the lake were occupied by the population of the Neolithic Funnel Beaker Culture (phase 6 = phase IIId in paper quoted above, ca. 5500–5200 cal BP). Once again the high rise of *Aphanizomenon* occurred during the Late Neolithic (ca. 1200 %, phase 7 = phase IV in paper quoted above, ca. 4800–5000 cal BP). The settlement of Comb-Pitted Pottery Culture was situated directly at the lake then, and inhabited this area during a fairly long time. Throughout the Bronze and Early Iron Ages, and the Roman Iron Age, the frequencies of Cyanobacteria remain low (Van Geel et al. 1994), suggesting lack of strong anthropogenic influences on the lake itself. Considerable blooms of Cyanobacteria started only during the Early-Medieval times, after AD 1000.

The interpretation of the fossil Medieval record does not differ from the present situation in polluted lakes: phosphorous enrichment from effluent and excreta in the catchment area of the lake can at times become so high that nitrogen-limited growth conditions occur. In such conditions Cyanobacteria, capable of active nitrogen fixation, became very efficient in the competition with the green algae and they showed strong increases, often with negative effects for other organisms as a consequence of the production of toxic substances by the Cyanobacteria. However, in the deposits representing the last ca. 330 years (Goslar et al. in print) there was a decline of Cyanobacteria and Chlorophyta (green algae) took over the dominance. This is interpreted as the effect of a change from nitrogen components as a limiting factor (as a consequence of phosphate eutrophication) to light as a limiting factor, under conditions of extreme eutrophication and increased turbidity as a consequence of dense algal populations. The process of nitrogen fixation is an energy (light) consuming process and in conditions where Chlorophyta are able to survive and to live in water with a dense population of algae, the Cyanobacteria lose their strong position in the competition as a consequence of lack of sufficient light.

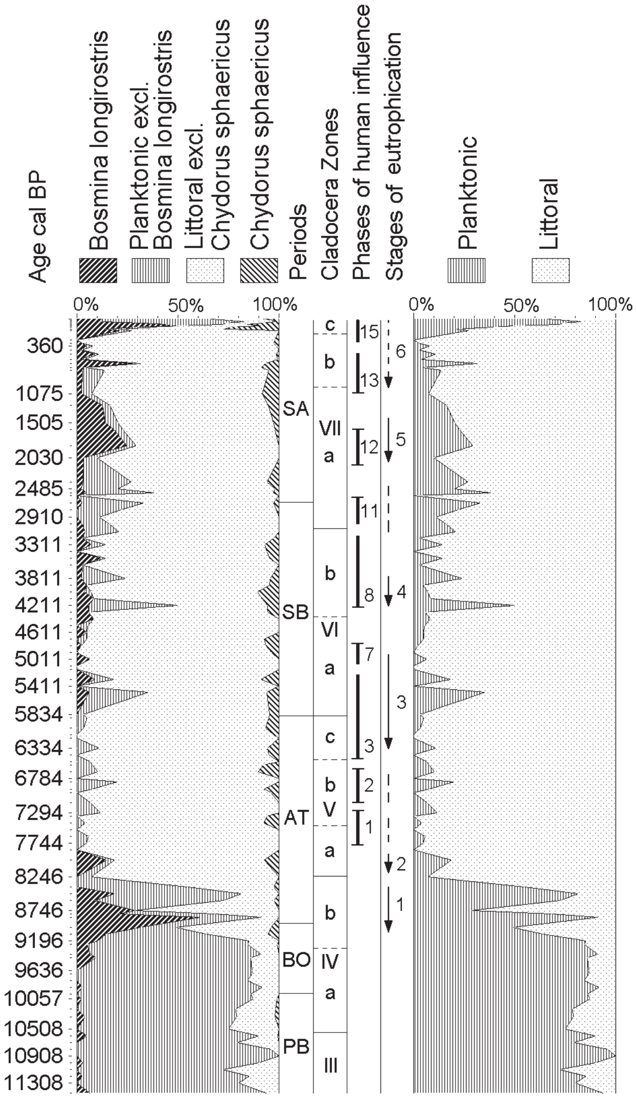

Fig. 9.18. The planktonic/littoral ratio in the cladoceran stratigraphy and eutrophication in profile G1/87 (Holocene) in comparison with the pollen zonation and phases of human influence (after Ralska-Jasiewiczowa & van Geel, Chapter 9.1.3).

