

# Evolution of an Eemian lake based on Cladocera analysis (Konin area, Central Poland)

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## ABSTRACT:

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The succession of Cladocera assemblages in the Eemian Sławoszewek palaeolake (Central Poland) and the inferred environmental parameters are presented. The Cladocera assemblages provide a rich and relatively complete record of the Cladocera succession of the Eemian Interglacial, and are similar to those from other Eemian sites in Poland. The species composition and the variability in frequency of specimens of Cladocera made it possible to distinguish five zones of their development, which correlate well with pollen data. The Sławoszewek palaeolake existed from the early Eemian to the late Eemian Interglacial; at the end of the middle Eemian, the lake dried up temporarily. The cladoceran assemblages show that the initial shallow, oligotrophic status of the lake was followed by an increase to eutrophic status, especially during the interglacial optimum. Based on cladoceran composition, changes in climatic conditions in the mid-pollen zone E1, the late pollen zone E5 and in pollen zone E7, were recognized. It appears that cladoceran development was due mainly to climate changes, but also to changes in the locally prevailing conditions within the water body. The high frequency of cladocerans and the presence of cladoceran taxa preferring warmer water in mid-pollen zone E1 show an increase in temperature. The appearance of cold-tolerant Cladocera species at the end of pollen zone E5, suggests unfavourable conditions, probably cooling. Changes in Cladocera patterns in pollen zone E7 show that warm conditions still obtained in this area.

**Key words:** Cladocera; Eemian; Poland; Development of palaeolake.

## INTRODUCTION

The Cladocera, a group of small crustaceans living mostly in lakes, is a very useful tool in palaeoecological reconstructions of Eemian lake deposits. Because all of the Eemian Cladocera species are living species, their ecological preferences are relatively well-known, and the group may thus directly be used in estimating certain environmental parameters. Several species (e.g., *Bosmina longirostris* (O.F. Müller, 1785), *Alona rectangula* (Sars, 1862), *Chydorus sphaericus* (O.F. Müller, 1785), and *Leydigia acan-*

*thocerooides* (Fischer, 1854) are considered good eutrophication indices (Goulden 1969; Whiteside 1970; Alhonen 1972, 1986; Boucherle and Züllig 1983; Hofmann 1986; Korhola 1990; Szeroczyńska 1991a, 1995, 1998a), whereas the reconstruction of water-level fluctuations may be based on the ratio of planktonic (P) to littoral (L) species (the P/L index; see, e.g., Alhonen 1970, Szeroczyńska 1998b, Sarmaja-Korjonen and Alhonen 1999).

There are only few reports on Cladocera in Eemian lakes in Poland (Szeroczyńska 1991b; Pawłowski 2004; Mirosław-Grabowska and Niska 2005, 2007a, b; Kupry-

janowicz *et al.* 2005; Mirosław-Grabowska *et al.* 2009). This paper documents, for the first time, the Cladocera succession in the Eemian sequence of the Sławoszewek palaeolake of the Konin (Central Poland) lignite open-cast mine. The changes in the composition of the cladoceran assemblages document the palaeoenvironmental changes during the Eemian Interglacial of Central Poland.

## MATERIALS AND METHODS

The Sławoszewek palaeolake is located on the land of the KWB Konin lignite open-cast mine, near Kleczew, 16 km north of the town of Konin, central Poland (Text-fig. 1A). It is situated within a local gully structure of the Struga Kleczewska. Lithofacies analysis of the lake infillings indicates that it was formed from the thawing of dead ice (Pawłowski and Włodarski 2001; Stankowski *et al.* 2003).

The stratigraphy of the Sławoszewek palaeolake deposits is based on pollen data (Stankowski *et al.* 2003). Eight local assemblage pollen zones (LPAZ) were distinguished and correlated with regional assemblage pollen zones (RPAZ) (Mamakowa 1988, 1989; Tobolski 1991), and assigned, accordingly, to the Eemian Interglacial (Stankowski *et al.* 2003) (Text-fig. 3).

The Eemian sediments are sandwiched between series of till of the Wartanian (=Late Saalian) Glaciation (below) and the strata of the Vistulian (=Weichselian) Glaciation (on top) (Text-fig. 1B). The succession studied here is up to 3 m thick, and is composed of mud, gyttja and peat. A layer of grey calcareous mud occurs at the base of the succession over the entire palaeolake.

The predominantly calcareous gyttja is thickest in the central part of the lake and is composed of loamy and (mid-) detritus gyttja. Brown and black peat (mostly sedge-moss) occurs at the top of the succession. The succession under examination represents the central part of the basin.

