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A REPORT FROM SUMMER RESEARCH ON ZOOPLANKTON COMPOSITION AND DISTIBUTION IN THE LAKES OF DIFFERENT PH.

One of the two main goals of my study was to explain why crustacean zooplankton of acid lakes is usually dominated by the same species in Poland it is Ceriodaphnia sp. and Eudiaptomus sp, here often Bosmina longirostris and Diaptomus minutus. My assumption was that low pH itself is not the main factor responsible for the shift towards the dominance of particular species. Decrease in pH is usually accompanied with the changes in composition and amount of algae and organic matter, so food base for zooplankton is obviousely affected. So some species are not found in acid lakes probably not only because they are physiologically unable to tolerate the condition of high acidity, but also for the quantity and quality of their food is changed.

Plankton abundance and composition was compared in ten lakes differing in their pH. Vertical hauls from the bottom to the surface were taken near the deepest spot in each lake, with the quantitative plankton net of 50 um mesh size. The derease in number of cladocerans, calanoids and cyclopoids was observed with decreasing pH (Fig.1). But together with pH decline the amount of food available for herbivores also decreased (Fig.2). It was measured as an amount of chlorophyll a and phaeopigments in the fraction of algae smaller than 35 um. At the same time the biomass of algae bigger than 35 um, wich still may be utilised by some herbivores, but may disturb the action of filtering appendages in some of them also decreased. So decreasing amount of food, but not its decreasing availability may be a true limiting factor for some herbivores. Another, more complete index of the amount of food available for herbivores is the concentration of organic carbon in the fraction of seston particles smaller than 35 um (for financial and time limitations I'm going to perform this analysis in Poland). Anyway, it's usually good negative correlation between the amount of organic suspension and water transparency. Along the pH gradient water transparency increased with decreasing pH, so food conditions for zooplankton deteriorated (Fig.2). It doesn't seem that temperature and oxygen conditions recorded at consecutiv depths could affect the observed differences in zooplankton abundance (Fig.1) The changes in plankton composition also were observed with decreasing pH, the most spectacular occuring in cladocerans. The increasing share of Bosmina and Diaphanosoma together with decreasing share of Daphnia was the most distinct regularity (Fig. 3). Judging from my results this shift did not only result from the simple extinction of acid-sensitive cladocerans like Daphnia. Serious differences in fecundity were observed in most of species - increasing fecundity of Bosmina and decreasing that of Daphnia with pH decline (Fig.3). Besides the possible low tolerance of Daphnia to low pH, changing food conditions may via fecundity also affect individuals of Daphnia, stimulating at the same time the increase in number of Bosmina and Diaphanosoma.The individuals of these two species are able to retain much smaller food particles than Daphnia; the amount of the finest particles is usually higher in more acid lakes, if one may rely on data known from some papers.Of course some experimental support would be required to make this statement more reliable.

Two experiments have been run to prove that other factors than pH itself might be responsible for the differences between zooplankton communities in different pH conditions. Zooplankton from Upton Lake (PH=9) was exposed to different pH conditions from 4.0 to 8.0, in the trash containers (Fig. 4A). pH was adjusted with $CaCO_3$ and H_2SO_4 additions. It wasn't success for although I've been able to keep the animals alive for at least two weeks they didn' t reproduce. Anyway, mortality of neither cladocerans and calanoids, nor of cyclopoids wasn' t higher in low than in high pH. In the second version of the experiment I've created not only the pH gradient, but also accompanying food level gradient Water from Lake Mohonk (pH=6.6) was mixed with water from Lake Awosting (pH=4.3) in different proportions (Fig. 4B). Zooplankton from Lake Mohonk was exposed in these mixtures. The cladocerans were first to dissapear: this time some differences could be observed in the mortality of plankton in different pH conditions, the rate of desappearance being greater in more acid mixtures (Fig. 4B). The experimental difficulties were rather discouraging, so I've decided to concentrate myselfon the second part of my project.

Among the serious effects of lakes' acidification, the losses of fish populations are probably the most serious. As lakes are acidified to a pH approaching or less than 5.0, fish populations decline or desappear.This disaster however offers the ecollogically interesting situation - possibility to observe plankton populations under the evolutionary new, fishless circumstances, and to compare them with the lakes where fish are present.

Fish obviousely affect both plankton composition, abundance and distribution, eliminating some specimens from some parts of the reservoir, and stimulating the development of the defensive behavior of migrations.

The vertical distribution of plankton in the fishless and fish stocked lakes was the subject of my most intensive study. Lake Mohonk as fish stocked and Lake Awosting as fishless were chosen for this purpose. The fish disappeared from Lake Awosting between 1900 and 1920 due to the inabilityof its basin to buffer acid precipitation. Lake Mohonk continues to retain its buffering capacities thanks to the shales around. The monthly changes of species number are shown on Figs. 5 and 6.

I was observing the mid-day distribution of plankton in both lakes in the August and September, taking the 5 and 4 meters long vertical hauls with the quantitative plankton net. Daphnia pulex, Daphnia ambigua and Diaptomus minutus occured consequently in deep waters in Lake Mohonh, while Daphnia catawba, Bosmina longirostris and Holopedium gibberum were also found in quite big numbers close to the surface (Fig. 7). It doesn' t seem that temperature, oxygen or pH conditions could influence strongly this pattern of distribution (Fig. 8), neither relatively homogenous food conditions (Fig.8).

At least Daphnia pulex for its big body size and Dipatomus minutus for soft, slowly moving, and, according to Confer (personal communication) also "tasty" body are most endangered by fish, "trying" to find a shelter in deep waters. Daphnia catawba and Bosmina longirostris for small size, Holopedium gibberum for the presence of protective gelatineous sheat, and Mesocyclops edax for great motion velocity are relatively safe in the presence of fish, occupying the surface waters, probably most intensively penetrated by fish, for light and oxygen facilities.

At the same time the vertical distribution of Diaptomus minutus was very homogenous in Lake Awosting (Fig. 9), while cladocerans being more frequent in deep waters, most probably for better food conditions (Fig. 10). The temperature and oxygen conditions were surprisingly uniform at consecutive depths (Fig. 10).

The pattern of vertical distribution was also observed at 5-6 hours intervals, within the period of 24 hours. In Lake Mohonk those species which as well occupied the surface layers during the day, didn't change their position in water column (Fig. 11). Those species which occured close to the bottom during the day, were migrating towards the surface during the night. It was the case of Daphnia pulex, Dap-hnia ambigua and Diaptomus minutus. It again doesn't seem that diel changes in temperature, oxygen, pH or food regime could influence this behavior(Fig. 12). Unlike in Mohonk, Diaptomus minutus in Lake Awosting didn't change its position in water during the 24 hours period, being distributed rather uniformely (Fig. 13). Cladocerans didn' t neither move towards surface, all species showing during the 24 hour period almost the same pattern of vertical distribution as during the day. Abiotic and food conditions were constant enough (Fig. 14) to assume, that they didn't affect of vertical distribution.

It then seems, that fish absence or presence is the key factor responsible for the vertical distribution and migrations of some planktonic species in these two reservoirs.