9.1.4. Correlation between human activity and trophic stages in Lake Gościąż development based on cladoceran analysis

Krystyna Szeroczyńska

Results of Cladocera analysis are very important and useful for reconstruction of the history of lakes and of lake trophy, usually connected with human activity. Cladocera remains have been present in Lake Gościąż from its initial period until the present day.

According to concentration and percentage diagrams of species composition (Figs 9.18, 9.19 and Fig. 8.30 in Chapter 8.4), and in particular the curves of *Bosmina longirostris*, *Alona rectangula*, and *Alonella exigua*, increased trophy existed in Lake Gościąż in periods: 9100–8500, about 8000, 5800–5200, 4200–3800, 1800–1400, and 600–100 cal BP.

A considerable increase of trophy was noted before the record of human impact begins, in the sediments accumulated during the time 9100–8500 and about 8000 cal BP. It was registered by a drastic expansion of the eutrophic species *Bosmina longirostris*. This increase of trophy was probably a result of changing climate.

The stages of increased trophy partly correlate with phases of human activity identified on the basis of palynological analysis, partly supported by results of archaeological research (Pelisiak & Rybicka 1993, Pelisiak & Rybicka, Chapter 9.1.1. and 9.1.2., Ralska-Jasiewiczowa & van Geel, Chapter 9.1.3). Therefore, it may be supposed that the increase of trophy in the lake was provoked by the activity of people settled near the lake. Such a relation was also confirmed in the studies by Alhonen