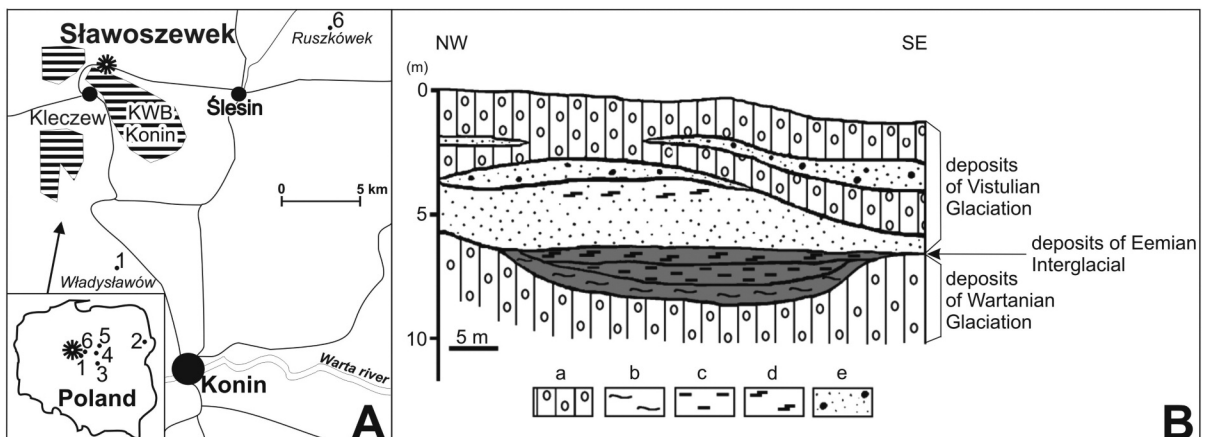
Twenty-nine samples were collected at intervals of 5 to 10 cm, based on lithological changes in the succession. The samples (consisting of 1 cm<sup>3</sup> of fresh sediment) were prepared according to the standard procedure (Frey 1986). A minimum of 200 remains of Cladocera (3–5 slides) was examined from each sample.

The taxonomy of the Cladocera applied here follows Frey (1962) and Szeroczyńska and Sarmaja-Korjonen (2007). The results were plotted on a relative-abundance diagram using POLPAL software (Walanus and Nalepka 1999). The ecological preferences of the cladoceran taxa were determined on the basis of Whiteside (1970) and Szeroczyńska (1998a).