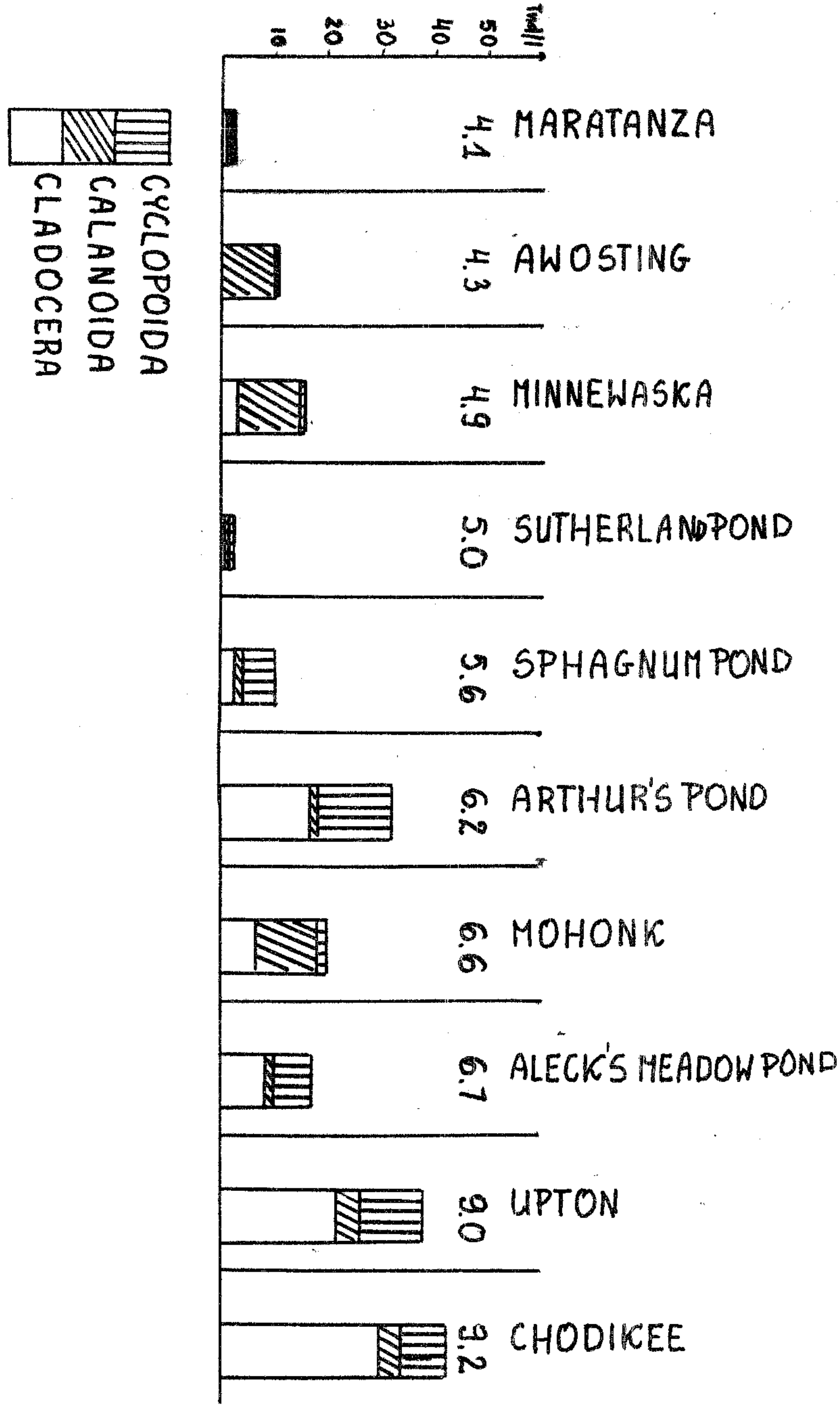

Ind/l
10
20
30
40
50
MARATANZA
4.1
AWOSTING
4.3
MINNEWASKA
4.9
SUTHERLAND POND
5.0
SPHAGNUM POND
5.6
ARTHUR'S POND
6.2
MOHONK
6.6
ALECK'S MEADOW POND
6.7
UPTON
9.0
CHODIKEE
9.2
CYCLOPOIDA
CALANOIDA
CLADOCERA

