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ABUNDANCE ESTIMATION OF *CHAOBORUS* LARVAE AND FISHES IN LAKE AYDAT BY ECHO-INTEGRATION.

D. GERDEAUX (1), J. GUILLARD (1) and J.L. JAMET (2)

(1)INRA -Station d'Hydrobiologie BP 11F 74200 THONON France
(2)Université de Clermont II BP 45 63170 AUBIERE France

I-INTRODUCTION

The migration of *the Chaoborus* larvae is a widely-known phenomenon which has been observed for a long time (1,2). In general, the larvae rise to the superficial layers at sunset, and go down at sunrise (3).
The acoustic methods to describe this phenomenon have already been used but, mostly with high frequency transducers (200 kHz) (4). We could clearly show the vertical migration of the *Chaoborus* larvae with a 70 kHz echo-sounder. We also made sure of this identification and of the absence of other detectable zooplankton. Estimations of the larvae densities by echo-integration have been correlated with fish biomass estimations.
We observed this phenomenon in July 1988 in a shallow lake (max.depth = 15.5m, mean depth = 7.4m, surface = 60.3 hectares, volcanic dam, eutrophic). It becomes thermally stratified early in the season and usually has no measurable oxygen in the hypolimnion (below 5 m).

II-THE MIGRATION OF *CHAOBORUS* LARVAE

2-1 Acoustic detection

The echo-sounder was a Simrad EY-M, 70kHz transducer, beam angle 22°, gain 6, TVG function: 20 log R.
From 9.20 p.m., we observed some higher signals than the level noise (120mv) in the deep layers (fig. 1). We recorded the digitized signal on a video tape and simultaneously made plankton net samples between 6 p.m. and 7 a.m.. During the day, no echo response was received from the hypolimnion.
Till 10.30 p.m. approximately, the migratory movement went on and stopped in the deep part of the epilimnion. It started again in the opposite direction about 5 a.m..
We echo-integrated the signal to obtain a relative density of *Chaoborus* (fig. 2).

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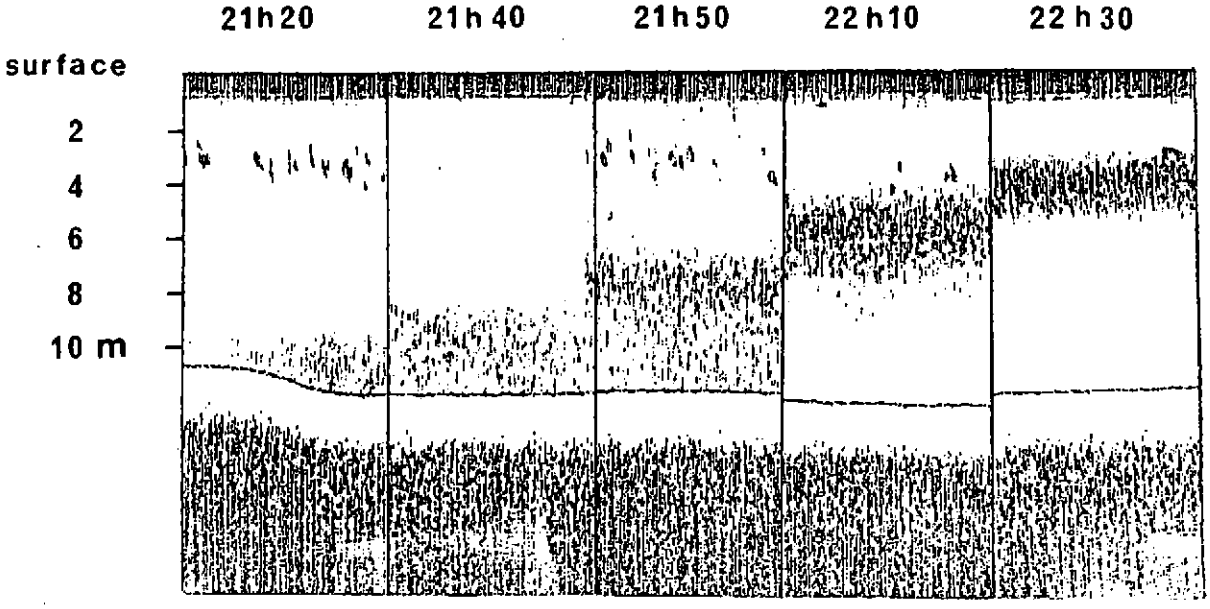

Figure 1: Echograms showing the *Chaoborus* larvae migration at sunset on Lake Aydat.

