SPC-R isolates for adenine and methionine requirements showed that at least the bulk are genuine recombinants, for they include 68 $ad^+ met^+$, 19 $ad^- met^-$, and 7 $ad^+ met^-$ colonies; the first and third groups differ from each parent by two characters that arise only rarely by mutation.

We conclude from these results that streptomycin resistance and dependence are allelic, and infer that the *E. coli* C strain (N873) differs from K12 donor strains in at least two mutational sites. One of these is the allele that specified streptomycin sensitivity or resistance; the other is a modifier which, in its form in N873, changes the phenotypic expression of the resistance allele from resistance to dependence. These genetic sites are closely linked, since they can be cotransduced to yield STR-R transductants of strain C (Table 1), but are probably in different genes, since they are frequently separable (Table 1). From the transductions and the cross diagramed above, the "modifier" locus would lie between the *str* and *met* loci, closely linked to the *str* locus.

Since resistance resides in the 30*S* ribosome (*4*), and there is evidence that the *str* gene specifies a ribosomal protein (*5*), we suggest that resistance to and dependence on streptomycin, as well as the modifier, result from specific changes in 30*S* ribosomal proteins. The effects of this modifier are in accord with the model of the ribosome as a complex of highly interacting components, a notion we have proposed also on the basis of some other data (*6*).

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Bivalves: Spatial and Size-Frequency Distributions of Two Intertidal Species

Abstract. *Individuals of* Mulinia lateralis *are randomly distributed over a homogeneous area (0.25 square meter) of a mudflat. Second-year individuals of* Gemma gemma *also are randomly distributed, but its total population is aggregated because of its ovoviviparous habit. As expected for two species having different life histories, their size-frequency distributions are very different, the indication being that the nature of a size-frequency curve may not be a reliable index of the degree of transport or integrity of a fossil assemblage.*

The horizontal spatial distributions of two species of intertidal bivalves, *Mulinia lateralis* Say, 1822, and *Gemma gemma* Totten, 1834, were studied in an inlet off Long Island Sound, west of Guilford, Connecticut; they were collected on a small mudflat at an arbitrarily determined spot 10 m shoreward of low water, an area of 0.25 m² being chosen to ensure homogeneity of environment throughout the sample. A metal grid with cells 5 by 5 by 3.5 cm deep was used to divide the sampling area; 100 such cells covered 0.25 m². The sample from each cell was washed through a 1-mm sieve, and the bivalves were counted, the lengths of their shells being measured in increments of 0.1 mm.

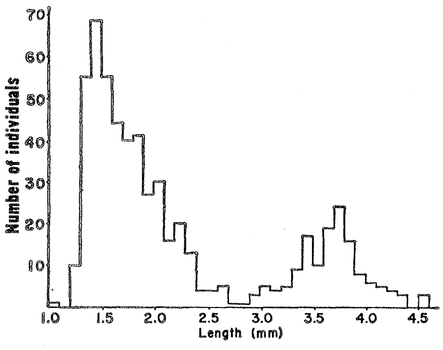
The frequency distributions of the individuals per cell were compared with the expected random frequency of the binomial distribution (*1*) by the chi-square goodness-of-fit test. Populations were taken as random when the observed distribution did not differ from the expected at the 95-percent level of confidence.

Fisher's variance-ratio statistic (*2*) was computed for each of the species distributions (live and dead), and the criterion of randomness was again set at the 95-percent level of confidence. This duplication of tests was necessary in order to avoid difficulties in interpolation of binomial values for "half individuals" in the dead-shell distributions.

The results of the analyses (Table 1) show that *M. lateralis* was always randomly distributed as was to be expected for a population in a homogeneous environment—one in which biological parameters are not important in determination of the distribution of individuals of the population. Thus each individual is independent of all others within the area observed, and the arrival of new individuals is independent of those either already present or entering the area at the same time; this condition is provided for *Mulinia* by its planktonic larval stage and consequent random settling within a limited area of uniform substrate. Moreover, *Mulinia* is somewhat unusual among the suspension-feeding bivalves, at least in the adult stage, in its apparent ability to withstand the high content of silt and clay in mudflat sediments; thus it can utilize the very high concentrations of organic matter characteristic of these

Table 1. Variance, means, and spatial distributions for living and dead populations of *Mulinia lateralis* and *Gemma gemma*. Aggr., aggregation.

Year class	Nos. (*N*, *n*)	Variance	Mean	Spatial distribution: Variance ratio	Spatial distribution: Binomial
		Live Mulinia lateralis			
	100, 27	0.26	0.27	Random	Random
	25, 27	.66	1.08	Random	Random
		Dead Mulinia lateralis			
	100, 54.5	0.38	0.55	Random	
	25, 54.5	2.46	2.18	Random	
		Live Gemma gemma			
All	100, 575	11.83	5.75	Aggr.	Aggr.
All	25, 575	53.67	23.00	Aggr.	Random
1st	100, 434	7.72	4.34	Aggr.	Aggr.
2nd	100, 141	1.66	1.41	Random	Random
		Dead Gemma gemma			
All	100, 729.5	282.83	29.18	Aggr.	
All	25, 729.5	51.02	7.29	Aggr.	
1st	100, 465	19.52	4.65	Aggr.	
2nd	100, 264	7.70	2.64	Aggr.	