Fig. 1

Fig. 2

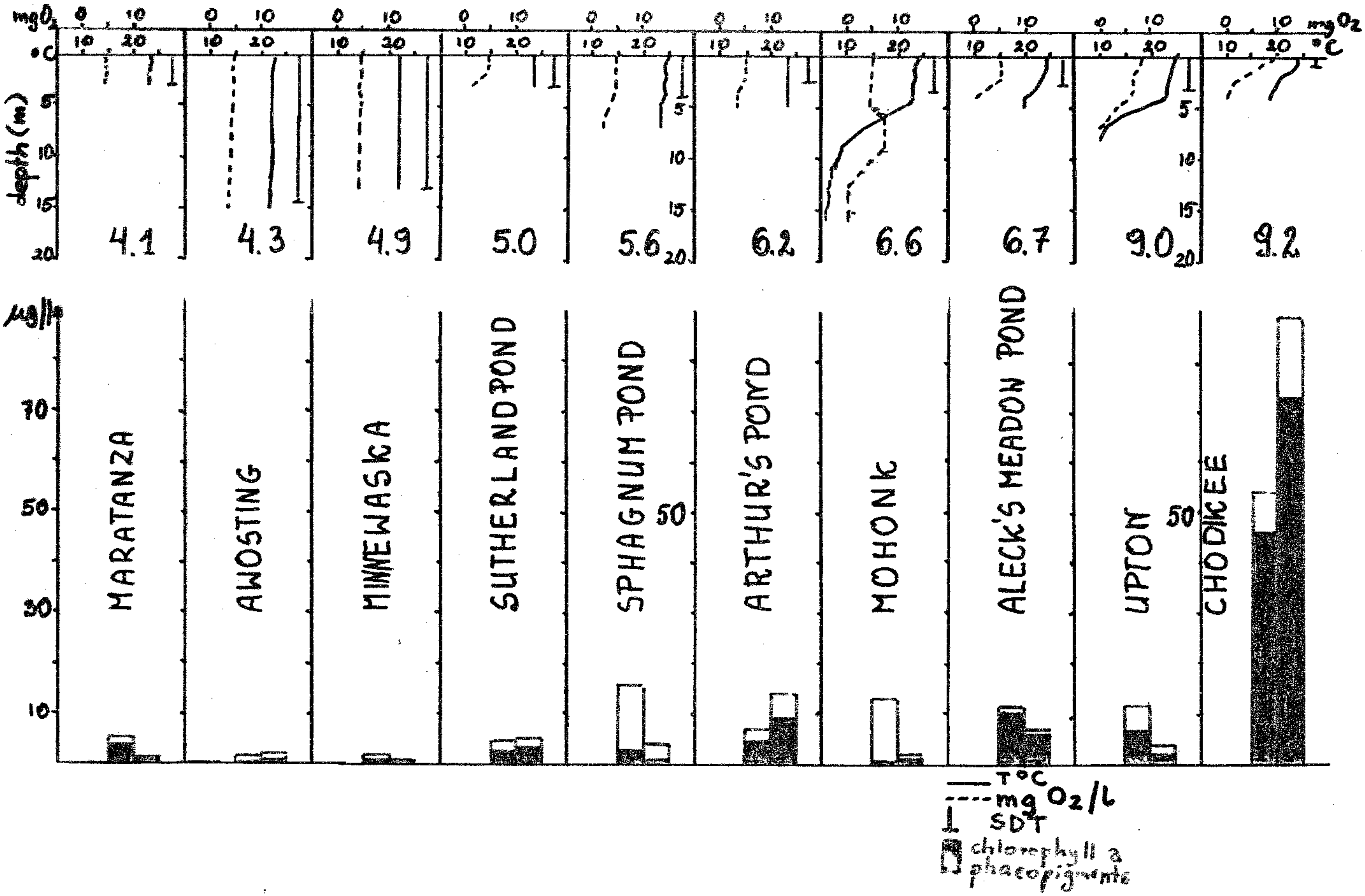
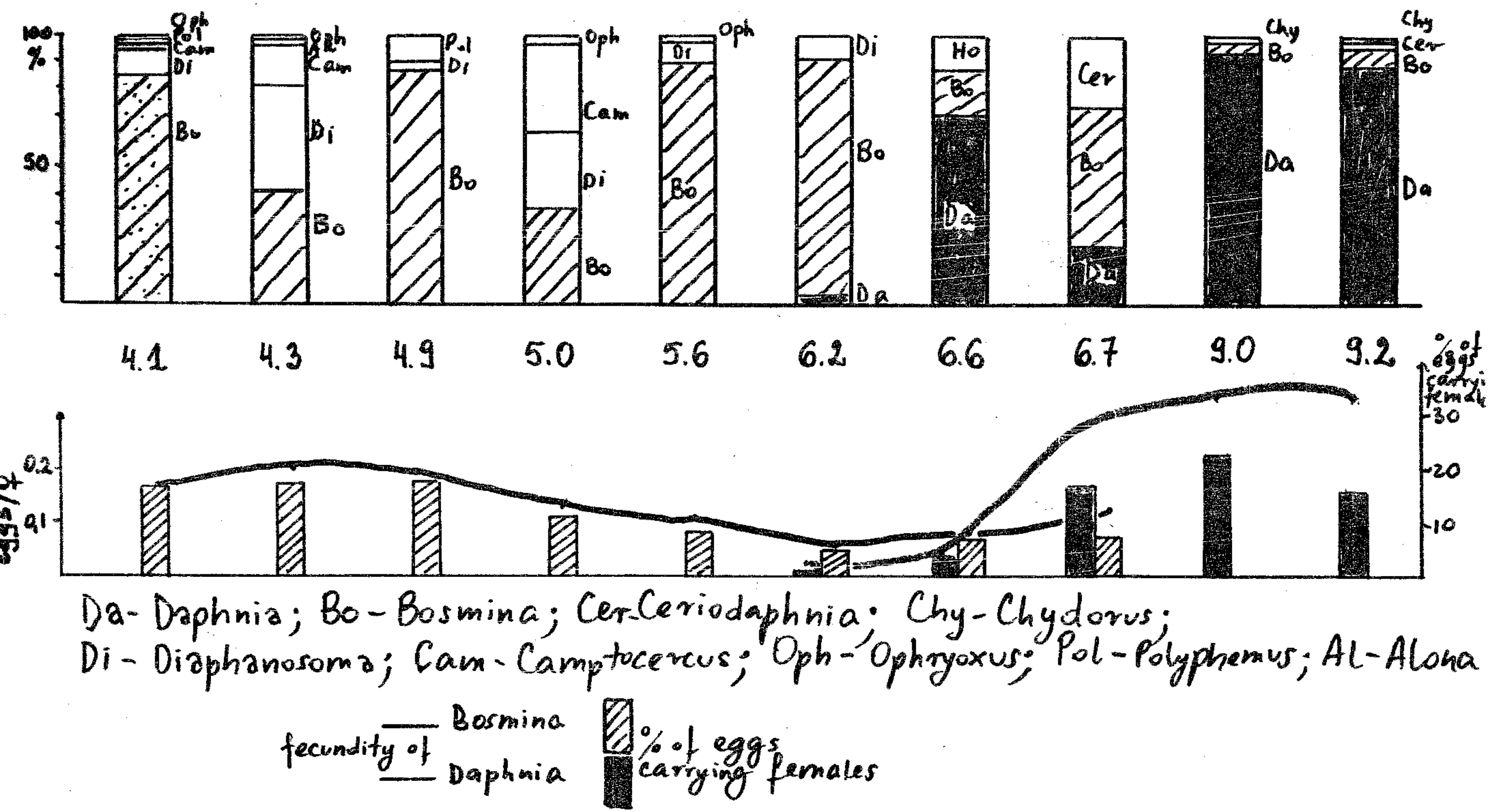

mg O2
°C
depth (m)
μg/l
4.1
4.3
4.9
5.0
5.6
6.2
6.6
6.7
9.0
9.2
MARATANZA
AWOSTING
MINNEWASKA
SUTHERLAND POND
SPHAGNUM POND
ARTHUR'S POND
MOHONK
ALECK'S MEADOW POND
UPTON
CHODIKEE
T°C
mg O2/l
SDT
chlorophyll a
phaeopigments

Fig. 3



Da- Daphnia; Bo- Bosmina; Cer-Ceriodaphnia; Chy-Chydorus;
Di- Diaphanosoma; Cam- Camptocercus; Oph- Ophryoxus; Pol- Polyphemus; Al- Alona

Fig. 4

Upton plankt. 3x cond.

	4.0 (0 → after 3 days → 10 days)	5.0	6.0	7.0	8.0
Gyl	100 → 63 → 8	100 → 70 → 11	100 → 59 → 11	100 → 70 → 13	100 → 66 → 7
Cal	100 → 53 → 3	100 → 50 → 3.	100 → 49 → 10	100 → 56 → 4	100 → 51 → 2
Cla	100 → 44 → 1	100 → 41 → 1	100 → 50 → 1	100 → 47 → 1	100 → 42 → 0

