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# Influence of Turbulence and Turbidity on Growth and Survival of Laboratory-Reared Bivalve Larvae

by

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## ABSTRACT

Laboratory-reared larvae of mussels (*Mytilus galloprovincialis*) were incubated with and without sediment in a novel turbulence-producing machine. The sediments used were fine silt from the Gironde estuary and from the German Wadden Sea.

Larvae incubated in turbulence without sediment, and in suspended sediment concentrations similar to *in situ* conditions had growth rates which did not vary significantly from those of the controls. The growth rates of larvae incubated in 5 to 20 g/l of sediment were reduced by 20 to 50%. Survival was lower in larvae incubated with sediments than in turbulent and non-turbulent controls, but it was not correlated with sediment concentration.

The results indicate that the mechanical effects of turbulence and turbidity on mussel larvae are minor. However, there are probably complex biological and chemical effects (e.g. from organic matter, diatoms / bacteria, hydrogen sulfide or pollutants) associated with sediments in suspension. Therefore, it is probably impossible to generalize conclusions on ecological effects of natural turbidity regimes.

## INTRODUCTION

The effects of suspended solids on bivalve larvae have only rarely been studied (Davis 1960, *Mercenaria mercenaria*; Davis & Hidu 1969, *Crassostrea virginica* and *Ostrea edulis*; Robinson 1983, *Mercenaria mercenaria*; Huntington & Miller 1989, *Mercenaria mercenaria*), in spite of the fact that almost all of the commercially important bivalve species live near the shore, and are therefore often subjected to the influence of sediments in suspension (studies of turbidity effects on adults, however, are quite common). The lack of investigations on larvae is presumably due in part to various experimental difficulties presented by this type of study (cf. Moore 1977).

Bivalve larvae have often been used for toxicity studies and water quality bioassays (e.g., Woelke 1967; Phelps & Warner 1990; His & Quiniou 1991), including the assessment of the toxicity of natural sediment extracts (His, unpublished). On the other hand, there has been renewed interest in bivalve settlement and recruitment lately, and the present study is part of an attempt to integrate both aspects from an ecological perspective. It forms part of a project on the recruitment of cockles and mussels in the Wadden Sea, and is probably the first investigation into the effects of suspended sediment on *Mytilus* larvae.

**MATERIAL AND METHODS**

Two different sediments were analyzed: The first originated from the Wadden Sea east of Amrum Island, and the second was from the central sector of the Gironde, the water of which is non-toxic to larvae of *Crassostrea gigas* (Robert & His 1985). The sediments were decanted in sea water to eliminate sand and larger silt particles (Fig. 1), concentrated to about 100 g/l, and stored in glass bottles at 18°C in the dark. For the experiments, appropriate amounts of the sediment concentrate were made up to 1 l with 0.2 µm filtered sea water and mixed for several hours prior to use.

The experiments were conducted at IFREMER and IUBM Arcachon between March and August 1991. Larvae were obtained by spawning mature adults collected from jetties in Arcachon Bay; spawning was induced by thermal stimulation (18°-28°C). Six series of experiments were carried out with larvae from four separate spawnings; larvae were raised in turbid conditions for 2 to 13 days, and then allowed to recover without turbulence or turbidity for another 6 to 13 days. Water changes were effected upon completion of embryonal development on day 2, and every three days thereafter. The larvae were raised at densities up to 10,000/l and fed daily with laboratory-grown *Isochrysis galbana*, *Chaetoceros calcitrans* and *Tetraselmis suecica*, following standard methods (cf. His 1991; Utting & Spencer, in press).

The larvae were incubated in 1 l polyethylene beakers made from soft-drink bottles with a spherical bottom. Turbulence and turbidity were maintained by a novel machine (Fig. 2) with plexiglas discs moving up and down in the beakers at a speed of 3.3 cm/sec; preliminary experiments showed that beakers must have a spherical bottom for achieving quantitative suspension of the sediment. In order to simulate tidal conditions, the machine was set to run in six hour cycles as follows: 1.5 hours of continuous mixing, 1.5 hours of intermittent mixing (15 min. on / 15 min. off), 1.5 hours pause, 1.5 hours intermittent mixing.