2-2 Plankton net sampling

The samples were taken with a biconic-plankton net (length 86 cm, opening diameter 21 cm, mesh size 75 µm.n). No *Chaoborus* larva was caught before 8 p.m. The net hauls went from the bottom, from 7.8m or 5.1 m, to the surface. We caught larvae since only 8 p.m., in the net hauls from the bottom. These samples proved the zooplankton migration (fig.3). They also confirmed that the detected signals did correspond to *Chaoborus* larvae and that no plankton other than *Chaoborus* could be the source of any detection. The maximum density in net samples was estimated at about 320 *Chaoborus* larvae per cubic metre in the layer 5.1 m - 7.8m.

2-3 Comparison of both methods

Thanks to the net stratified samples it is possible to obtain densities of *Chaoborus* larvae at different moments. From 8.40 p.m., larvae were caught while the echo-integration counted echoes higher than the noise level from 9.20 p.m.. At that time, the estimated density of larvae was of 172 larvae par m^3 in the 10-12m layer. This density level corresponded to 1 unit of echo-integration per m^2. Then at 9.40 p.m., 10.10 p.m. and 10.30 p.m., we could estimate the larvae density per m^3 with the net; on the other hand, their density per m^2 with echo-integration, for different layers (8-10m, 6-8m, 4-6m) during the migration. With these 4 points, the correlation coefficient is 0.99 (fig.4). The

ABUNDANCE ESTIMATION OF *CHAOBORUS* LARVAE AND FISHES IN LAKE AYDAT BY ECHO-INTEGRATION.

equation of regression curve is :

$Y = 2.35 X + 180$

Y = *Chaoborus* larvae per m^3

X = echo-integration units per m^2

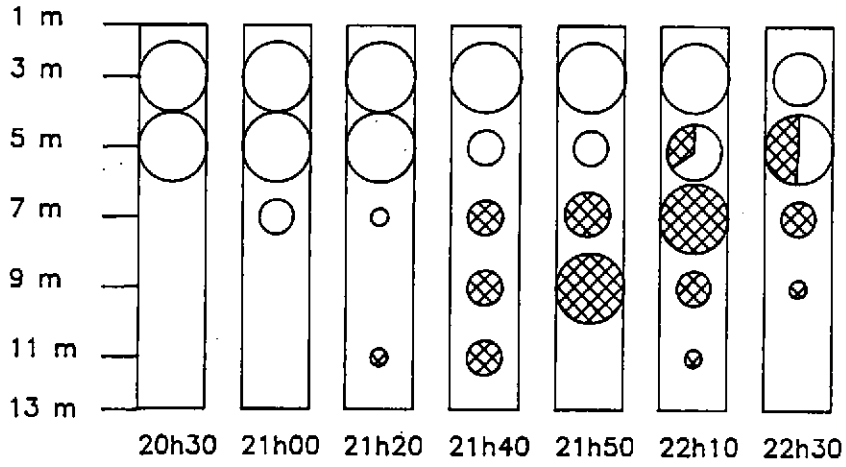

Figure 2: Echo-integration results in each 2m water layer at sunset on Lake Aydat. The circle diameter is proportional to the echo-integration units in each layer. The plain surface represents the fish part and the squared one the *Chaoborus* larvae.