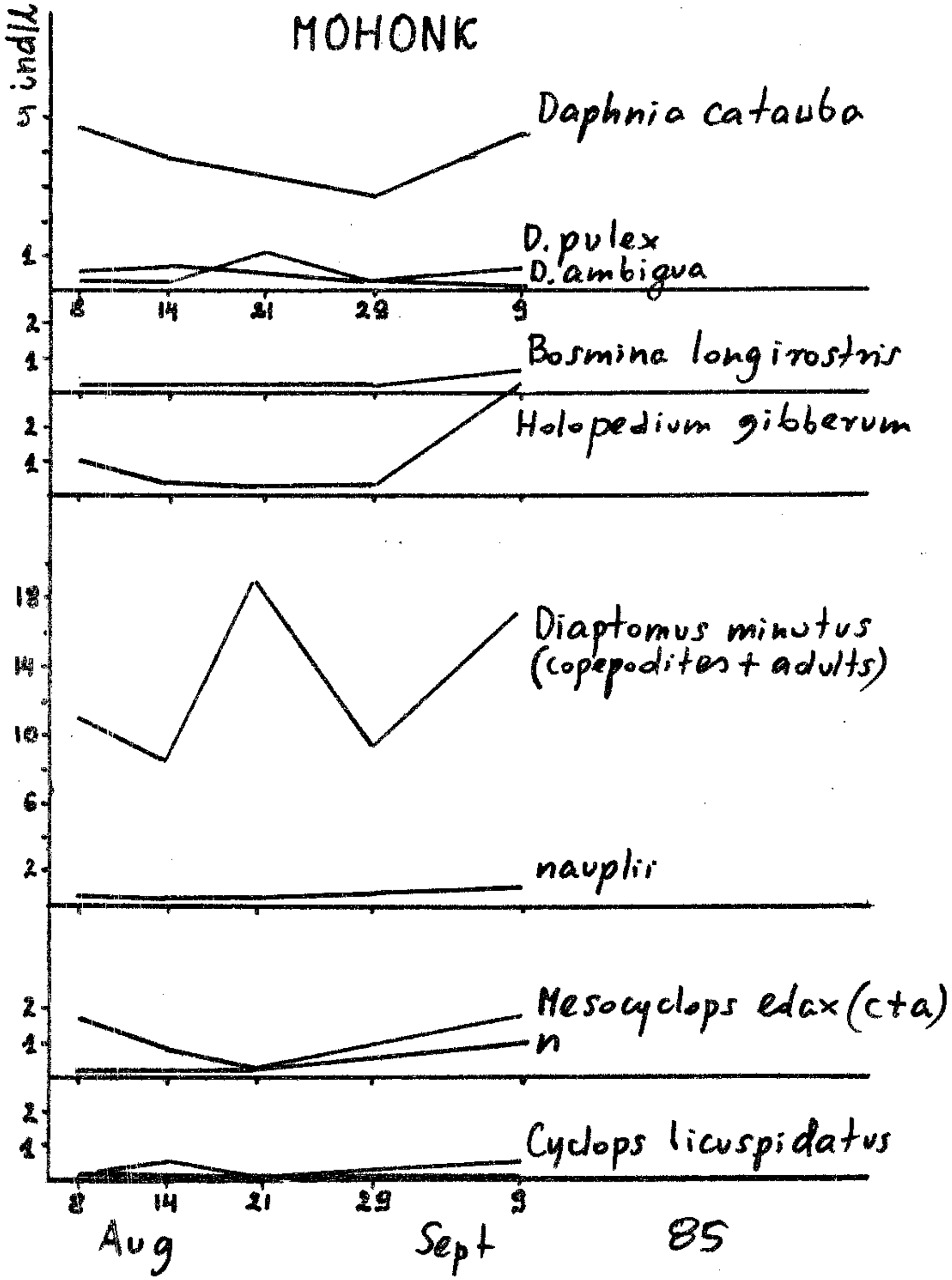
% of initial number

	6.4 M (0 → after 10 days)	5.9 M:A=3:1	5.1 M:A=1:3	4.4 A
Gyl	100 → 24	100 → 25	100 → 23	100 → 22
Cal	100 → 10	100 → 10	100 → 10	100 → 10
Cla	100 → 3	100 → 3	100 → 2	100 → 3

% of initial number

Mohonk plankton 2.5 x cond.

Fig. 5



MOHONK
indl/l
5
1
2
Daphnia catauba
D. pulex
D. ambigua
8
14
21
29
9
Bosmina longirostris
Holopedium gibberum
18
14
10
6
Diaptomus minutus
(copepodites + adults)
nauplii
Mesocyclops edax (c+a)
n
Cyclops bicuspidatus
Aug
Sept
85

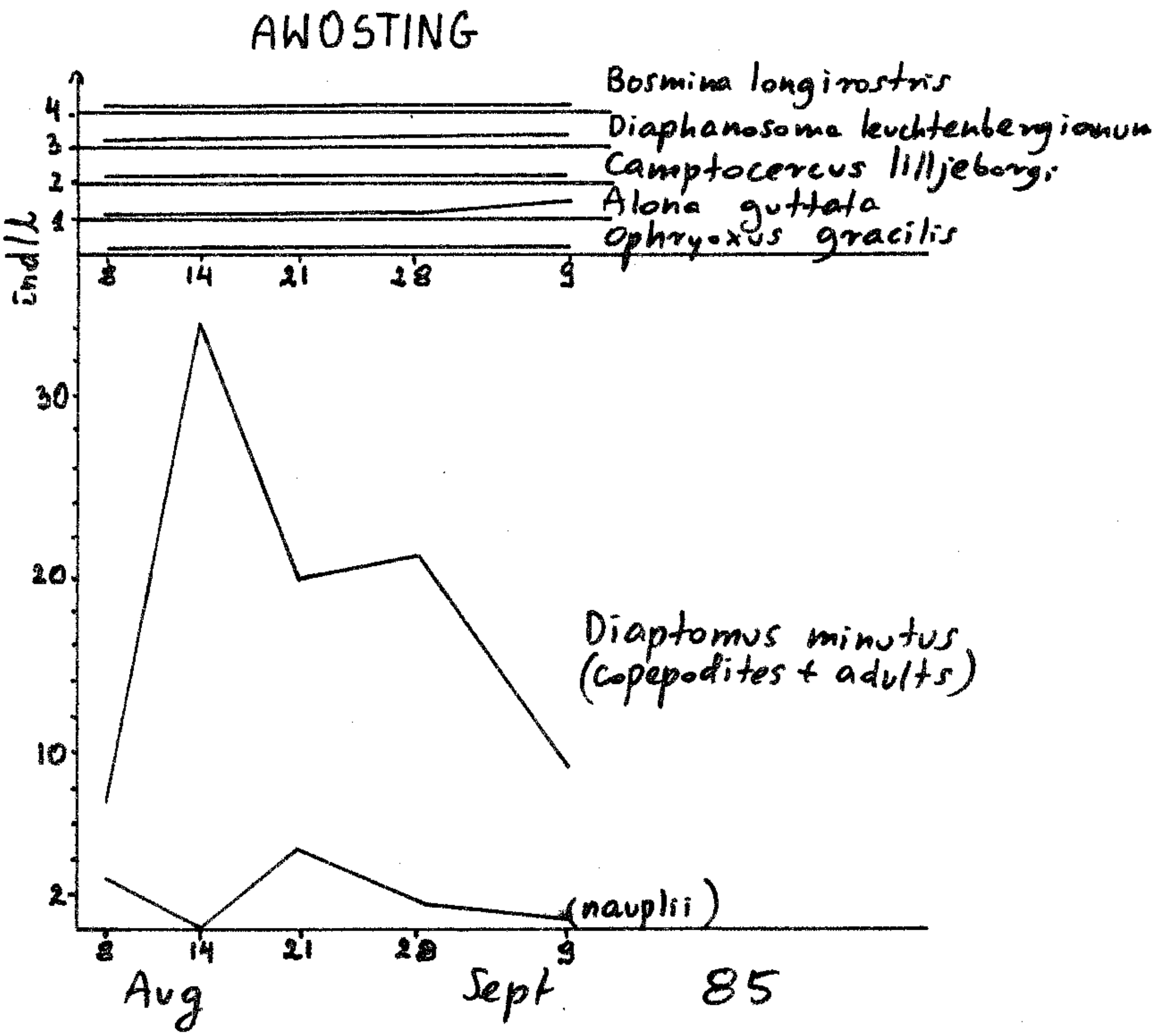

AWOSTING
Bosmina longirostris
Diaphanosoma leuchtenbergianum
Camptocercus lilljeborgi
Alona guttata
Ophryoxus gracilis
ind/l
4
3
2
1
8
14
21
28
9
30
20
10
2
Diaptomus minutus
(copepodites + adults)
(nauplii)
8
14
21
28
9
Aug
Sept
85