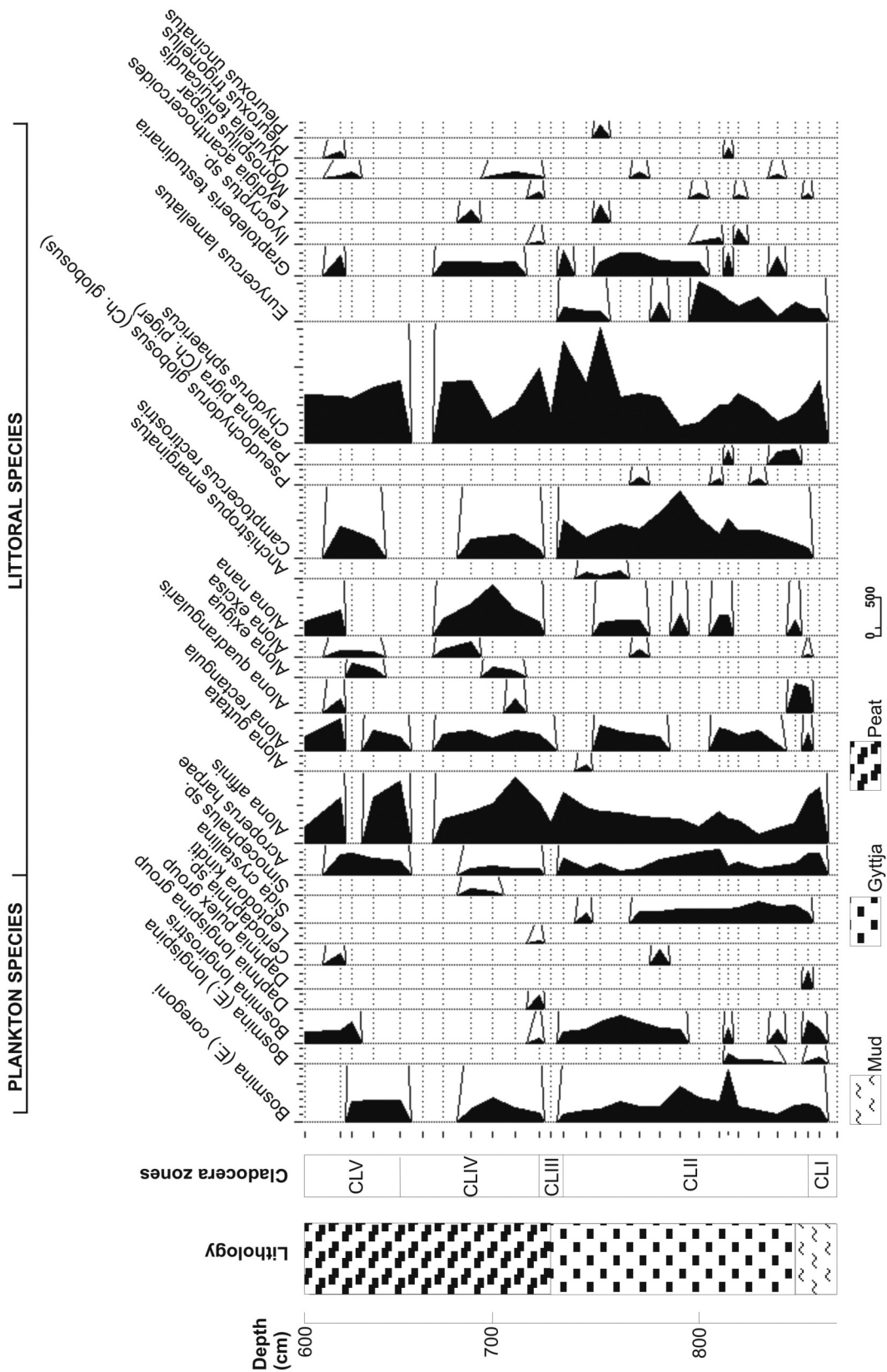
## RESULTS

Thirty Cladocera species, representing six families (Text-fig. 2), were recognized in the section studied. The most numerous are littoral species of the family Chydoridae. The pelagic forms do not exceed 30% of the total number of Cladocera individuals.

Based on the species composition and relative frequency, five successive Cladocera assemblages were recognized, on which are based the corresponding local Cladocera zones (CL I through CL V) (Text-fig. 2): **CL I (depth 870–855 cm)**: planktonic species are represented by *Bosmina longirostris* (O.F. Müller, 1785), *Bosmina*



Text-fig. 1. A – Location of research area (small square) and the position of the Sławoszewek site (small star) within the area of the KWB Konin lignite open-cast mine (hatched field): 1 – Władysławów site; 2 – Solniki site; 3 – Biesiekierz site; 4 – Kaliska site; 5 – Studzieniec site; 6 – Ruszków site; B – Simplified geological setting of the Sławoszewek palaeolake: a – diamicton; b – mud; c – gyttja; d – peat; e – sand and gravel



Text-fig. 2. Diagram of the absolute number of Cladocera individuals in the sediments of the Slawoszewek palaeolake. The scale below the diagram shows the number of specimens in 1 cm<sup>3</sup> of fresh sediments

(*Eubosmina coregoni* (Baird, 1857), *Bosmina (Eubosmina) longispina* (Leydig, 1860). Littoral species are represented by *Acroperus harpae* (Baird, 1835), *Alona affinis* (Leydig, 1860), *Chydorus sphaericus* (O.F. Müller, 1785) and *Eurycercus lamellatus* (O.F. Müller, 1785).

**CL II (depth 855–731 cm):** planktonic species are represented by *B. longirostris*, *B. (E.) coregoni*, *B. (E.) longispina*, *Ceriodaphnia* sp. (Dana, 1853), and also by *Daphnia* (belonging apparently to the *Daphnia pulex* group (Leydig, 1860)), while the littoral species are represented by *Ac. harpae*, *A. affinis*, *Ch. sphaericus* and *E. lamellatus*. A number of new species appear: *Alona guttata* (Sars, 1862), *Alona quadrangularis* (O.F. Müller, 1785), *Alona rectangula* (Sars, 1862), *Alonella nana* (Baird, 1843), *Alonella excisa* (Fischer, 1854), *Anchistropus emarginatus* (Sars, 1862), *Camptocercus rectirostris* (Schoedler, 1862), *Pseudochydorus globosus* (formerly *Chydorus globosus* (Baird, 1843)), *Paralona pigra* (formerly *Chydorus piger* (Sars, 1862)), *Graptoleberis testudinaria* (Fischer, 1848), *Ilyocryptus* sp. (Sars, 1861), *Leydigia acanthocercoides*, *Monospilus dispar* (Sars, 1862), *Oxyurella tenuicaudis* (Sars, 1862), *Pleuroxus trigonellus* (O.F. Müller, 1776), *Pleuroxus uncinatus* (Baird, 1850) and *Sida crystallina* (O.F. Müller, 1776).