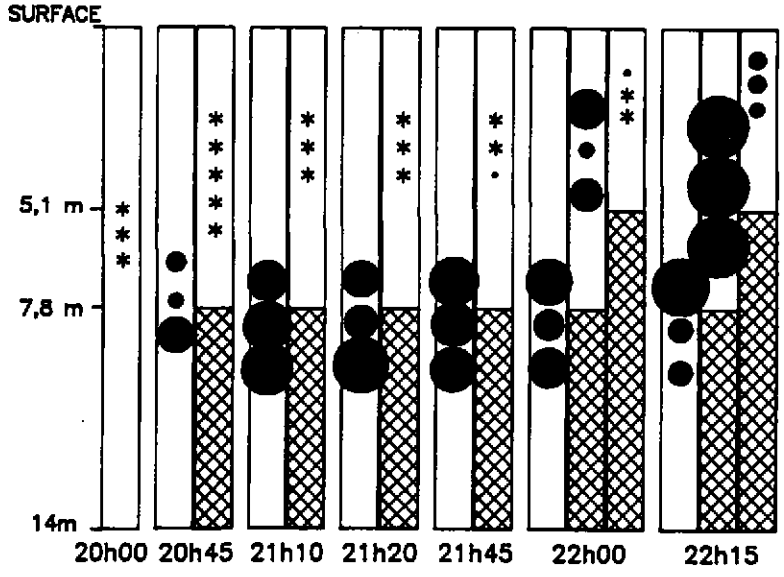

Figure 3: Results of stratified net samples at sunset on Lake Aydat. At 8.00 p.m., nothing is caught (*). The circles are proportional to the number of caught larvae. The squared surface represents the water layer which is not sampled.

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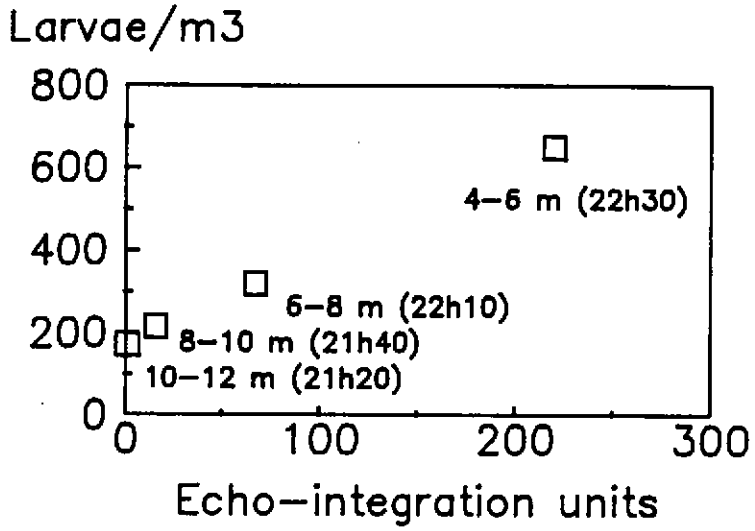

Figure 4: Relation between the echo-integration units and the *Chaoborus* larvae densities at different hours and depths during the vertical migration.

Looking at this regression curve, we noted that the minimum density of the larvae per m^3 really had to equal to 180 to give echo-integration units in our experimental conditions. Furthermore we did not observe signal saturation at the maximum density.

III- SPATIAL DISTRIBUTION OF *CHAOBORUS* LARVAE AND FISHES IN LAKE AYDAT

3-1- Fish distribution

The acoustic survey consisted of a dozen transects with 200 m intervals on one hand during the middle of the day and on the other hand at the beginning of the night. The spatial fish distribution is heterogeneous (fig. 5). During the day, fishes were in the 2-4m layer while the 4-6 m one was almost empty. During the night, we found fishes in 4-6 m layer but most of them were still in the 2-4m layer. Further down, no fish was detected. We calculated the fish mean density, thanks to geostatistic methods, which took into account the spatial heterogenity of the distribution. In the day, the mean biomass in echo-integration units equals to 10 000 more or less 3 000 (5% level). Whereas in the night, it equalled to 33 000 more or less 7 000 (5% level). We noted on more times that the fishes were less detectable during the day than during the night. As a matter of fact, the difference is all the more important because the fishes were near the surface of the water.

ABUNDANCE ESTIMATION OF *CHAOBORUS* LARVAE AND FISHES IN LAKE AYDAT BY ECHO-INTEGRATION.

We mapped the distribution of the *Chaoborus* larvae by using the echo-integration values between a threshold of 120 mV and another of a 400 mV. We measured the voltage of the fish echoes, and found that they were over 400 mV on average. Therefore, we considered that the echo-integration between 120 mV and 400 mV was proportional to the densities of the *Chaoborus* larvae . We could check on the map the heterogeneity of the distribution in Lake Aydat (fig. 6).

3-2 Relation between the distribution of the *Chaoborus* larvae and the distribution of the fishes.