Samples of more than 30 larvae were photographed through a microscope at each water change, and larval size was determined by measuring the height (dorso-ventral distance from the umbo) on the photographs. Mortality was assessed quantitatively only at the end of three of the experimental series; the larvae of a 1 l sample were collected on a 100 µm sieve, resuspended in 50 ml of water, and the number of larvae in four subsamples of 100 or 200 µl were counted.

## RESULTS

There was no apparent difference in response to the experimental conditions by larvae of different ages (from D-larvae of 70 µm to pediveligers of over 200 µm), and the data from the different series of experiments have been pooled in Figs. 3 and 4. As this combines the results of trials of different

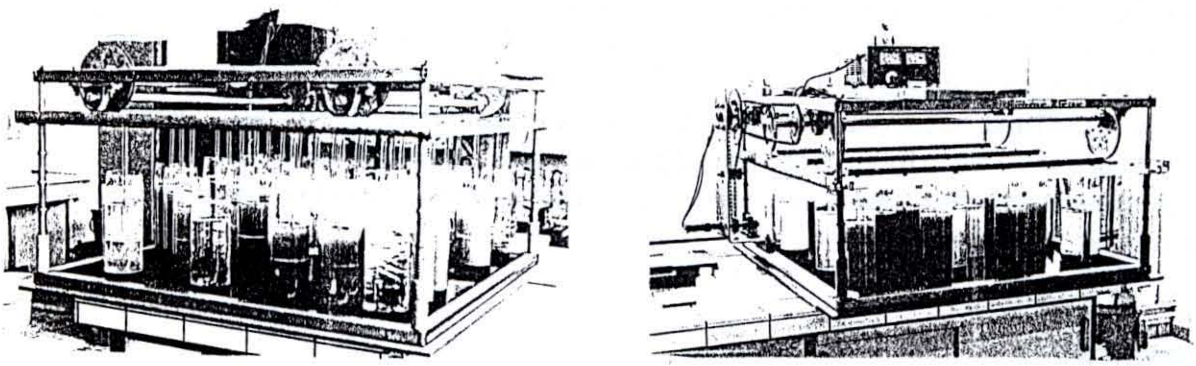

**Fig. 1:** Turbulence apparatus. The eccentric disks in the corners rotate and push down the central plate, which is pushed back up by springs. Turbulence is created by plexiglass disks attached to the plate by rods.