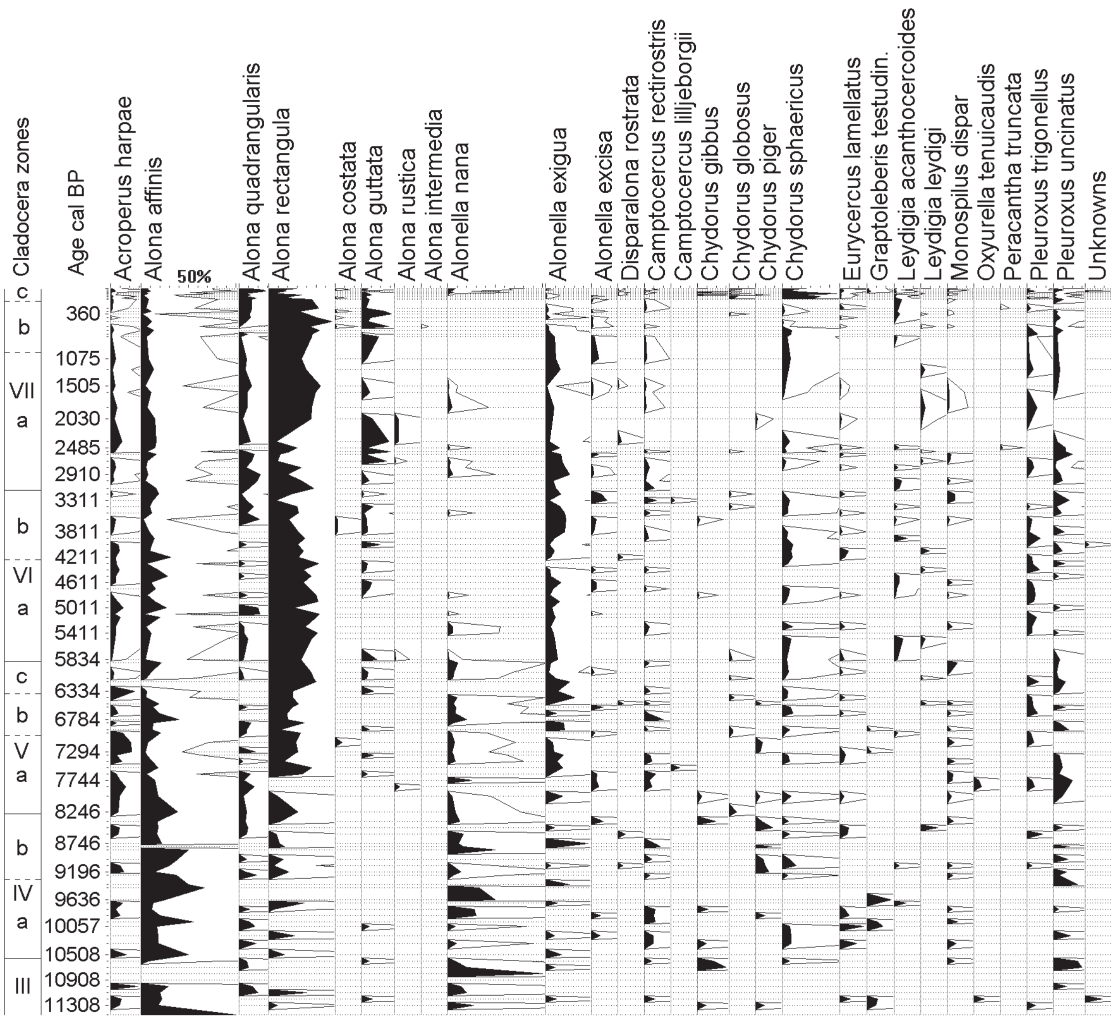

Fig. 9.19. Holocene part of percentage diagram of Chydoridae species in profile G1/87.

(1970, 1986), Bilska & Mikulski (1979), Bińka et al. (1991), Birks et al. (1976), Boucherle & Züllig (1983), Goulden (1964), Korhola (1990), Szeroczyńska (1991), and Whiteside (1970).

Generally, on the basis of changes in the species composition of Cladocera, we can assume that out of six stages of increased trophy distinguished for Lake Gościąż, the last four were probably connected with human influences. The 15 settlement phases distinguished in the pollen record (Ralska-Jasiewiczowa & van Geel, Chapter 9.1.3) are partly reflected in the history of the lake by faunal changes (Fig. 9.18).

Phases 1 and 2 corresponding with Mesolithic settlement, are not precisely reflected in the results of Cladocera analysis. No intensive increase of eutrophic species was observed, but some important changes took place in the lake during these periods. Due to an absolute absence of Bosminidae, in particular the eutrophic species *Bosmina longirostris*, these changes cannot be precisely interpreted, especially in terms of their relation to the activity of Mesolithic tribes. The observed change in the species composition of Cladocera, a complete disappearance of Bosminidae, and a development of littoral forms such as Chydoridae and a few species from the families Daphnidae and Sididae, may have been provoked by other factors, such as climatic or chemical changes. Also predation pressure by fish should be taken into consideration. However, in lakes earlier studied the situation of an absolute disappearance of all Bosminidae for such a long time (about 2,000 years) provoked by fish predation has never been noted. Changes in the lake level also seem to be an insufficient explanation. How great should fluctuations of the water level have been that Bosminidae were not able to exist any more? It is also possible that water chemistry may have radically changed. Changes of living conditions were recorded in the results of chemical analysis (Łącka et al., Chapter 8.2., Kuc et al. 1993), and palaeomagnetic analysis (Sandgren 1993).

An increase of certain species of Chydoridae during these periods is worth noting. According to diagrams of absolute concentration and percentage composition (Figs 9.18, 9.19 and Fig. 8.30 in Chapter 8.4), *Alona rectangula* and *Pleuroxus uncinatus* rose in numbers. Some of the authors, who recognize these species as indicators of rising trophy in the lake, often connect their increase with man's activity (Sandoy & Nilssen 1986, Whiteside 1970). Therefore the supposed increase of trophy estimated on the basis of the abundance of these two species, whose development may have been provoked by an intervention from outside the lake, was marked with a dashed line in the diagram (Fig. 9.18).

Phases 3–7 corresponding with the Neolithic settlement are also poorly reflected in the Cladocera record and are only indicated by a domination of *Alona rectangula, Alonella exigua*, and *Pleuroxus uncinatus* and reappearance of the eutrophic species *Bosmina longirostris* (eutrophication stage 3). So it may be supposed that activity of Neolithic settlers was similar in abundance and in range to that of the Mesolithic. Maybe this similarity, in particular of the older Neolithic phase (Pelisiak & Rybicka 1993), provoked analogous effects. In the lakes of Northern and Central Poland studied earlier, influence of the Neolithic settlement was represented by a distinct domination of eutrophic species (Bińka et al. 1991, Mikulski 1977, Szeroczyńska 1985, 1991). However, those lakes were not very deep, so their rapid and distinct reactions to changes in water chemistry were easier reflected in changes of trophy. This may explain the differences between records of the influence of Neolithic activity in Lake Gościąż and other lakes.