**CL III (depth 731–719 cm):** it is composed of three littoral species: *A. affinis*, *A. rectangula* and *Ch. sphaericus*.

**CL IV (depth 719–648 cm):** planktonic species are represented by *B. (E.) coregoni*, *B. longirostris*, the *Daphnia longispina* group (O.F. Müller, 1785), *Leptodora kindti* (Focke, 1844), and *Simocephalus* sp. (Schoedler, 1858); the littoral species are represented by the family Chydoridae: *Ac. harpae*, *A. affinis*, *A. rectangula*, *A. quadrangularis*, *Alonella exigua* (Lilljeborg, 1853), *Al. excisa*, *Al. nana*, *C. rectirostris*, *Ch. sphaericus*, *G. testudinaria*, *Ilyocryptus* sp., *L. acanthocercoides*, *M. dispar* and *O. tenuicaudis*. No Cladocera remains were found in the upper part of this zone.

**CL V (depth 648–600 cm):** planktonic species are represented by *B. (E.) coregoni*, *B. longirostris*, and *Ceriodaphnia* sp.; the littoral species are represented by *Ac. harpae*, *A. affinis*, *A. rectangula*, *A. quadrangularis*, *Al. exigua*, *Al. excisa*, *Al. nana*, *C. rectirostris*, *Ch. sphaericus*, *G. testudinaria*, *O. tenuicaudis*, and *Pl. trigonellus*.

## RECONSTRUCTION OF SŁAWOSZEWEK PALAEO-LAKE EVOLUTION

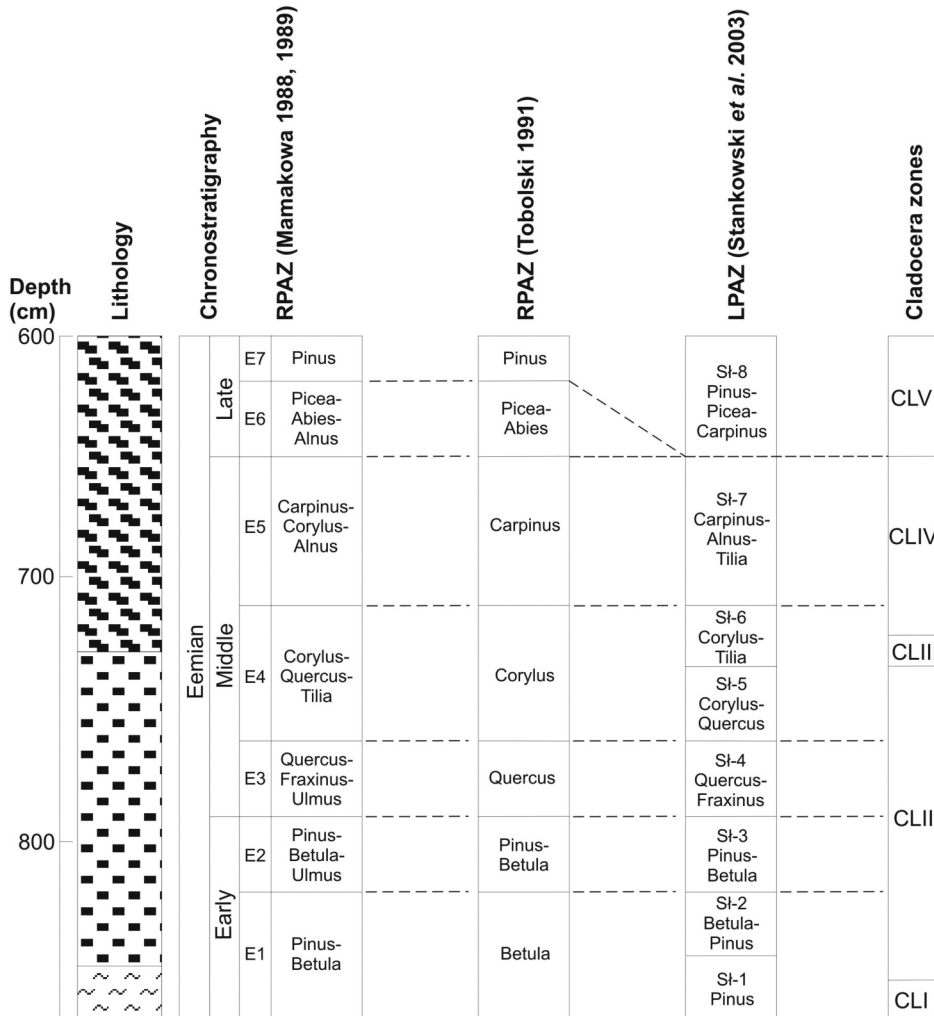
The five Cladocera zones recognized in the Sławoszewek palaeolake (Text-fig. 2) may be correlated with the local and regional pollen assemblage zones (Text-fig. 3).