Fig. 7

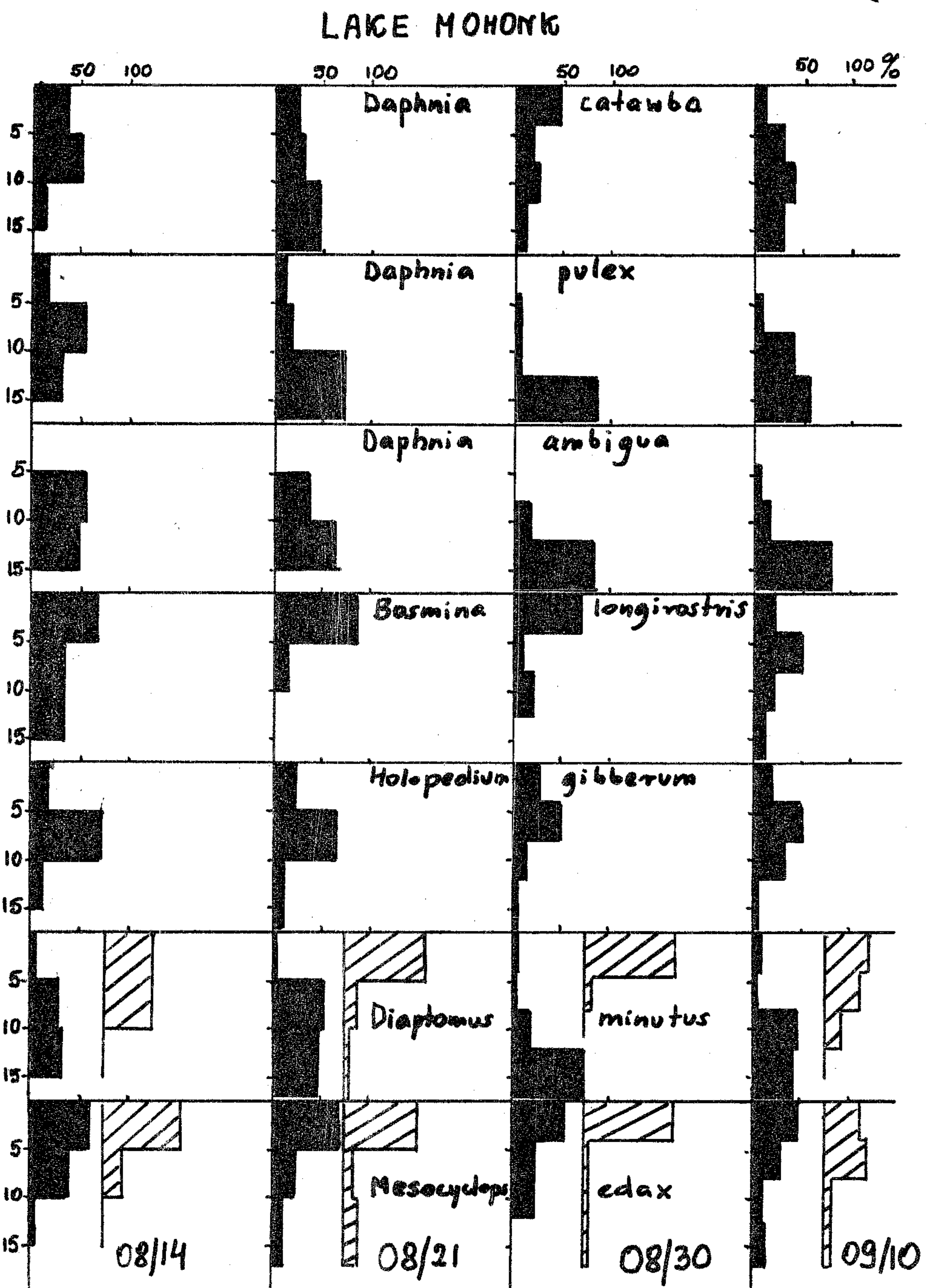

LAKE MOHONK
50
100
%
Daphnia catawba
Daphnia pulex
Daphnia ambigua
Bosmina longirostris
Holopedium gibberum
Diaptomus minutus
Mesocyclops edax
5
10
15
08/14
08/21
08/30
09/10