Phases 8–11 correspond with the settlement of the Bronze Age. They are recorded in the species composition of Cladocera by a slight increase in abundance of species indicating rising trophy (eutrophication stage 4). Species of Bosminidae, especially the eutrophic species *Bosmina longirostris*, reappeared in the lake (Fig. 9.18). The abundance of littoral species, such as *Alona rectangula* and *Pleuroxus uncinatus*, was at the same level as noted during earlier periods of human activity. Also the ß-mesotrophic species *Alonella exigua* significantly increased in number, thereby indicating rising trophy in the lake (Fig. 9.19 and Figs 8.29, 8.30 in Chapter 8.4).

Phase 12 – corresponds with Roman settlement. It is distinctly recorded in the species composition of Cladocera by an expansion of eutrophic species population (eutrophication stage 5). The rising eutrophication is well demonstrated in a concentration diagram showing the abundance of *Bosmina longirostris*, *Alona rectangula*, and *A. quadrangularis* and species of *Pleuroxus* (Fig. 8.30 in Chapter 8.4). A sudden increase of these species indicates an excessive inflow into the lake of compounds provoking rising eutrophy, which might have been a result of neighbouring settlers' activity what is, however, not confirmed by any archaeological finds.

Phases 13–15 correspond with the Medieval and modern times up till the present day (eutrophication stage 6). During these periods a lot of changes recorded in palynological analysis and Cladocera analysis took place in the lake. The number of littoral and planktonic Cladocera species changed. It should be assumed that suitable climatic and edaphic conditions for Cladocera development existed in the lake at this time. With the beginning of the activity of Early-Medieval settlers, a rise of trophy was marked by a domination of the trophic indicator species such as *Alona rectangula*, *Chydorus sphaericus*, *Leydigia acanthocercoides*, and other littoral taxa. According to concentration curves of eutrophic species, especially *Bosmina longirostris* and *Alona rectangula*, about 800–600 cal BP the eutrophication process was temporarily restricted. These changes may have been connected with settlement fluctuations in this time.

Nowadays the lake is surrounded by forest and thus from the time of its early growth it probably has been less exposed to direct influences of human activity. It may have been a temporary restriction of the eutrophication process, in particular in the sediments deposited during the last decades. In the recent sediments, all species from the family Bosminidae were found. *Bosmina coregoni* was dominant among planktonic forms, and littoral forms were dominated by species from the alkaliphilous and "indifferent" groups (Krause-Dellin & Steinberg 1986). At present the lake is considered to be eutrophic (a lot of phosphorus and nitrogen, Kentzer & Żytkowicz 1993). The lake is not exposed to high anthropopressure, such as sewage inflow or excessive tourism. Its evolution is mainly natural (Żbikowski 1993). Therefore, according to the results of analyses of water and sediments deposited during recent years, the number of species existing in the lake is relatively high (Tab. 8.5, Chapter 8.4). Littoral species are insignificant due to a weakly developed littoral zone, whereas planktonic zooplankton species are of great importance in the ecosystem energy chain. The large number of planktonic species may indicate weak predation pressure by fishes (Błędzki 1993). Błędzki recovered the greatest percentage of zooplankton in the epilimnion during the summer months. Megard et al. (1993), observed the culmination of zooplankton in the metalimnion and hypolimnion of Elk Lake (Minnesota) during the spring and autumn months and their decrease in summer. The authors interpret this as a result of predation by fishes. So the statement by Błędzki that in Lake Gościąż the predation pressure is weak is important for the interpretation of Cladocera evolution in this lake. It is particularly important for examination of increased trophy periods marked by a domination of *Bosmina longirostris,* which, in this instance, is an indicator of rising trophy, the predation pressure by fishes being not the limiting factor here.

The influence of settlers resident in the proximity of Lake Gościąż since the Mesolithic is much weaker than in other Polish lakes studied earlier (Bińka et al. 1988, 1991, Szeroczyńska 1985, 1991). In these lakes strong induced eutrophy existed during the periods of intensive anthropopressure, from Neolithic times to the present day. However, the lakes studied earlier, such as Błędowo, Skrzetuszewskie, Woryty, are small. Therefore an inflow of organic and mineral compounds into a lake, provoked by settlers' farming, radically changed the water chemistry and was followed by an intensive expansion of cladoceran species that prefer eutrophic living conditions.