### Early Eemian (pollen zones E1–E2)

The initial stage of the Sławoszewek palaeolake development, characterized by muddy deposition, is represented by the zone CL I, which corresponds to the early pollen zone E1 (Text-fig. 3). A low species diversity (seven species) in the zone indicates unfavourable conditions during this interval. A cool climate is suggested by the presence of cold-tolerant (so-called arctic) species of the family Chydoridae: *Ac. harpae*, *A. affinis*, *Ch. sphaericus*, and *E. lamellatus*. These are the pioneer species (the first immigrants to appear) after the recession of the ice sheet (Poulsen 1928; Goulden 1964; Meijering 1983; Szeroczyńska 1984, 1998a, b; Duigan and Birks 2000). It is worth noting, however, that most of these species are associated with macrophytes.

The dominant planktonic species in the zone CL I is *B. (E.) coregoni*. This species also dominated the initial phase of development in some other Polish Lowland lakes (Szeroczyńska 1991a). The dominance of littoral species (70% of Cladocera) lasted as long as the lake existed, which clearly demonstrates its shallow-water character (Text-fig. 4).

During the middle pollen zone E1 (Text-figs 2, 3) and the whole of pollen zone E2, a gradual warming is observed, expressed by an increased diversity and frequency of the Cladocera (zone CL II). This interval is characterized by gyttja deposition. The increased frequency of littoral species, especially of warm-water species (*A. quadrangularis*, *C. rectirostris*, *G. testudinaria* and *Pleuroxus* sp.; Frey 1962; Goulden 1964; Whiteside 1970), as well as a simultaneous decrease in frequency of cold-tolerant species, is indicative of a mild and warm climate. This interval clearly marks the beginning of the Eemian Interglacial's optimum climatic conditions. Additionally, the increase in the number of deep-water species, such as *B. (E.) coregoni*, *B. (E.) longispina* and *B. longirostris*, indicates water-level stabilization. The presence of more demanding species, such as *Bosmina longirostris*, *Alona rectangula*, *Ch. sphaericus* and *Monospilus dispar* (Adamska and Mikulski 1968; Whiteside 1970; Hofmann 1986), suggests slightly better edaphic conditions.



Text-fig. 3. Comparison of the results of Cladocera analysis in relation to biostratigraphic divisions. For lithology explanations, see Text-fig. 2; RPAZ – regional pollen assemblage zones; LPAZ – local pollen assemblage zones