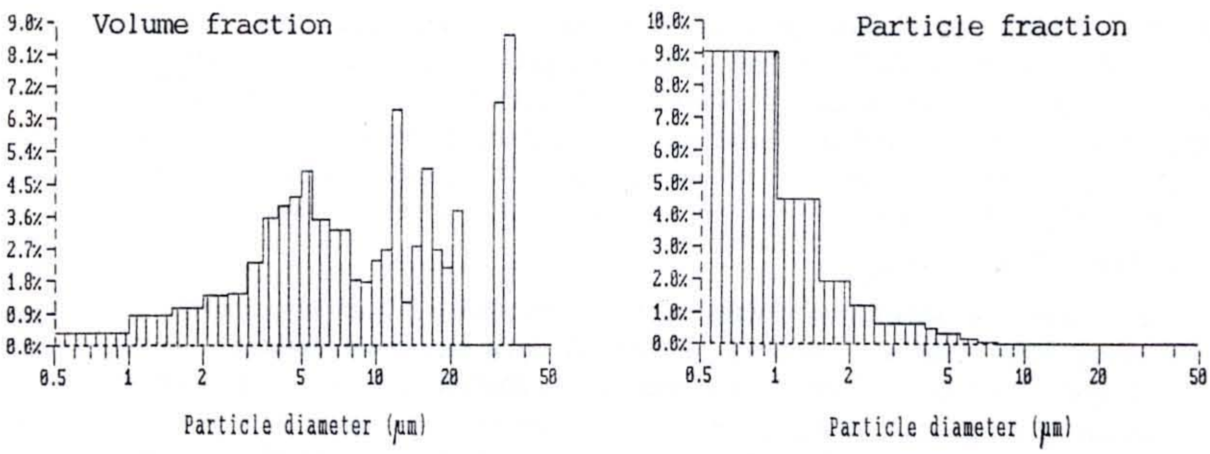


**Fig. 2:** Size spectrum of the Gironde sediment, by volume fraction (left) and by number of particles (right). Wadden Sea sediment was very similar.

duration on larvae of different sizes, the survival rates (Fig. 3) and the median shell height (Fig. 4) of the controls were set to 100, and the data for the experimental groups are given as percentages of the performance of the corresponding experiment's control groups.

Gamete fertilization and survival were not influenced by turbulence, nor by Gironde sediment at concentrations between 0.2 and 5 g/l, as compared to the controls. Gamete fertilization in Wadden Sea sediment, on the other hand, led to over 80% mortality; of the surviving embryos, only about 20% developed normally, independent of sediment concentration (0.2 to 5 g/l). As a whole, there was no apparent correlation between mortality and sediment concentration. Overall survival rates varied greatly (Fig. 3); survival was somewhat reduced by incubation in the turbulence machine, and considerably reduced by turbid conditions. In all trials, Wadden Sea sediment caused the highest mortalities.

Larvae grown in turbulence at sediment levels below 500 mg/l were larger than the corresponding controls, but growth was reduced at higher sediment levels (Fig. 4a). Subsequent recovery under non-turbulent and non-turbid conditions apparently led to improved growth, so that most of the experimentals attained a larger final size than the controls (Fig. 4b). Variability in the data was higher for the experimentals, particularly in the case of Wadden Sea sediment; the same holds true for the variability of larval size within the samples.

**DISCUSSION**

The amount of suspended sediments in coastal areas is generally well below 100 mg/l, and will rarely exceed 1 g/l, e.g. in the surf zone during a storm (Moore 1977; Eisma, pers.comm.). The present results thus indicate that natural turbidity regimes improve growth in *Mytilus* larvae, as compared to clear water; this confirms the findings of Davis (1960), Davis & Hidu (1969) and Huntington & Miller (1989) on other bivalve larvae.

Stebbing (1982) mentioned this as an example of hormesis, but we see no reason to define suspended natural sediments *per se* as toxic to larvae. There are indications that mildly polluted sediments may generate hormesis effects (His, unpublished), and accelerated growth during recovery in non-turbulent clear water (Fig. 3b) would also point to a stimulatory effect. This remains to be confirmed, however, because selective mortality of small larvae would generate similar results.

In our study, we sometimes found better survival of larvae at high sediment concentrations than at low ones. Although this may seem unusual, Davis & Hidu found the same effect in *O. edulis* incubated in 1 to 4 mg/l of clay. The seemingly erratic results on larval survival in parts of both investigations require further study; they might be linked to experimental conditions such as prior storage of the sediment (Eisma, pers.comm.; Phelps & Warner 1990), or turbulence regime.

The turbulence created by our machine was quite brutal; the larvae were propelled back and forth through the water at more than 15 cm/sec, and simultaneously whirled around in small eddies. This type of turbulence is probably exceptional in the natural environment, and it remains to be clarified whether it might cause mortality in combination with the particles in suspension. Robinson (1983) found that high concentrations of latex particles