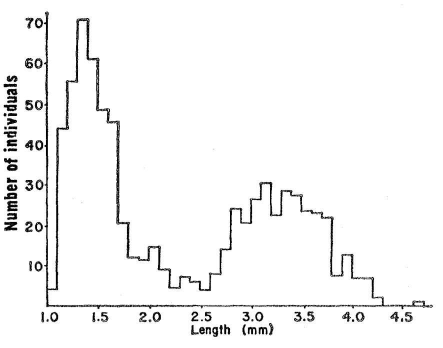


Fig. 1 (left). Size-frequency distribution of live *Gemma gemma*. Fig. 2 (right). Size-frequency distribution of the dead *Gemma gemma*.

waters, so that intraspecific competition for food does not occur.

The total *G. gemma* population was aggregated for $N = 100$ but randomly distributed when the cells were lumped for the binomial calculations ($N = 25$). Lumping produced subareas too large for detection of the true aggregated distribution, and therefore randomness was not rejected. Apparently the 5- by 5-cm cell gives an appropriate sample for study of these species. Randomness was rejected in both instances by the more sensitive variance-ratio test.

Aggregation was not expected, as the environment appeared to be homogeneous. However, examination of the distribution of *Gemma* in relation to its reproductive habits and to the size-frequency data explains the anomaly. This species is ovoviviparous, and gravid females commonly contain as many as 300 young (*3*); moreover it has only one reproductive season in northern waters, and the juveniles are released in June and early July (*3*). Two classes, 1st- and 2nd-year, are easily distinguishable (Fig. 1), and a length of 2.8 mm appears to be a reasonable separation point. Of the 575 live individuals collected, 434 (75 percent) were in the 1st-year class. The 2nd-year class were near the end of their lifespan (average age in November, almost 1.5 years).

The distribution of the 2nd-year class was random; that of the 1st-year class, aggregated. This fact can be explained by the comparatively recent release of the young bivalves by their mothers and by their failure to disperse (or to have been dispersed) since "spawning." Therefore clustering of 1st-year individuals, still close to their mothers, gives an overall aggregated distribution to the population that is greater than the degree of aggregation of the 1st-year class alone.

It is not clear why the 2nd-year population should be randomly distributed, unless distribution results from lateral movements associated with burrowing; *Gemma* is a moderately efficient burrower and consequently can live just below the sediment surface in a tidal environment. Moreover, mortality should be spatially random for individuals of any one age or sex, and so should not alter the original aggregate distribution unless the population is reduced to very low densities.

Tidal currents and storms are undoubtedly effective in the transport and reworking of dead shells, as are shown by extensive accumulations of remains of both species on the shores of the inlet. However, the effects on each species are different, for the dead shells of *Mulinia* remain randomly distributed on the flat whereas those of *Gemma* become strongly aggregated relative to the living population. This difference may result from the difference in size and shape (and hence hydrodynamic properties) of the shells of the two species, or from the much greater degree of articulation of dead *Gemma* than of *Mulinia* (or from both factors). However, if tidal currents or storms cause the aggregation of dead *Gemma* shells, they cannot also cause the random distribution of the live 2nd-year population.

The size-frequency distribution of dead *Gemma* shells (Fig. 2) resembles that of live individuals at the time of sampling, but the modes of both classes are shifted slightly to the left. For both year classes, the peaks correspond to the period between early summer and early fall, which is their time of most-rapid growth and highest mortality (*3*). So, although the size-frequency distribution of the living population changes each year from bimodal to unimodal and back again, that of the dead-shell assemblage is probably constant because of the very different seasonal mortality rates. This fact may relate to greater vulnerability to environmental stress at times of more rapid growth or of reproduction (or of both), or to mass kills during periods of abnormally high temperatures. Evidently winter freezing is no major threat to this small species, probably because of burrowing during cold periods—often to depths of 7 to 8 cm within the sediment (*4*). The possible correlation of bimodal or polymodal size-frequency distributions with ovoviviparity merits further research; if this is a common phenomenon it could help considerably toward interpretation of the life histories of ancient species.

The population density of *Mulinia* was too low in the sampling area for significant analysis of size, but measurement of 1723 single valves from another part of the same mudflat yielded a strongly positively skewed curve, reflecting very high juvenile mortality for this species. This mortality probably results from poor adaptability by *Mulinia* to the very turbid waters and soft substrate of the mudflat environment before a comparatively large shell is formed (*5*). On the other hand, *Gemma* is well adapted to this environment from the beginning of its free-living existence, having an inhalent siphonal membrane (*3*).

It seems that size-frequency distributions of bivalves, even roughly similar forms from the same environment, may differ greatly because of simple and basic variations in their life histories. Therefore, contrary to certain conclusions (*6*), generalizations on the paleoecological significance of one sort of size-frequency distribution or another seem inappropriate without some idea of the life histories of both species involved. Consequently no one curve or set of curves serves as a reliable indicator of past transport or of the degree of compositional integrity in a fossil assemblage, or of both.

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