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Distribution and invasion ecology of *Marenzelleria viridis* in the Estonian coastal waters

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Abstract

The habitat selection and invasion of a new polychaete *Marenzelleria viridis* is described. Up to now the species has low biomass and abundance values in Estonian coastal waters. *M. viridis* prefers gravel substrate. The increase in the abundance of *M. viridis* coincides with the decline of that of another polychaete, *Nereis diversicolor,* in uniform habitats but not in the patchy environment. It is likely that *M. viridis* may become a numerically dominant species in the zoobenthos of the region in the following years.

Key words: *Marenzelleria viridis,* Gulf of Riga, Gulf of Finland, Väinameri Archipelago.

Introduction

Salinity in the greater part of the Baltic Sea is less than 8 PSU. The Baltic Sea is the largest marine area of such low salinity in the world. As compared to other brackish waters, the number of species in the Baltic fauna is low (Segerstråle, 1957). This makes the ecosystem more vulnerable to external factors.

In recent years several non-indigenous estuarine and marine species have appeared in the eastern part of the Baltic Sea, among them *Hemimysis anomala* G.O. Sars and *Dreissena polymorpha* (Pallas). This phenomenon has been explained as the result of weakening of the physical barriers due to human activities (Salemaa & Hietalahti, 1993; Valovirta & Porkka, 1996; Kotta et al., 1998).

Marenzelleria viridis (Verrill), originally inhabiting only North American estuaries, was for the first time found in the Baltic in 1985 (Bick & Burckhardt, 1989). Since then the species has successfully spread to the coasts of Sweden (Persson, 1991), Finland (Norkko et al., 1993), Poland (Gruszka, 1989), Lithuania (Churbanova & Olenin, 1992), and Latvia (Lagzdins & Pallo, 1994). In this paper the invasion of *M. viridis* to Estonian waters is described and an overview of its habitat preferences is given.

Material and Methods

The investigation area covers the main waterbodies around Estonian coast: the southern part of the Gulf of Finland, the Väinameri Archipelago area, and the Gulf of Riga (including southern bays of Saaremaa Island and eastern and central parts of the Gulf of Riga). A total of 476 stations were sampled. In the present study the data from different mapping studies during 1991-97 are used. For more detailed information about sampling sites see Kotta et al., 1998. Most samples were collected by a diver (Tvärminne or suction sampler) at depths less than 15 m. A van-Veen bottom grab was used in the deeper areas.

Salinity is very low in our study area: values between 3 and 7 PSU have been measured (Segerstråle, 1957; Järvekülg, 1979). Sampling was performed on various bottom substrates. Depths ranged from 0.5 to 70 m.

Sediments were washed through a 0.25 mm mesh, and were preserved in 4% buffered formaldehyde solution. In the laboratory the animals were counted under a stereo dissecting microscope. The total biomass of the animals in each sample was weighed to the nearest 0.5 mg and calculated for an area of 1 m^2.

The significance level of 0.05 was adopted for all statistical tests. After testing for normality of the data (Kolmogorov-Smirnov test for goodness of fit) and homogeneity of variance (Bartlett's and Hartley's tests), analyses of variance (ANOVA) (Sokal & Rohlf, 1981) were performed on the abundances and biomasses of *M. viridis*. The sediment type was involved as a factor. The effect of depth, abundance, and biomass of the dominant polychaete, *Nereis diversicolor* (O.F. Müller), was tested on the abundances and biomasses of *M. viridis*.

Results

The first observation of *M. viridis* in Estonian waters dates from 1994. The polychaete was found in the eastern part of the Gulf of Finland near the estuary of the Pühajõgi River (Narva Bay, 27°21' E, salinity ≈4 PSU). Only a small individual (10 mm), probably just an occasional visitor, was recorded. Up to 1997 no other individual of the species was found at the southern coast of the Gulf of Finland.