Fig. 8

LAKE MOHONK

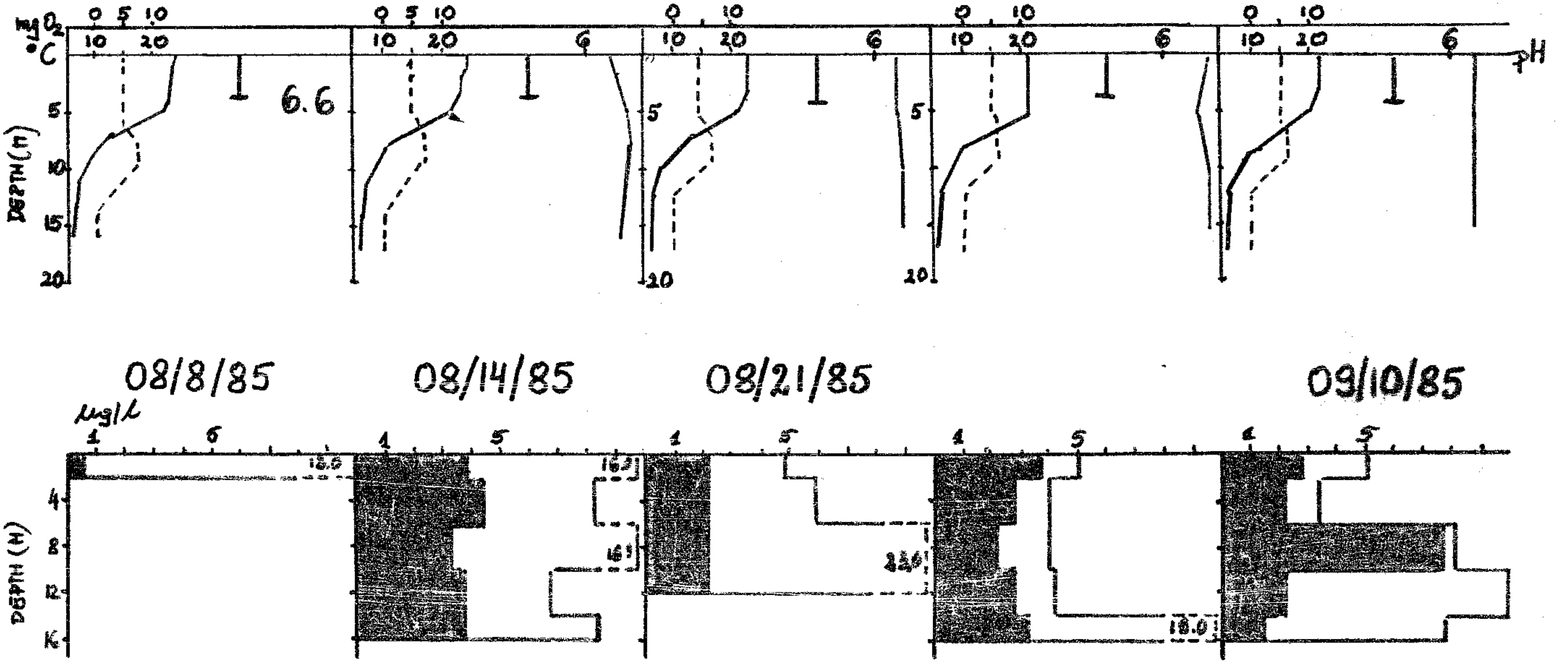


Fig. 9

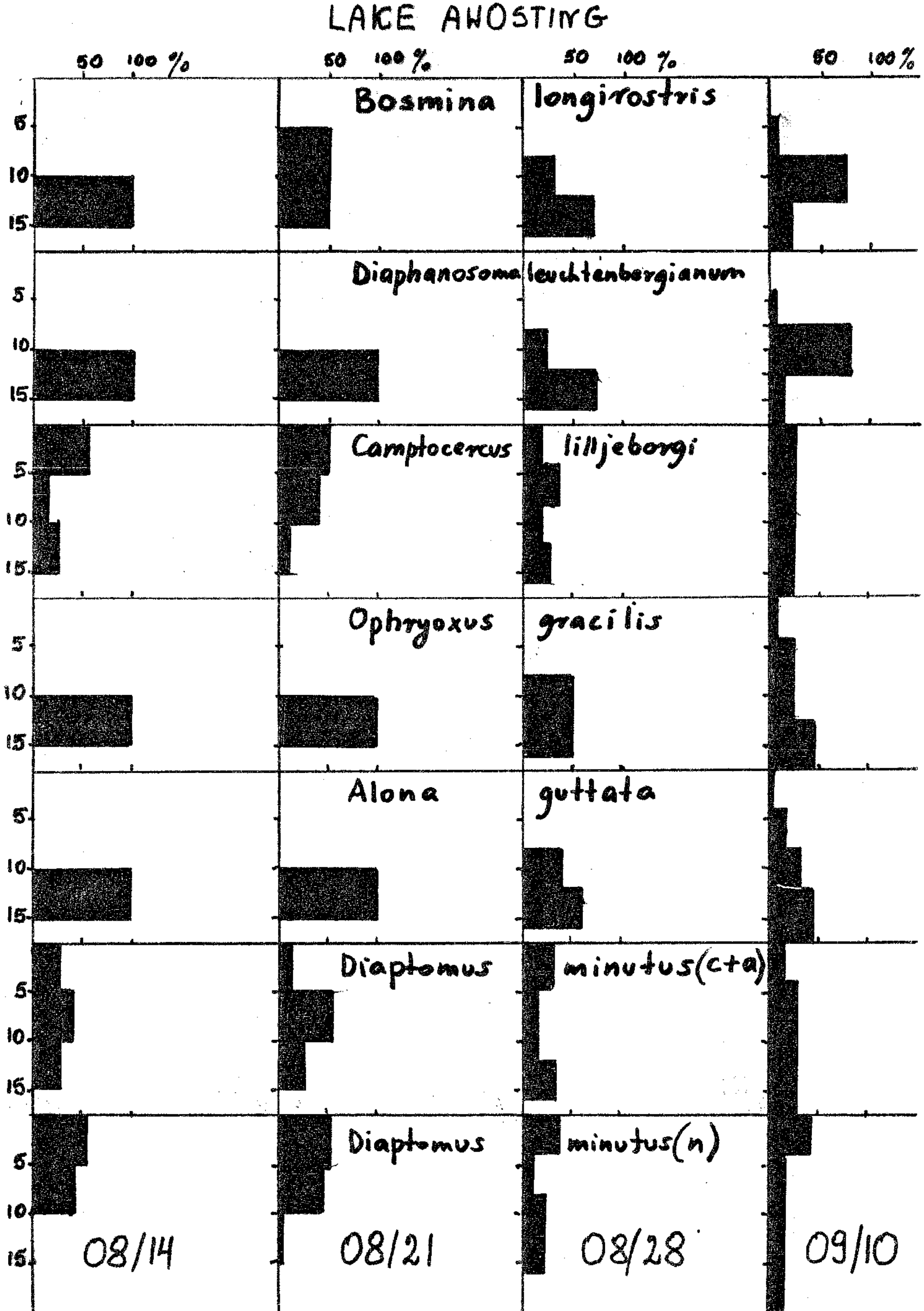
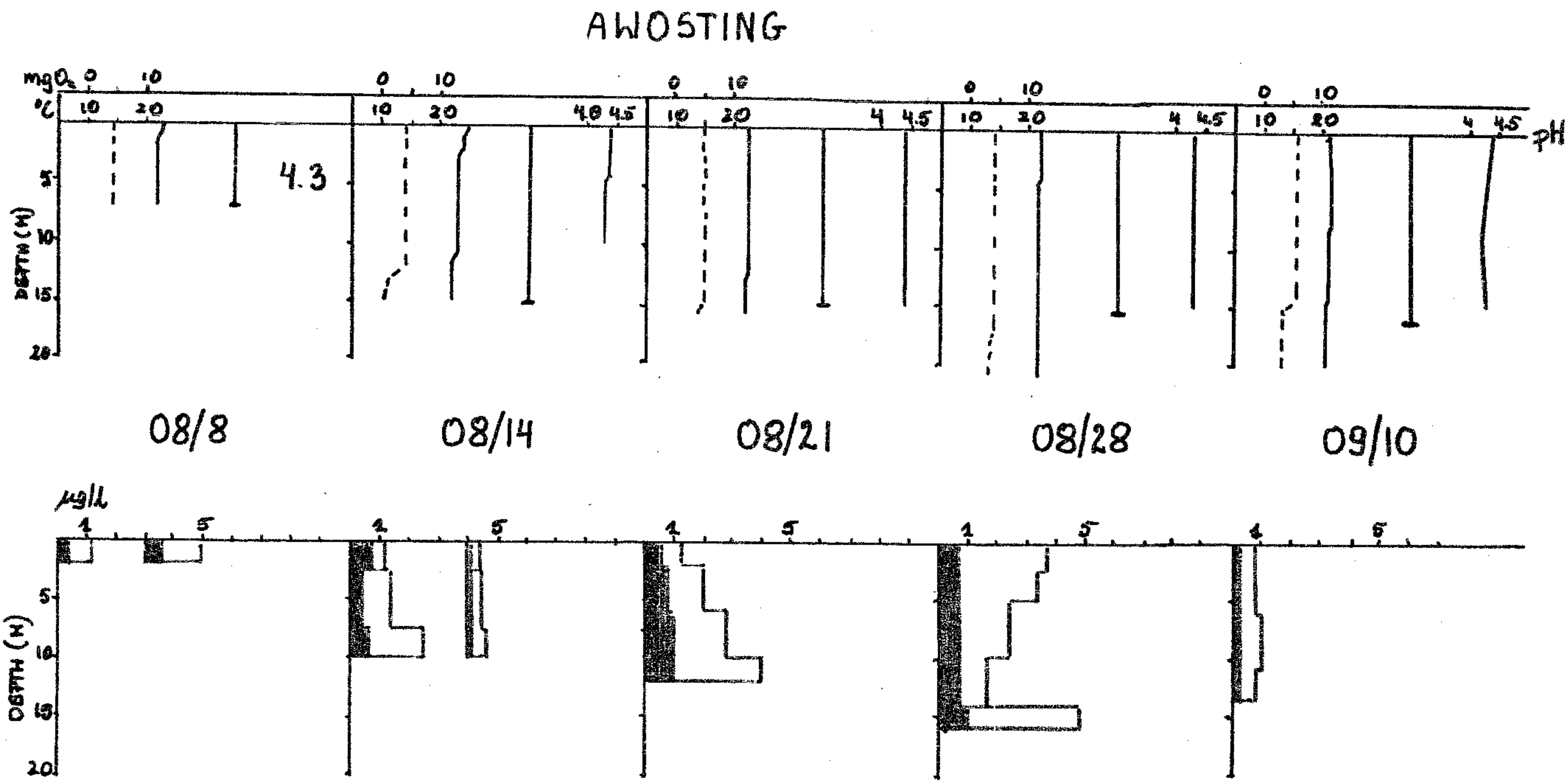