The analysis of the regression between the variable density of the *Chaoborus* larvae and the variable fish density was calculated for the 2-4m , 4-6m, and 2-6m layers. The correlation was not important in each layer of 2 metre . But in the 2-6m layer which hold all the fishes and the *Chaoborus* larvae, the correlation coefficient was significatively higher than 0 (r= 0.48). This proves that there is a statistical relation between both variables. A high level of the *Chaoborus* larvae density goes with a high level of the fish density.

IV-CONCLUSION

Thanks to our experimental device, we could follow the *Chaoborus* larva migrations. But the *Chaoborus* larvae were detectable only from a threshold of more than 180 larvae per cubic metre. This study was also possible thanks to the high density of the zooplankton, and to the short thermocline which concentrated all the organisms in a small layer of water.

ACKNOWLEDGEMENTS

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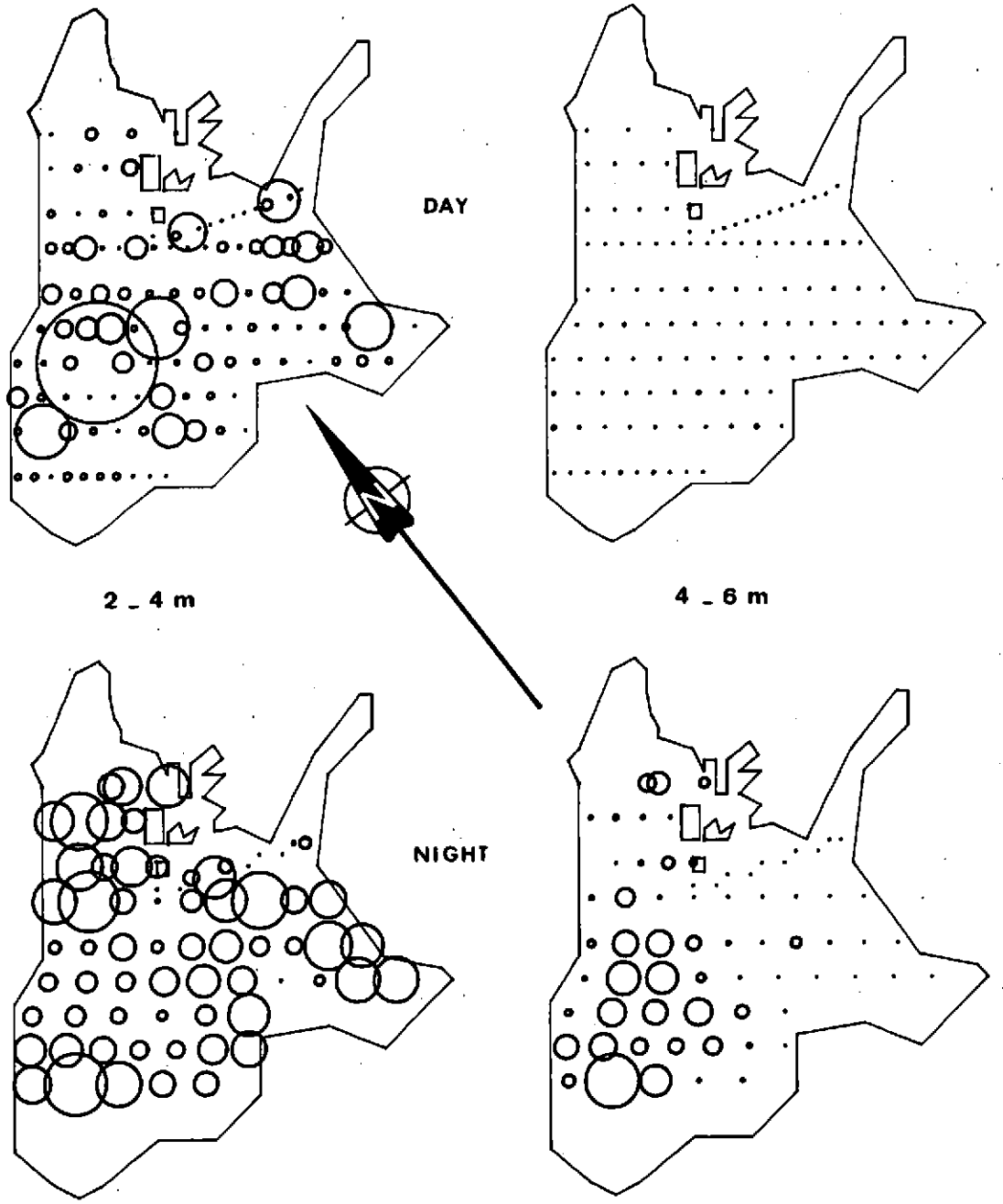

Figure 5: Spatial distribution of the fishes in the 2-4m layer and 4-6m layer by day and night on July 26th, 1988. The circle diameter is proportional to the echo-integration units.