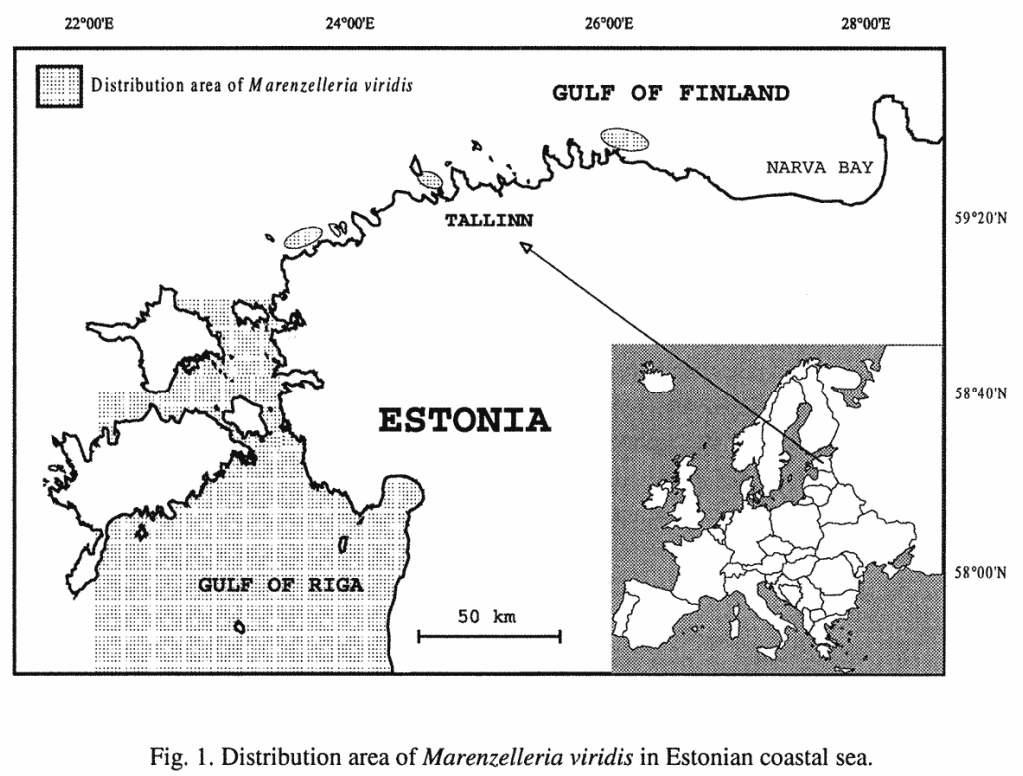

Fig. 1. Distribution area of *Marenzelleria viridis* in Estonian coastal sea.

In 1995 *M. viridis* was caught practically in the whole littoral zone as well as in the deeper parts of the Gulf of Riga (salinity ≈5.5 PSU). In shallower areas of the gulf (0-3 m), the species prefers sand or gravel bottoms. Its abundances are higher at more densely vegetated areas. At higher depths (>10 m) *M. viridis* is confined to silty clay bottoms. In the same year *M. viridis* spread also north from the Gulf of Riga, into the

Väinameri Archipelago area. However, there the polychaete is restricted to the deeper parts of the archipelago (7-11 m), which corresponds to sandy clay sediments. In both regions, the communities were dominated numerically by *Macoma balthica* L. and *Cerastoderma lamarcki* (Reeve). The proportion of *M. viridis* in these communities was rather low, comprising 10% at the most. Figure 1 depicts the distribution of *M. viridis* in Estonian coastal waters.