LAKE AHOSTING
50 100 %
Bosmina longirostris
Diaphanosoma leuchtenbergianum
Camptocercus lilljeborgi
Ophryoxus gracilis
Alona guttata
Diaptomus minutus(c+a)
Diaptomus minutus(n)
5
10
15
08/14
08/21
08/28
09/10

Fig.10


AWOSTING
mgO2
°C
pH
DEPTH (M)
4.3
08/8
08/14
08/21
08/28
09/10
µg/l
DEPTH (M)

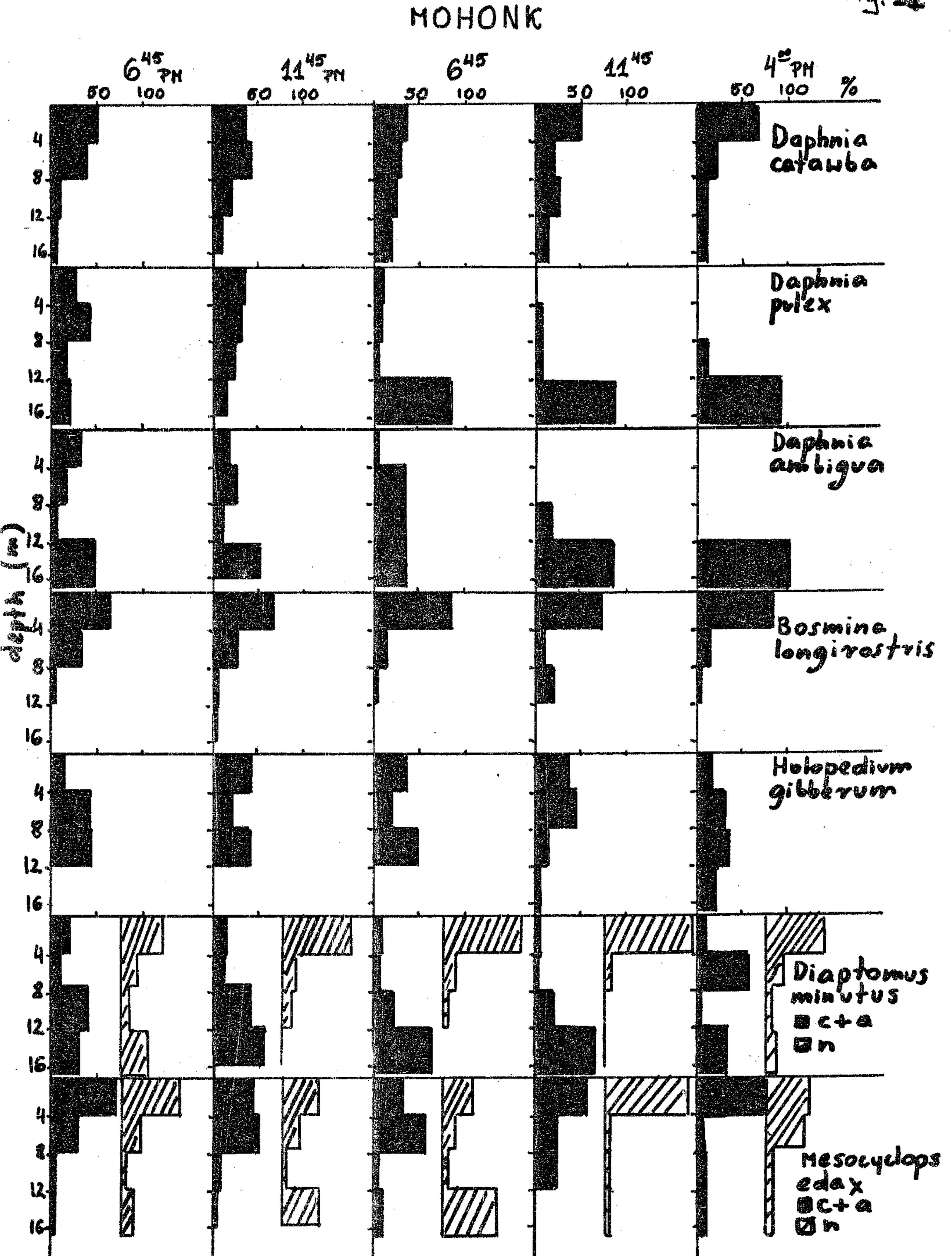
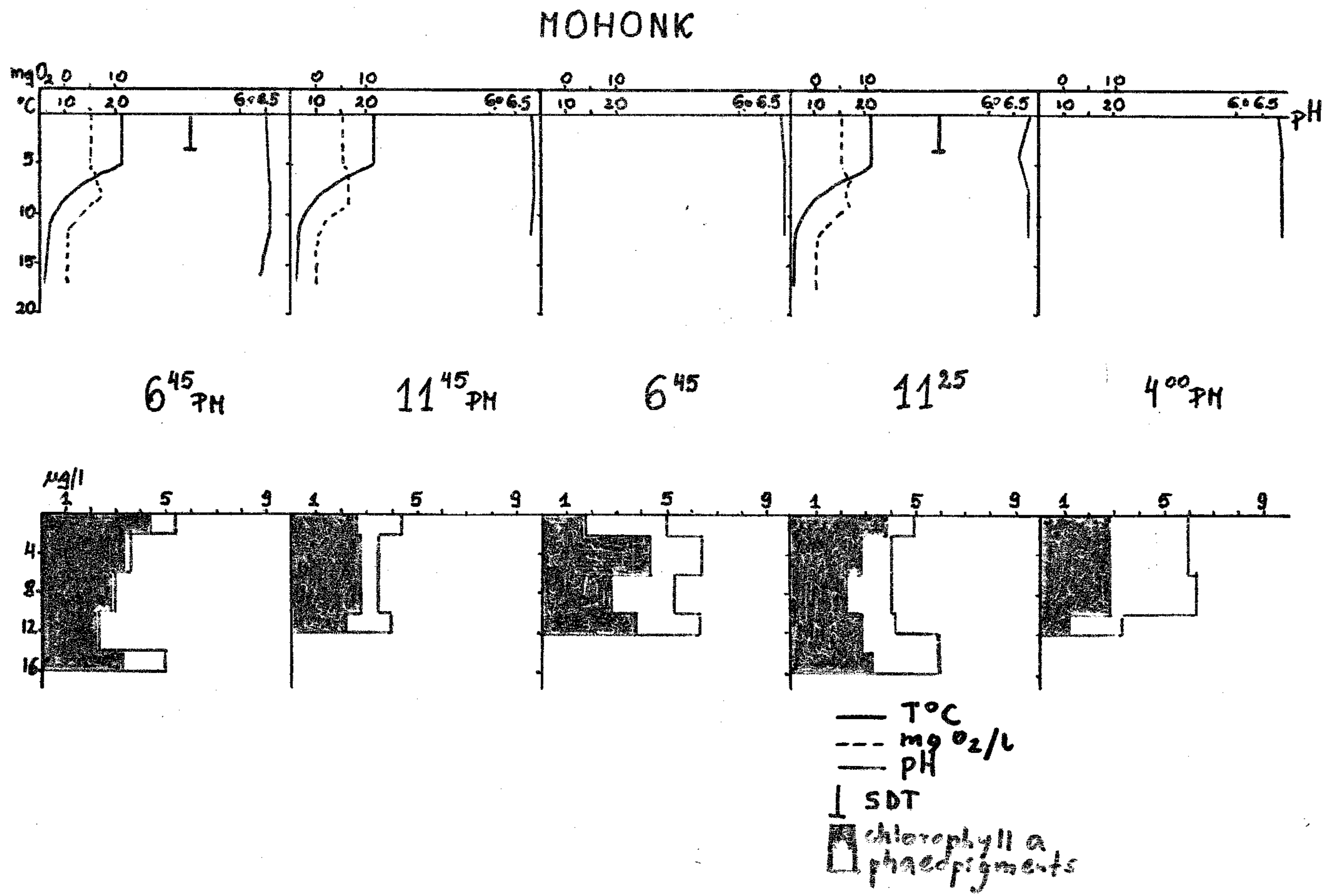