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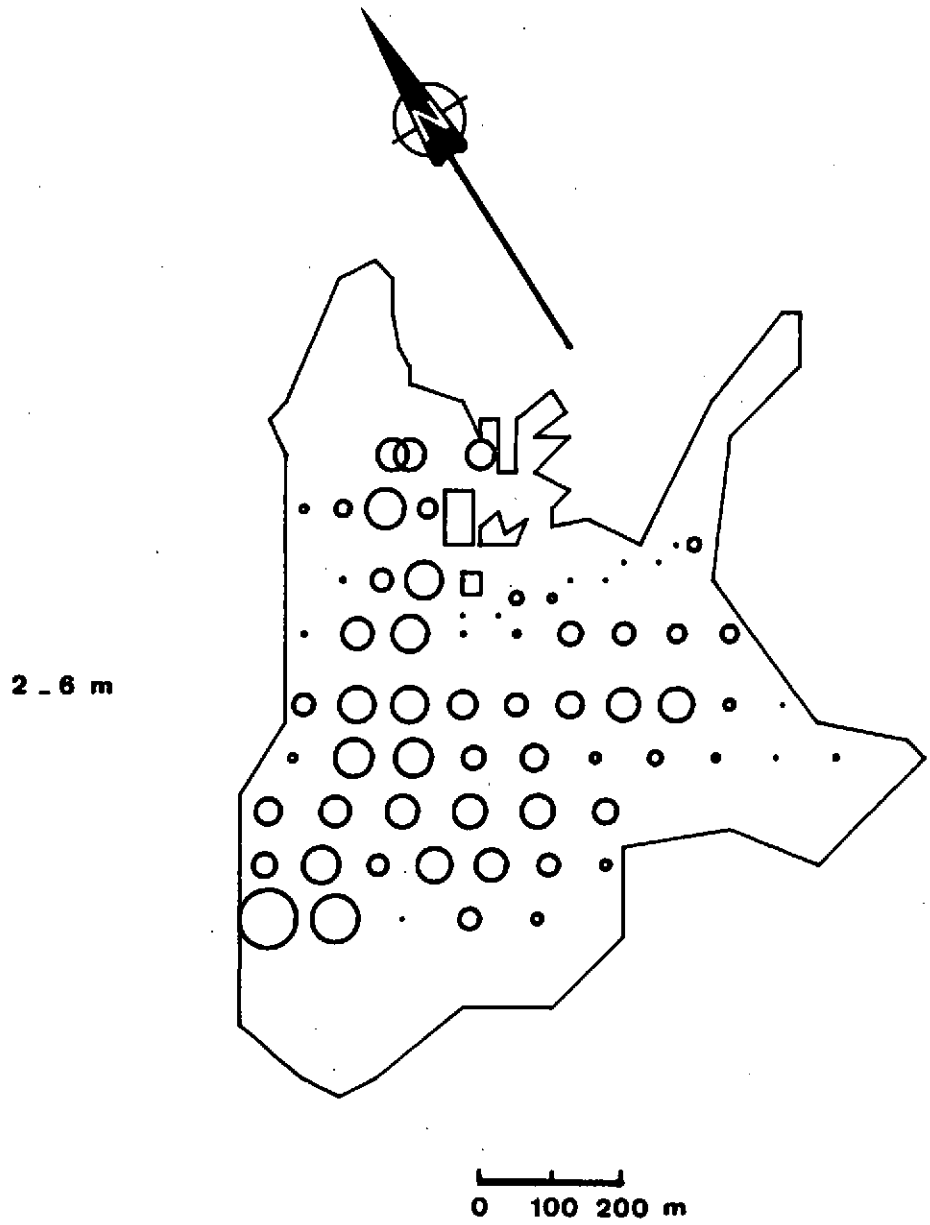

Figure 6: Spatial distribution of the *Chaoborus* larvae in the 2-6m layer by night on July 28th, 1988. The circle diameter is proportional to the echo-integration units.