According to Cladocera analyses for deep lakes, such as Lake Gościąż (25 m) and Lake Lednickie (15 m) (Szeroczyńska 1998), the settlement was not too important for changes in the species composition. It caused only a slight increase of species preferring rising trophy, and it eliminated neither planktonic nor clear-water species. An extraordinary period in Lake Gościąż history was the period of the Mesolithic settlement, characterized by a long-lasting absence of Bosminidae. Such a situation was noted in lake sediments in Poland for the first time. An absolute absence of Bosminidae for the Preboreal period was observed by Flössner (1990) in Barsch-See (Germany), but this lake is an acid one with a dominance of the acidophilous species *Alonella excisa*, so it cannot be compared to Lake Gościąż.

This phase is connected with the Atlantic period, with a warm and humid climate. In the Polish lakes studied earlier the presence of both the families Bosminidae and Chydoridae was noted during the Atlantic period. What caused such drastic changes in the plankton composition in Lake Gościąż? What caused an almost total extinction of the *Bosmina* species? Was it a result of the activity of the Mesolithic people? It seems rather unlikely, because their activity is only insignificantly reflected in the history of the lake. It should not be forgotten, that the lake has always been supplied by ground water. So it may suggest that a change in the ground-water supply caused an important change in the oxygenation of the lake and thereby in the species composition of Cladocera.

9.2. RECORD OF HUMAN IMPACT FROM AD 1660 TILL RECENT TIMES IN THE LAKE GOŚCIĄŻ SEDIMENTS

9.2.1. Archive data and economic-social background to the anthropogenic changes in the Lake Gościąż region from AD 1700 until today

Tomasz Goslar

Lake Gościąż is situated in the Gostynińskie Lake District, being now protected by the Włocławek-Gostynin Landscape Park. Due to its situation far from towns (20 km east of Włocławek with >100,000 inhabitants, 15 km northeast from Kowal with <3500 inhabitants, and 6 km south of Dobrzyń at the opposite bank of Vistula River with <2500 inhabitants) and from industrial plants, and on sandy soils of low fertility, it has never been too strongly influenced by human activity. Also for that reason the historical sources do not give too many details about human occupation of the lake vicinity. Instead, only general remarks about the developing settlements are available.

The Lake District is placed in the southeastern part of Kujavia historical region. In 16th century, the majority of the area was the property of Polish kings. In nearby Kowal, the king Kazimierz the IIIrd, called "the Great" was born in 1310.

At present the whole catchment area of the small stream Ruda, connecting a system of four lakes (Fig. 9.20), is almost completely covered by pine forest. The southern edge of the forest lies ca. 6 km from Lake Gościąż. The area south of lake, at the present forest limit, is covered by relatively high unsettled sand dunes. Probably also for that reason, any data about settlement in that area has not been found. Directly north of lake, and farther west, the forest nearly reaches the dammed Włocławek lake on the Vistula River. To northeast the forest limit approaches the lake at ca. 2.5 km. The nearest public road runs along the Vistula bank. Forest roads are closed for public traffic. Human settlements closest to the lake include a small farm situated ca. 1 km downstream from the Lake Mielec and a forester's lodge ca. 1 km farther down, where Ruda stream is dammed (by 1–2m). The individual farms dispersed outside the northern forest edge form small villages: Dąb Mały, Dąb Wielki, Dąb Polski, Skoki Duże, and Dobiegniewo.

The earliest written remarks on village Dąb (old spelling "Domb") come from 1228 (Pelisiak & Rybicka, Chapter 9.1.2) and 1489 (Senkowski 1961). The villages Dąb, Dobiegniewo, and the "industrial settlement" Ruda are mentioned in 1565 (Tomczak 1963, Guldon 1964) and are also documented in the 17th century (Guldon 1981). The name of village Ruda (ore) corresponds to that "...a mill and primitive smelting factory, 10 buildings altogether..." existed there already in AD 1565 (Tomczak 1963). In the mill, situated probably near the present dam on Ruda stream, a rye flour was produced (Tomczak 1963). The date when the smelting was stopped is not known, but the settlement (10 inhabitants) is mentioned in a Geographical Lexicon (Sulimierski et al. 1882). On the other hand, the mill was working in 1634 (Guldon & Guldon 1973) and in 1760 (Żytkowicz 1957), and according to A. Rerych (oral inf.) it was burnt in January 1945.

The development of Dąb, mentioned as a single settlement still in 1786 (Wizytacja 1786), is documented by a growing number of villages of related names (Dąb Wiel-