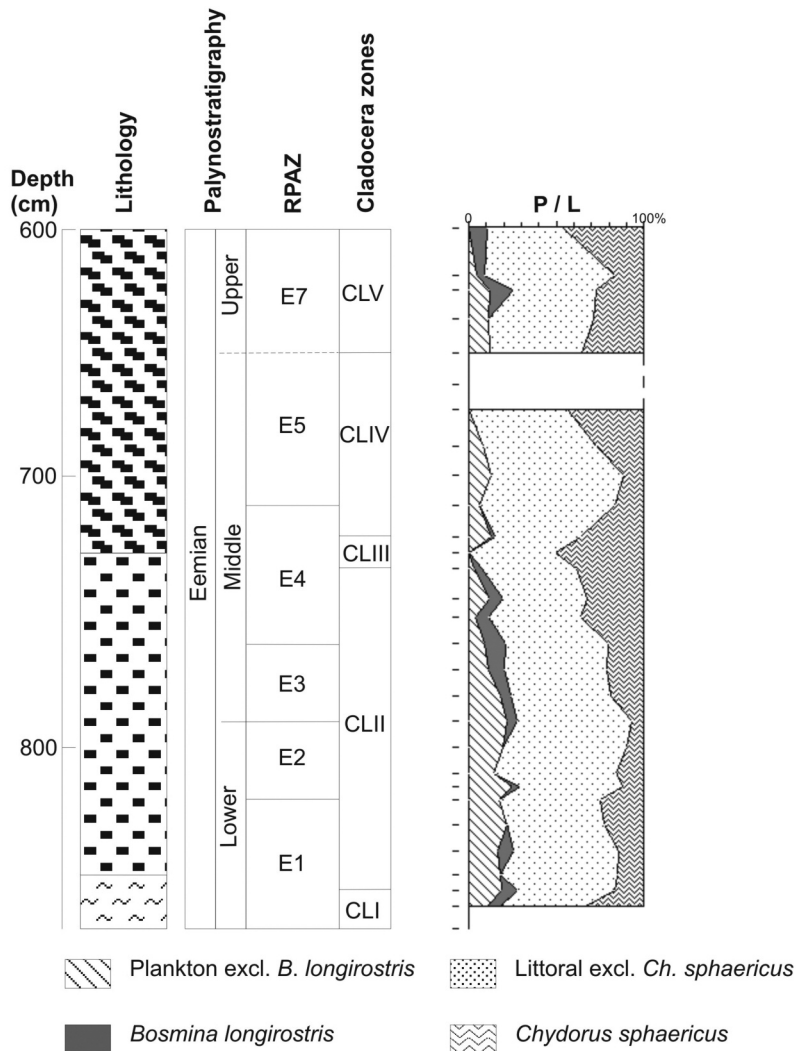
**Middle Eemian (pollen zones E3-E5)**

From the beginning of pollen zone E3, the water in the Sławoszewek palaeolake became more fertile. This is documented by the abundance of *B. longirostris*, *A. rectangula*, and *Ch. sphaericus* (Text-fig. 2: see middle zone CL II) (e.g., Korhola 1990). A high count of this species is also documented in pollen zone E4. This period of increased trophicity clearly correlates with the Eemian climatic optimum. The presence of *C. rectirostris* and *G. testudinaria* (Text-fig. 2), living in warmer waters, suggests a higher temperature.

During the late pollen zone E3, the water level dropped. The planktonic assemblage started to become impoverished, with some species disappearing completely (Text-fig. 4). The occurrence of numerous Chydoridae species (e.g., *Ac. harpae*, *E. lamellatus*, *A. affinis* and *O. tenuicaudis*) reflects, as suggested by Flössner

(1972), the existence of a high density of water plants in the littoral zone of the lake (Text-fig. 2). At the end of zone CL II, the hydrological and edaphic conditions deteriorated, due to increased temperature.

During zone CL III, corresponding to the late pollen zone E4 (Text-fig. 3), conditions were unfavourable for Cladocera. This is marked by a dramatic fall in the numbers of Cladocera and in their species diversity, resulting from the transformation of the lake into bog. The decline in planktonic species diversity was followed by their total extinction (Text-fig. 4). Only three littoral taxa survived (Text-fig. 2). The low water level and the probable moderate acidity of the reservoir, accompanied by an increase in Cladocera species tolerating low pH (*A. affinis*, *Ch. sphaericus*), are characteristic of this time. The abundance of *A. affinis* and *Ch. sphaericus* also indicates a high density of water plants, and their tolerance of cool water.



Text-fig. 4. Chronostratigraphy, regional pollen assemblage zones (RPAZ, after Mamakowa 1988, 1989; Tobolski 1991), proposed Cladocera zones, and ratio of planktonic to littoral forms (P/L index) in the sediments of the Sławoszewek palaeolake. For lithology explanations, see Text-fig. 2

The upper part of pollen zone E4, and of the whole pollen zone E5 (zone CL IV; Text-fig. 3) are characterized by the accumulation of peat. A slight increase in the diversity of planktonic species at the beginning of that time indicates stabilization of hydrological conditions in the lake (Text-fig. 4). The abundance of some of the species (i.e., of *Al. exigua*, *A. rectangula*, *Ch. sphaericus*, *L. acanthocercoides* and *M. dispar*; see Text-fig. 2) suggests a high trophic status of the palaeolake. Later, in the middle part of CL IV (early pollen zone E5), these conditions were interrupted. The maximum of *Al. nana* was associated with a low abundance of *Ch. sphaericus* (Text-fig. 2), indicating a low trophic status (Adamska and Mikulski 1968). Additionally, *Al. excisa*, which tolerates a low pH, appeared at this time.

During most of zone CL IV, warm conditions in the basin were supported by the presence of *A. quadrangu-*

*laris*, *C. rectirostris*, *G. testudinaria* and species of the genus *Pleuroxus*, but these conditions deteriorated near the end of CL IV, when planktonic species began to disappear, while the so-called arctic species *A. affinis*, *Ac. harpae* and *Ch. sphaericus* dominated. These latter species also indicate a higher density of water plants. Thus, a small, shallow reservoir with a high density of macrophytes was present at this time.

In the latest part of pollen zone E5 (end of zone CL IV), conditions were unfavourable for Cladocera. In the Sławoszewek section at a depth of 660 cm (Text-fig. 2), no Cladocera remains or pollen were noted. The pollen spectra of the deposits accumulated just above the depth of 660 cm seem to suggest that this part (Text-fig. 3) might correspond to pollen zone E5, but might also correspond to the late pollen zone E6 (Stankowski *et al.* 2003). This shows that a hiatus occurred at this time as

a result of a drop in the lake's water level (Text-fig. 4). The Sławoszewek reservoir dried up, as is documented by the layers of pressed, decomposed peat.

