This finding contrasts with the interpretation of the *Betula* depression as a period with cooler summers viz. an Older Dryas. KOLSTRUP (1982) and AMMANN and TOBOLSKI (1983) discussed some arguments for the interpretation of this interval as a drier one.

At the transition from L 5 to L 6 the dipteral fauna undergoes a major change from dominant Chironomidae to dominant Ceratopogonidae.HOFMANN (1983) suggested this to be an indication for a change from an aquatic to a semiterrestrial environment. The maximum fall in water level can only have been approximately one meter (littoral position of the core, continuous sedimentation of lake marl). But unpublished data on plant macrofossils (TOBOLSKI, in prep.) point to the establishment of *Phragmites* along the shore at that time. This is in agreement with the finds of ELIAS and WILKINSON (1983) : from the transition L 5/L 6 on beetles dependent on reed vegetation occur.

L 7 = **second *Betula alba*** -paz is again a period when birch forests dominated the landscape around Lobsigensee. Two new temperate beetle species are recorded : *Hygrotus inaequalis* and *Ochthebius foveolatus*.

3. THE ALLERÖD

During L 8 = ***Betula- Pinus***-paz pine is expanding while the tree-birches are loosing ground. Also herb vegetation (NAP as percentages and in concentrations) is decreasing. At the beginning of this paz the number of individuals of molluscs drops. This is the only faint indication for a possible climatic cooling shortly after 12 000 B.P.

During L 9 = ***Pinus- Betula***-paz the pine forest is well established, birches are abundant as well. NAP and water plants are at their minimum. The temperate beetle *Ochthebius foveolatus* and the temperate caddisfly *Athripsodes aterrimus* occurred. Towards the end of this pollen zone the volcanic ashes from the Laach eruption were found (as identified by P. van den BOGAARD, 1983 : MLST = Middle Laacher See Tephra of mostly highly differentiated phonolitic composition). This eruption is dated at several places to about 11 000 B.P.

4. THE YOUNGER DRYAS

About 7 cm above the remains of the Laach eruption the pollen of herbs (especially *Artemisia* and Gramineae) and of *Ephedra*, *Juniperus* and *Hippophaë* increase in percentages and concentrations : the pine forest with birches was thinned in places and heliophilous species could regain some ground. This change in vegetation - slight but consistent in the lowland and very marked near the timberline (WELTEN, 1982) - can be correlated with the Younger Dryas. Among the insect fossils, the Coleoptera, Trichoptera and the few Chironomidae and Ceratopogonidae show no change in species composition; the general decrease in numbers of individuals need not indicate a cooler climate, but possibly changing local conditions. The same holds true for the decrease in molluscs found. *Sphaerium corneum* appearing in the Younger Dryas is even considered a rather thermophilous species. On the other hand the fall of $\delta^{18}O$ at the beginning of pollen zone III is the most pronounced and most consistent feature of the lateglacial $\delta^{18}O$ curves at Lobsigensee, measured in lake marl as well as on shells of *Valvata piscinalis*. Such a decrease at the beginning of the Younger Dryas has been observed in many other marl profiles; obviously it reflects a large-scale climatic event.

5. THE PREBOREAL

This chronozone is represented by the local paz L 11 = *Pinus-Betula* -thermophilous-paz. Its beginning, i.e. the Late-Würm/Holocene boundary, is synchronous at Lobsigensee with the transition from lake marl to peat; this peat was only useful for pollen analysis. Therefore, no multidisciplinary studies of this very important transition could be performed at our site.