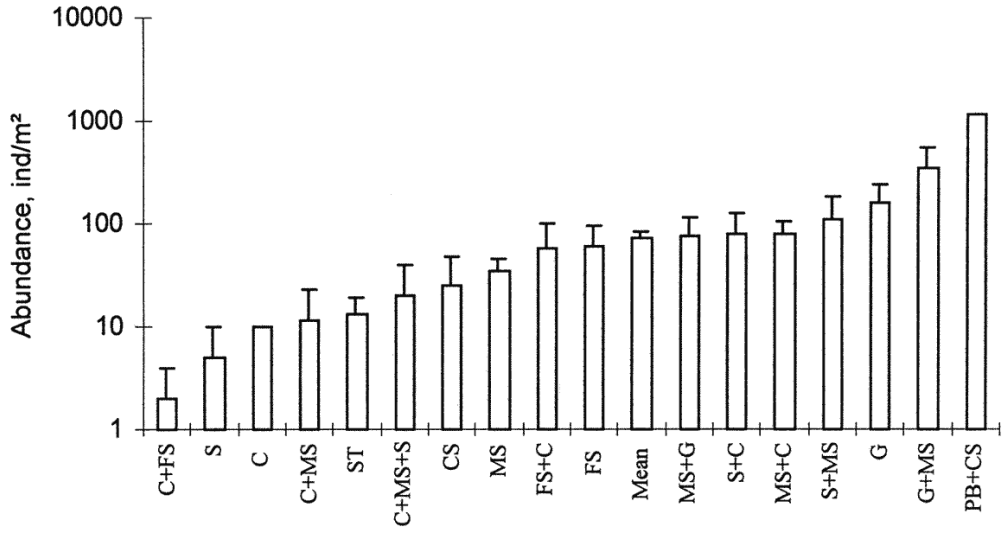

Fig. 2. Average values of the abundance of *Marenzelleria viridis* at different sediment types in the Gulf of Riga and the Väinameri Archipelago area. Sediment types: S, silt; C, clay; FS, fine sand; MS, medium sand; CS, coarse sand; ST, stone; PB, pebbles; G, gravel.

Sediment type is important in explaining the variance of abundance (ANOVA, $p = 0.003$) and partly the biomass of *M. viridis* ($p = 0.066$). Higher abundances were found on harder substrate (gravelly sand, pebbles mixed with sand) and lower abundances on different types of clay bottoms (clay and silt bottoms, clay bottoms mixed with sand and fine sand). Biomasses were higher on gravel bottoms and lower on clay bottoms mixed with fine, medium, or coarse sand (Figs. 2 and 3).

Depth had little effect on the abundance and biomass of *M. viridis* ($r = -0.05$, $p>0.05$). The species was found between depths of 0.1 and 55 m, the average depth was 10.3 m. Longitude correlated weakly with the abundance of *M. viridis* ($r = 0.16$, $p<0.05$).

During 1994-95 a significant decline of another polychaete, *Nereis diversicolor,* was observed in the deeper parts of the Vainameri Archipelago area. Its mean abundance was 600 ind m^{-2} in 1994. In 1995 we failed to find the species in most part of the Vainameri Archipelago area. When considering the whole study area no negative correlation between *M. viridis* and *N. diversicolor* was observed.

Discussion

Though the first finding of *M. viridis* in the Latvian side of the Gulf of Riga dates from 1988 (Lagzdins & Pallo, 1994), it did not invade Estonian waters during the next five years. Extensive mapping studies of macrozoobenthos were carried out in Parnu Bay and the surroundings in 1991 and at the coastal sea of Saaremaa Island in 1993 (Kotta & Kotta, 1995, 1997). No individuals of *M. viridis* were detected in either studies.