MOHONK
6^45 PM
11^45 PM
6^45
11^45
4^00 PM
50 100
%
depth (m)
4
8
12
16
Daphnia catawba
Daphnia pulex
Daphnia ambigua
Bosmina longirostris
Holopedium gibberum
Diaptomus minutus
c+a
n
Mesocyclops edax
c+a
n

Fig.12


MOHONK
mg O2
°C
pH
6⁴⁵ PM
11⁴⁵ PM
6⁴⁵
11²⁵
4⁰⁰ PM
µg/l
T°C
mg O2/l
pH
SDT
chlorophyll a
phaeopigments

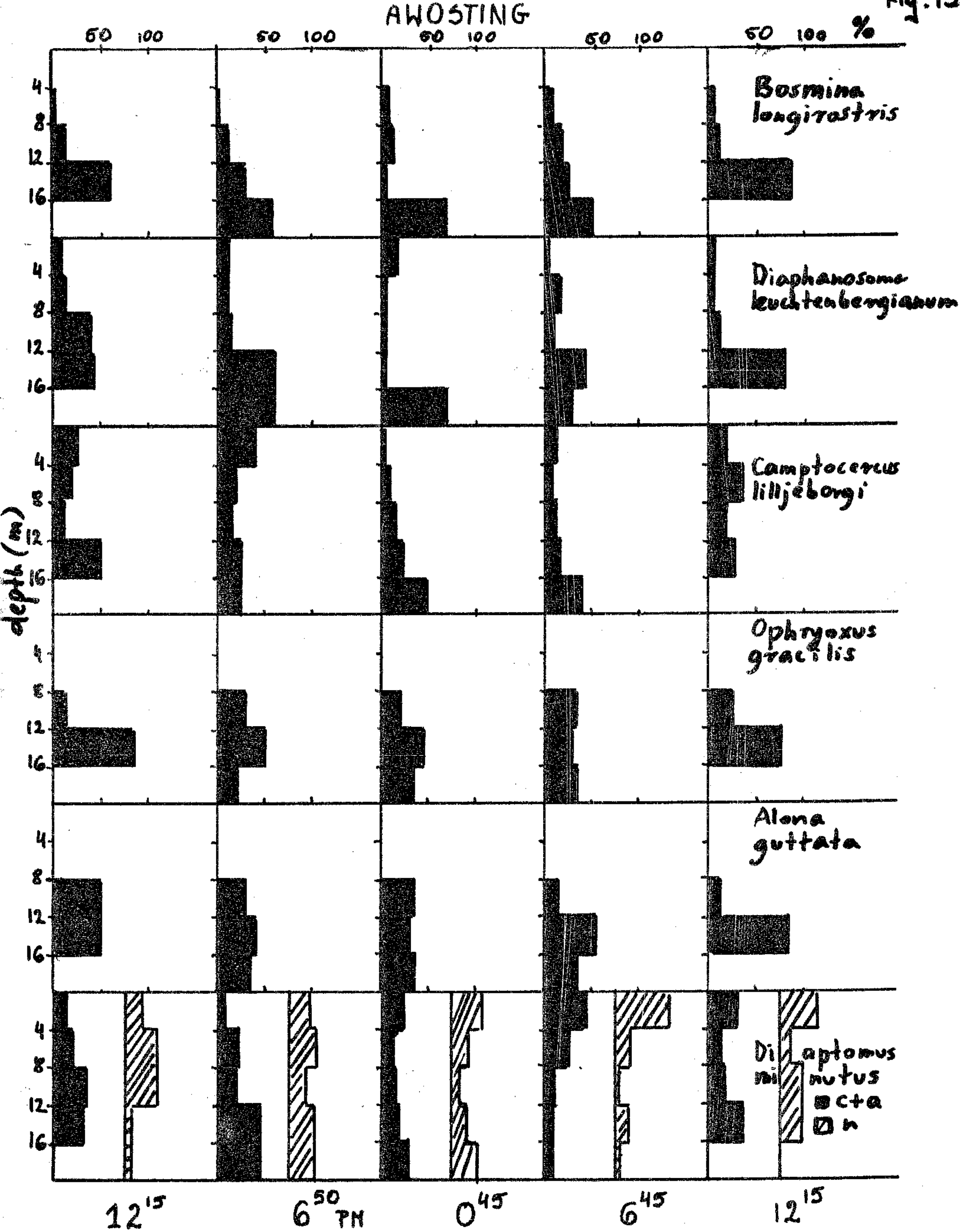

AWOSTING
50 100
%
Bosmina longirostris
Diaphanosoma leuchtenbergianum
Camptocercus lilljeborgi
Ophryoxus gracilis
Alona guttata
Diaptomus minutus
c+a
n
depth (m)
4
8
12
16
12^15
6^50 PM
0^45
6^45
12^15

Fig. 14