C. CONCLUSIONS

1. ENVIRONMENTAL HISTORY OF THE LATE-WÜRM AT LOBSIGENSEE

- During the Oldest Dryas (?16 000-13 000 B.P.) the expansion of *Betula nana* (L 2/L 3) was a major ecological event at Lobsigensee because it is synchronous with the opening of the fossil record for Coleoptera, Trichoptera and Mollusca and with a change in the fauna of Chironomidae. Thus, this is an example where ecological changes in terrestrial and aquatic environments occurred simultaneously. In the discussion whether the expansion of dwarf birch was a successional phase of pioneers on morainic soils or an indication for a warming climate (GAILLARD, 1981, 1983), this synchronism may be evaluated as an argument for the hypothesis of a climatic warming. But we will keep in mind that the trophic state of a lake and the development of soils are partly dependent on climate as well; moreover, the trophic state of a lake is partly controlled by the developing soils around it. Our data do not strictly support one or the other hypothesis mentioned above (pioneer succession or warming climate).
- The lower boundary of the Bölling is the sharpest change during Late-Würm : reforestation by *Juniperus* and *Betula alba* takes place, the fauna of Chironomidae looses its cold stenothermic species, the number of mollusc individuals rises greatly. The $\delta^{18}O$ values do not show a change as sharp as observed at this time in other Central European sites (EICHER and SIEGENTHALER, 1976; EICHER *et al.*, 1981).
- During the Bölling (13 000-12 000 B.P.) a faunal shift among Coleoptera and Trichoptera is recorded : a boreal/boreo-montane fauna is replaced by a temperate one. A rise in mean July temperatures from 10-12°C to 14-16° is deduced.
- In contrast to the British results (COOPE, 1970, 1975) the main change among the Coleoptera useful for temperature interpretation (independent from host plants) occurs after reforestation i.e. in the central part of Bölling. This may be taken as an argument for the hypothesis that the sequence of pollen zones during the Bölling (L 4 to L 7) does not represent climatic warming so much as just vegetational succession. Among the plant dependent beetles, the birch/willow feeders appear with the Bölling pollen change in L 4 and L 5.
- During the Bölling the Chironomidae decrease in numbers of individuals and of species while the frequency of the Ceratopogonidae (Dasyhelea) increases. This indicates a shift from an aquatic to a semi-terrestrial environment (lake level falling and establishment of *Phragmites* reeds along the shore). Coleoptera dependent on reed plants are abundant.
- The highest $\delta^{18}O$ values of the whole profile are observed in the early Bölling. This might suggest that this was the warmest phase of the whole Bölling-Alleröd Interstadial. However, this conclusion is not firm because temperature is not the only parameter determining $\delta^{18}O$; but probably temperature was never higher in later periods of that interval than in early Bölling. $\delta^{13}C$ variations in Lobsigensee marl are in general parallel to $\delta^{18}O$ variations. $\delta^{13}C$ does not directly reflect climate, but it may respond to changing bioproductivity, higher productivity leading to higher δ^{13} values. Thus the parallelism of $\delta^{13}C$ and $\delta^{18}O$ can tentatively be interpreted such that bioproductivity was enhanced in warmer periods.
- Indications of a climatic cooling between Bölling and Alleröd are not found.
- A depression in the *Betula* curve, correlated with higher frequencies of *Artemisia*, Gramineae and *Salix* and with the first occurrence of temperate Coleoptera, could possibly represent a period of a drier climate. The interpretation as a cooler phase is less probable because the local vegetation is progressing and the $\delta^{18}O$ curves show no negative fluctuation.
- During the Alleröd (as a chronozone from 12 000 to 11 000 B.P. according to WELTEN 1982) the pine forest expanded and dominated around the lake. Faunal changes were not observed.
- The Younger Dryas is visible in the pollen diagrams and in the $\delta^{18}O$ curves; but the insect fauna does not show any changes in species composition (quantitative reductions are difficult to interpret as long as we do not know the sedimentation rates).
- Among the molluscs the occurrence of the rather thermophilous *Sphaerium corneum* suggests - just as the insect record does - that any cooling at the beginning of the Younger Dryas can not have been very strong, at most only within the temperature tolerance of the species considered.
- For the Younger Dryas at Gerzensee EICHER and SIEGENTHALER, 1976 estimated a temperature drop of about 3-4°C or more. This estimate is based on $\delta^{18}O$ in carbonates which mainly reflect variations of the mean value of $\delta^{18}O$ in precipitation and thus of mean annual temperature. For the central Alps of western Tyrol KERSCHNER, 1980 estimates a depression of about 2.5-3°C for the summer temperature (but against present values, not against Alleröd values). As KERSCHNER, 1980 demonstrated the precipitation patterns may have changed as well. WATTS, 1980 reviewed how the climatic cooling of the Younger Dryas was strongly marked in Ireland and Britain but less and less so on the continent. This is in agreement with the view that the Younger Dryas reversal was controlled by the pattern of the polar front in the North Atlantic (RUDDIMAN *et al.*, 1977, 1981 a,b). In the Alps the Younger Dryas was not a minor event either since the glaciers readvanced considerably. But besides temperatures the amount of summer precipitation strongly influences the state of activity of glaciers. For the central Alps WELTEN, 1982 discussed some arguments for an early Younger Dryas with cooler as well as wetter summers than during the Alleröd; for the second half of YD cool and dry conditions are suggested. At our lowland site we can not subdivide the Younger Dryas.