### Late Eemian (pollen zone E7)

Early in pollen zone E7, and contemporary with zone CL V, the hydrological and climatic conditions were favourable for Cladocera, which is confirmed by the occurrence of planktonic species (from the family Bosminidae; Text-figs 2, 4), the presence of warm-water species (*A. quadrangularis*, *G. testudinaria*, *C. rectoris*), and the presence of species associated with a high density of water plants (*E. lamellatus*, *A. affinis*, *Ac. harpae*). The highest frequency of *Ch. sphaericus* and *A. rectangula*, species which live in turbid waters, suggest an increase in trophic conditions. The trophic increase in Sławoszewek was caused by the shallowing of the reservoir (a decline of planktonic species other than *B. longirostris*, and the presence of *O. tenuicaudis*, typical elements of various amphibian biotopes).

The upper part of pollen zone E7 is characterized by a restricted occurrence of Cladocera (Text-fig. 2), with a continuous upward decrease in species diversity and in the number of warm-water species. The presence of *Ch. sphaericus*, *A. affinis* and *Al. nana*, indicates a low trophic status of the lake (Whiteside 1970) and may suggest climatic cooling (Harmsworth 1968). It is worthy of note, however, that the presence of the "arctic species" does not always indicate cold water, and their occurrence may be connected with a high density of macrophytes, even in warmer waters.

## DISCUSSION

The successions of Cladocera assemblages from the Sławoszewek palaeolake were compared to those of other Eemian palaeolakes in the Polish lowlands (Władysławów (Szeroczyńska 1991b); Ruszków (Mirosław-Grabowska *et al.* 2009); Biesiekierz (Mirosław-Grabowska and Niska 2005); Studzieniec (Mirosław-Grabowska and Niska 2007a); Kaliska (Mirosław-Grabowska and Niska 2007b), and Solniki (Kupryjanowicz *et al.* 2005)) (Text-fig. 1A). The main results of this comparison are as follows:

The record of the beginning of the Eemian Interglacial in Sławoszewek is very similar to records from the Studzieniec and Biesiekierz palaeolakes. The cold-tolerant species dominate in the lowermost part of pollen zone E1, and the presence of only rare planktonic species suggests shallow-water conditions. These initially cool climatic conditions in the area were confirmed

by pollen data (Tobolski 1991; Stankowski *et al.* 1999, 2003). In the succession studied, the presence of such conditions is confirmed by the pine-birch open assemblages, which reached the sub-arctic areas of Europe at that time.

Higher up in the succession (in Sławoszewek, in mid-pollen zone E1), the temperature began to increase. This is suggested by the continuous increase in the diversity of Cladocera species, as well as by the replacement of cold-tolerant species by taxa preferring warm water. These changes were accompanied by a slow increase in trophic conditions. This climatic change is also confirmed by changes in the flora (Tobolski 1991; Stankowski *et al.* 1999, 2003); the initially continental climate changed to oceanic, as suggested by the presence of oaks and hazels in the palynological records from the research area (Tobolski 1991; Stankowski *et al.* 2003), as well as from other areas in Poland (Mamakowa 1988, 1989).

The increase in temperature and trophic status, as well as the stabilizations in the level of the Sławoszewek palaeolake at that time, was caused by a more humid climate. It is possible that this situation also reflects the influence of intense precipitation, because at this time an estimated increase in precipitation of ca. 600 mm is indicated (Cheddadi *et al.* 1998).

The optimum of the Eemian Interglacial in Sławoszewek (pollen zones E3–mid-E5) was characterized by a warm, humid climate. This is confirmed by thermophilous pollen taxa in the palynological data from the section studied (Tobolski 1991; Stankowski *et al.* 2003), from other localities in Poland (Mamakowa 1988), and from numerous sites all over Europe (e.g., Zagwijn 1996; Björck *et al.* 2000; Klotz *et al.* 2003). 93 mins

Cladocera species from the Konin area indicate an increase in trophic status, warm water, and a gradual drop in the lake's water level. Similar conditions were also described in sections from Władysławów, Biesiekierz, Solniki, Studzieniec, and partly from Kaliska (in the beginning of pollen zone E4, very fast rates of sedimentation or other conditions unfavourable for fauna development (e.g., shortage of nutrients and/or a higher water level) have been interpreted; Mirosław-Grabowska and Niska 2007b). It is possible that the increase in fertility in the Sławoszewek palaeolake during the Eemian Interglacial optimum was caused by a more humid climate, with higher temperature, probably more intensive precipitation, and a more intensive supply of nutrients from the margins of the lake, because an increase in precipitation at that time of ca. 850 mm has been inferred (Cheddadi *et al.* 1998).