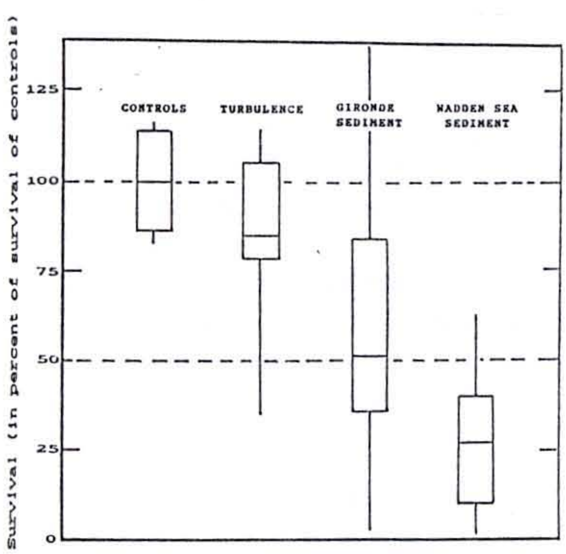


**Fig. 3:** Box and whisker plot of the survival of larvae of *Mytilus galloprovincialis* subjected to various turbulence / turbidity regimes.

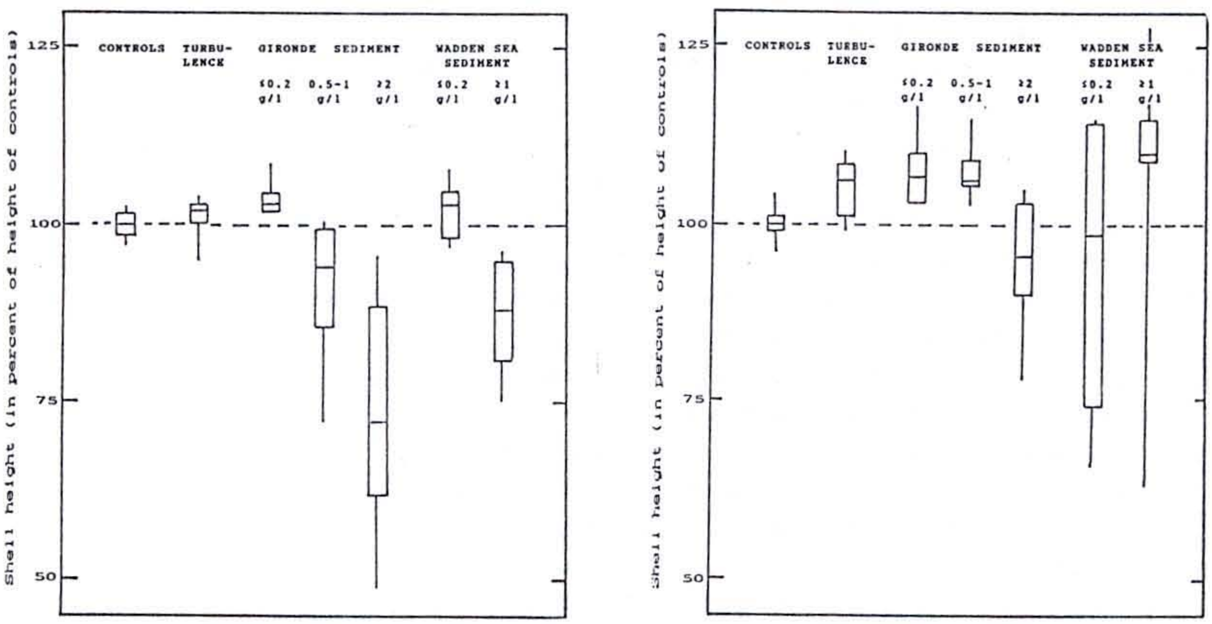


**Fig. 4:** Box and whisker plots of size in *Mytilus galloprovincialis* larvae.
**Fig.4a (left):** After 2 to 13 days of incubation in sediment and turbulence;
**Fig.4b (right):** After 6 to 13 days of recovery in non-turbulent clear water.

had no effect on *Mercenaria* larvae, and mechanical effects of suspended particles *in situ* seem improbable.

It is still unclear whether bivalve larvae actually ingest sediment particles of adequate size, and we hope to find an answer in biochemical analyses on larval samples collected during the experiments. The most important question - and the most difficult to study - probably concerns the biochemical interactions between bivalve larvae and sediments in suspension.

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