2. POSSIBILITIES AND LIMITATIONS OF THE METHODS USED

The combination of different palaeoecological methods applied to the same material helps to discuss the steps of interpretation.

a. The response lag of a species to a changing climate is determined by the reproductivity rate and the mobility of the organism (and thus by migration) : for insects this lag is much shorter than for woody plants. This is the plausible explanation COOPE 1970 gave for the difference between beetles and vegetation immigrating to Britain during the Late Devensian. But was the shift at Lobsigensee among stenothermic insect species (independent of the plants) shortly after reforestation as the Fig. 1 may suggest ? The absence of Trichoptera fossils, the scarcity of Coleoptera fossils belonging to stenothermic species and the differing thickness of samples (5 cm for insects, 1 cm for pollen) render this interpretation improbable. Does this then mean that, at Lobsigensee, the vegetational response to a warming climate was as fast as the response of beetles ? This seems true for pioneer species and the early woody genera (*Betula*, *Salix*, *Juniperus*, *Hippophaë*). The reason could be that the lake is only about 15 km from the nearest unglaciated area and about 35 km from the terminal moraines of the Würm-maximum of the Rhone glacier. But among species requiring summers as warm as 14-16°C or as warm as today (17°C mean July), shrubs and trees like *Corylus*, *Quercus* and *Ulmus* were obviously slower migrants than insects with similar requirements. Between the arrival of the first temperate Coleoptera and the first representative of the mixed oak forest at least 2500 years elapsed. The chironomid fauna on the other hand exhibits synchronous changes with the pollen zone transitions L 2/L 3 and L 3/L 4 (expansion of *Betula nana* and expansion of *Juniperus* respectively). In contrast to biological indicators, $\delta^{18}O$ in precipitation reacts immediately to climatic change; therefore $\delta^{18}O$ shifts in lake marl, such as observed at the beginning and end of Younger Dryas phase, can be used as time marks for synchronizing profiles from different sites.

b. The trophic state of a lake and the **soil development** around it (both partly controlled by climate) influence heavily the development of flora and fauna. For climatic deductions-e.g. mean July temperatures-it is therefore important to rely on species not dependent on food plants or substrate qualities; thus, it is crucial to examine e.g. predatory and scavenging beetles. Under favorable conditions, which seem to have prevailed in Lobsigensee, $\delta^{13}C$ variations in lake carbonates probably reflect changes in bioproductivity.

c. The temporal resolution of sampling is not always satisfactory in sediments growing as slow as 0,1 mm/year, especially when large samples are needed, as in the studies on Coleoptera and Trichoptera. More detailed investigations concentrating on the transition zones in the Oldest Dryas and in the Bölling would be desirable.

d. For long distance comparison we will need more and reliable radiocarbon datings. These could provide the basis for influx calculations, which are extremely helpful for ecological interpretations.

Concluding remark : The various scientists who participated in this study have all expressed an urgent need for additional multi-disciplinary studies of Late-Würm sites in the northern alpine foreland. The Lobsigensee study generated more questions than answers, and caused considerable re-evaluation of previously held views.

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