The changes in the composition of Cladocera species in the Konin area in pollen zone E4, i.e., the presence of

a few species characterized by a broad ecological tolerance, and a drop in species diversity, were an outcome of the drop in the water level and the transformation of the lake into a bog. It remains debatable whether this transformation was accompanied by warm, humid condition, or rather by warm, dry conditions; the regional floral records (Tobolski 1991) suggest warm, humid climatic conditions.

The recurrence of cold-tolerant species in the Sławoszewek palaeolake was probably connected with the gradual drop in trophic status which took place at the end of mid-Eemian, pollen zone E5, and might have been a result of unfavourable climatic conditions or of general cooling.

In the Kaliska and Studzieniec palaeolakes, “arctic species” were present at the end of pollen zone E5 (Mirośław-Grabowska and Niska 2007a, b). In the Studzieniec section, their presence indicates the approaching climatic cooling (Mirośław-Grabowska and Niska 2007a), while their presence in the Kaliska section might suggest a possible decrease in water temperature in the reservoir (Mirośław-Grabowska and Niska 2007b).

The cooling trend is partially corroborated by palynological records from the research area, and from other localities in Europe (Field *et al.* 1994; Björck *et al.* 2000; Klotz *et al.* 2003). A decrease in temperature (of ca. 8 °C) and in precipitation (of ca. 200–300 mm) is noted from many sections throughout Europe (Cheddadi *et al.* 1998).

Thus, the changes in the Sławoszewek section in pollen zone E5 indicate unfavourable conditions for zooplankton development – perhaps climatic cooling.

The Eemian Interglacial succession in the Sławoszewek section is represented by pollen zone E7. However, the Cladocera record shows slight discrepancies between sections from Poland. As with the Kaliska and Studzieniec sections (Mirośław-Grabowska and Niska 2007a, b), the initial hydrological and climatic conditions in the Sławoszewek section were favourable for Cladocera. Similar phenomena were also observed in the pollen and geochemical data in Central European sections, which show short warming phases towards the very end of the Eemian Interglacial (Boettger *et al.* 2009). At the end of zone E7, however, a change in the cladoceran communities suggests climatic cooling, and a similar trend was documented in the Solniki (Kupryjanowicz *et al.* 2005) and Ruszków sections (Mirośław-Grabowska *et al.* 2009). The cooling trend is also confirmed by palaeobotanical data from other areas of Poland and Europe (Tobolski 1991; Cheddadi *et al.* 1998; Björck *et al.* 2000), suggesting the broader nature of this trend.

In this situation, it is postulated that the Sławoszewek section lacks the top part of the Eemian Interglacial succession (the upper part of pollen zone E7 was probably eroded). Thus, the Cladocera assemblages (CL V) only show favourable conditions for zooplankton development just before the cooling in pollen zone E7; the presence in the Sławoszewek palaeolake of species which are associated with a high density of macrophytes, and which also occur in warmer water, might suggest ongoing warm climatic conditions, as in pollen zone E7 of the Kaliska and Studzieniec sections (Mirośław-Grabowska and Niska 2007a, b). On the other hand, some differences between cladoceran communities in the compared sections—especially in the Solniki section—might also be caused by geographical position (Solniki is situated in a colder region of Poland, where the influences of a more continental climate is noted) and by the varying depths of these reservoirs.

## SUMMARY

The Sławoszewek palaeolake provides a rich and relatively complete record of the Cladocera succession of the Eemian Interglacial. Five zones in Cladocera development have been distinguished: those favourable to Cladocera development probably reflect humid conditions, whereas those unfavourable to Cladocera development correspond to a dry and potentially cold climate.

The Sławoszewek palaeolake was small and shallow. The conditions for Cladocera development were, however, good, especially for those living on or among plants. The documented changes in trophic status of the lake indicate its dependence on changing climatic conditions. Initially, the lake had a low trophic status. With the Eemian optimum, the trophic status in the lake increased. At the end, the increase in trophic status was connected with the final developmental phase of the palaeolake.

Signs of climatic oscillations in the Eemian Interglacial in the Konin area, as recorded by the Cladocera, occurred in mid-pollen zone E1 (early Eemian), which is correlated with the beginning of zone CL II; in late pollen zone E5 (middle Eemian), corresponding to zone CL IV; and in pollen zone E7 (late Eemian), correlated with zone CL V. The first suggests the beginning of a warm and humid climate, the second probably a cool and dry climate. The change in the frequency of Cladocera species in pollen zone E7 leaves some room for discussion, but shows a relatively mild climate in the Konin area. A comparison of Cladocera successions from the research site and from sites of the same age in others areas of Poland suggests that these changes are very similar, and that they resulted only partly from individual features of the lakes.



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