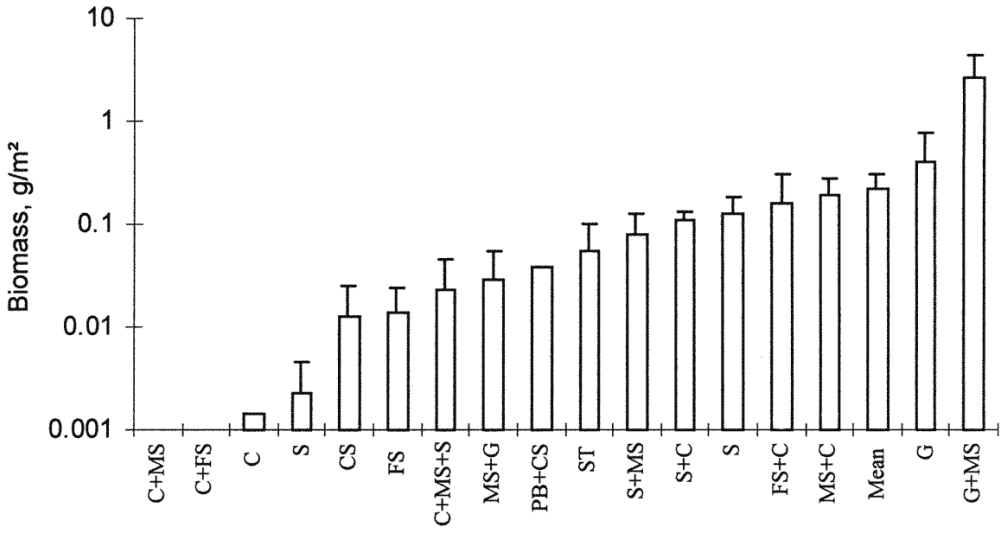

Fig. 3. Average values of the biomass of *Marenzelleria viridis* at different sediment types in the Gulf of Riga and the Väinameri Archipelago area. For sediment codes see Fig. 2.

Similarly, *M. viridis* was found in the Finnish (northern) side of the Gulf of Finland already in 1990 (Stigzelius et al., 1997). The sampling in the Estonian side of the gulf in 1990-96 proved that the polychaete had not succeeded in colonizing its southern coast. Some rare individuals of *M. viridis* were found in deeper areas of the western side of the Gulf of Finland and Tallinn Bay in 1997. The single individual found on the southern coast of the eastern part of the gulf in 1994 suggests that no stable community of *Marenzelleria* has formed in this region.

As previously suggested by other authors (Essink & Kleef, 1993) *M. viridis* may be transported in the ballast water, which could explain its presence far off its dispersion limits. Besides, anti-clockwise circulation of the currents would not permit *M. viridis* to spread from the northern side of the Gulf of Finland towards its southern side. The larvae are unable to complete their development at salinities below 5 PSU (George, 1966), which may frequently occur in the easternmost part of the Gulf of Finland.

Despite five years of "stagnation" the polychaete successfully spread over the Gulf of Riga in 1994-95. Specimens were found equally in the deeper part of the gulf (near Ruhnu Island) and in the transects of the southern coast of Saaremaa Island, the opening area of Parnu Bay, and the borderline between Estonia and Latvia.

Why did *M. viridis* keep waiting till 1994? The salinity of the Gulf of Riga did not vary much during 1992-94. Figure 4 depicts the temperature fluctuations of the Gulf of Riga in 1992-95. One may notice higher water temperatures in summer 1994, which might have led to a better condition and higher reproductive potential of *M. viridis.* A high reproduction rate of the polychaete is needed to exceed the critical abundance of juveniles in order to successfully invade new areas. The reproduction of *M. viridis* occurs in the Baltic in September-October (Zettler et al., 1995). Dominant wind directions at the gulf during this time of the year are from south-west or south (Berzinsh, 1995) assuring the dispersion of the myriad of larvae of *M. viridis* into Estonian coast and the establishment of a permanent community.

Already at the beginning of the 1990s the larvae of a polychaete (probably *M. viridis)* were observed in the plankton samples from the northeastern part of the Gulf of Riga

(M. Simm, pers. comm.). This finding is in disagreement with our data, as not a single individual of *M. viridis* was found in the benthic communities before 1995. As salinity did not limit the expansion of the distribution area of *M. viridis* in the 1990s it is possible that lower temperatures had a negative impact on the development and settlement of the larvae of *M. viridis* or the abundance values of the larvae were too low to colonize the northern part of the Gulf of Riga.

As compared to the figures presented by Lagzdins & Pallo (1994) for the Latvian side of the Gulf of Riga in 1990, the abundances here are rather low, hardly surpassing 100 ind m^{-2}. Though, one may assume that the carrying capacity of an environment is far higher than the abundances recorded during the first year of colonization (i.e. in 1995). Therefore higher abundances may be recorded in the following years.

In Estonian waters *M. viridis* inhabits similar bottom types (i.e., muddy, sandy, or gravelly sediments) as previously reported in the Baltic and North seas (Atkins et al., 1987; Bick & Burckhardt, 1989; Essink & Kleef, 1993; Lagzdins & Pallo, 1994). As a difference to Bick & Burckhardt (1989), the abundance and biomass values of *M. viridis* differed significantly between sediment types.

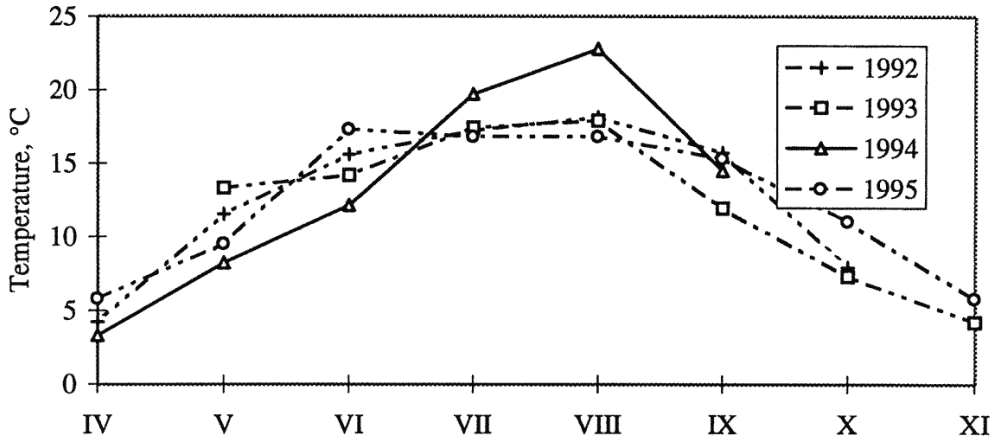

Fig. 4. Seasonal fluctuation in temperature in the Gulf of Riga in 1992–95.

Several authors have suggested the presence of interspecific competition between two polychaetes, *Nereis diversicolor* and *M. viridis* (Essink & Kleef, 1993; Lagzdins & Pallo, 1994), though the relationship was not found to be statistically significant. In the Gulf of Riga the increase in the abundance of *M. viridis* did not coincide with the decline of *N. diversicolor*. The region inhabited by *M. viridis* in the Väinameri Archipelago area is characterized as a very homogeneous in sediment type and algal community (i.e. sandy clay sediments are covered with a layer of red algae, *Furcellaria lumbricalis* (Huds.) Lamour). Among macrozoobenthos practically only *Macoma balthica, Cerastoderma lamarcki,* and *N. diversicolor* are present in these sediments, while *Mytilus edulis* L. is more abundant in the *Furcellaria* layer. Because of the uniformity and low number of species, this community is more vulnerable to an intruder such as *M. viridis*. In the shallow, patchier environment of the Vainameri Archipelago area, *M. viridis* has not yet been observed, and as usual, *N. diversicolor* dominates numerically among polychaetes.

As the benthic primary production of the Vainameri Archipelago area is relatively high due to the shallowness of the area, and the growth rate of *M. viridis* is strongly influenced by food quality and quantity (Bochert & Bick, 1995), supposedly this region will be the most densely populated by *M. viridis* in the next couple of years. One may already notice higher biomasses (though not significantly higher yet) in the Vainameri

Archipelago area. Consequently, this region may be regarded as the most probable source of *M. viridis* for the southern side of the Gulf of Finland.

As a conclusion, we can say that *M. viridis* has not yet reached its stable biomass values in the study area. Up to now *M. viridis* has colonized practically the whole possible substrate in the Gulf of Riga and the Vainameri Archipelago area. At the same time the species was found only at some places in the Gulf of Finland, including the deeper areas in the western part of the gulf and Tallinn Bay. *M. viridis* has invaded the former area possibly via the Vainameri Archipelago area, whereas the occurrence of this polychaete in Tallinn Bay is probably connected with the shipping activity. We predict that *M. viridis* will form a permanent community in the western and central parts of the Gulf of Finland in the next two years.

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