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SIZE SELECTIVITY IN THE CATCHES OF THE GULF III AND BONGO ZOOPLANKTON SAMPLERS

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Previous comparisons of the catching efficiencies of the Gulf III (Gehringer, 1952) and paired bongo samplers (Posgay, Marak, and Hennemuth, 1968), indicated that the abundance of the smaller zooplankters is underestimated in the Gulf III sampler (Sherman and Honey, 1968). These comparisons were made in autumn, 1967. Our experiments were continued to examine the effects of the seasonal changes in the size composition of the zooplankters in the catches of the two samplers. The present results were obtained from comparisons made in winter and summer, 1968.

Methods

As in our previous trials, the samplers were hauled simultaneously in a step oblique tow of 30 minutes --10 minutes each at 20 m, 10 m, and the surface during daylight. The nets were on the same wire; the bongo samplers were positioned about 25 cm above the Gulf III. Each of the samplers had mouth diameters of 20.3 cm. The amount of water strained was determined from a calibrated flow meter mounted in the mouth of one of the bongo nets, and in the tail section of the Gulf III. Each tow covered about 6.5 km and filtered approximately 165 m^3 of water. The towing speed was 308 cm/sec (6 knots). Volumes of the samples were measured in the laboratory by the mercury immersion method. Ctenophores, large coelenterate remains (>2 cm long) and all fish larvae were excluded. Zooplankton samples used for analysis ranged from the total sample to aliquots of one two hundred and fifty-sixth, depending on the mass of the samples. They were sorted into major taxonomic groups; copepods were identified to species, and numbers of copepods and other zooplankters per 100 m^3 of water strained were calculated.

Simultaneous tows were made in winter at twelve coastal locations between Cape Ann, Massachusetts and Machias Bay, Maine. One of the

bongos was fitted with 0.366 mesh. The other was fine mesh (0.158 mm) to sample the smaller zooplankters; this net, however, was torn repeatedly when towed at 308 cm/sec, and the resulting data were not used in the comparisons. In summer, 10 tows were made in coastal waters in the vicinity of Boothbay Harbor; the mesh apertures in both bongos and in the Gulf III were 0.366 mm. In each season, 25 specimens of each of the abundant taxa and copepod species were selected at random and measured for size in their widest dimension.

Composition of the Zooplankton

In winter copepods were the predominant zooplankters. Two species --Calanus finmarchicus and Pseudocalanus minutus--constituted 97 percent of the copepods in the samples. In summer 15 taxa were in the samples, ten constituted more than one percent of the total zooplankton--copepods, chaetognaths, fish eggs, crustacean nauplii, gastropod eggs, decapod larvae, brachyuran larvae, pteropods, cirriped larvae, and appendicularians. Copepods were the predominant taxa (63 percent of the total zooplankton); eight species were in the samples--C. finmarchicus, P. minutus, Centropages hamatus, Eurytemora herdmani, Temora longicornis, Acartia longiremis, A. clausi, and Tortanus discaudatus.

Group and Species Size Comparisons

The differences in the catches of the major taxa and copepod species between the bongo and Gulf III samplers were tested for significance with the Mann-Whitney U test for winter observations, and the Friedman two-way analysis of variance (Siegel, 1956) for the replicates in summer. A summary of the results is given in table , where taxa are listed by size.

In winter the overwintering population of the copepodite stage C. finmarchicus (mean width 0.79 mm) was sampled equally well in the Gulf III and bongos. In contrast, the adult but smaller copepod, P. minutus (mean width 0.56 mm) was undersampled in the Gulf III. In summer the five copepod species that were more numerous in the bongos--A. longiremis, A. clausi, E. herdmani, C. hamatus, and P. minutus--were also the smallest species in the samples (≤0.38 mm). C. finmarchicus was predominately in the third and fourth copepodite stages; the other species were, with few exceptions, fifth copepodites and adults.

The three copepod species--C. finmarchicus, T. longicornis, and T. discaudatus--and five other taxa--cirriped larvae, decapod larvae, pteropods, crustacean nauplii, and fish eggs-- that were collected equally well in the bongos and Gulf III were all relatively large organisms, equal to or greater than 0.38 mm in median width. Catches of appendicularians were also not significantly different among the bongos and Gulf III. The catches were, however, of tail remains only, and their median width (0.16 mm) is about 12 times less than the actual width of the organism with its outer gelatinous body. The added mass of the outer body that was lost during the sampling may have accounted for the similarity in catches among the samplers. Three remaining taxa, differentially retained in the samplers, were the relatively large cladocerans, more numerous in port bongo and Gulf III, brachyurans, more numerous in the Gulf III, and gastropod eggs more numerous in the bongos (table 1).

Sources of Variation Between Samplers

The possible influence in our experiments of the patchy microdistributions of zooplankters in the horizontal and vertical plane is considered minimal. Some differences occurred on the horizontal plane between the catches of the port and starboard bongos, suggesting that the patches of zooplankters were less than 40 cm distant. This effect, however, was not statistically significant ($P > 0.05$) over the series of replicate tows when examined with the Mann-Whitney U test, except for gastropod eggs and appendicularians which were more numerous in the port bongo. Within the water column we have found that zooplankters in coastal waters of Maine are more numerous at 10 meters than at the surface. In the last 10 minutes of the step-oblique tow, the bongo nets were positioned just below the surface film; the Gulf III was about 25 cm below on the towing wire. Differences in catches caused by vertical patchiness would have resulted in increased numbers of zooplankters in the Gulf III rather than the bongos. Catches of only three of the ten taxa and eight species in the samples appear to be anomalous; the reasons for the significantly greater catches of the relatively large gastropod eggs in the bongos, cladocerans in the port bongo, and Gulf III and brachyurans in the Gulf III are not clear and will require additional investigation.

The three copepod species that were collected equally effectively in summer in both samplers--C. finmarchicus (median width 0.43 mm), T. longicornis (median width 0.38 mm), and T. discaudatus (median width 0.36)--were identical or only slightly larger in median cephalothorax width than P. minutus (median width 0.36 mm). Irregularities in the retention of zooplankters at the level where the retention and passage of organisms through the meshes is approximately the same has been described by Saville (1958). It has been suggested that the escape of organisms larger than the meshes is aided by the compressibility of the organisms and the flexibility of the net (Vannucci, 1968). The retention of T. discaudatus and the loss of P. minutus may have been caused by differences in compressibility, not only of the cephalothorax, but also in the elongate maxillipeds and antennae of T. discaudatus, and the smaller maxillipeds and less rigid antennae of P. minutus. It is also likely that some of the smaller copepods ($\leq$ 0.36 mm median width) were lost through the 0.366 mesh apertures (0.517 mm diagonal measure) of both the bongos and Gulf III samplers.

Preliminary observations of the hydrodynamics of the Gulf III sampler indicate that when under tow the mesh velocities are high because of the differential flow of water through the net accentuated by the encasement; this results in a high velocity central core producing high mesh velocities in the lower third of the net (personal communication, Paul Smith, BCF, La Jolla, California). In contrast, the mesh velocity would be lower in an unenclosed net with a cylinder-cone configuration (Tranter and Smith, 1968). Significantly more of the smaller zooplankters ($<$ 0.38 mm median width) were retained in the bongos, but no significant differences were found among the samplers in the catches of the larger ($>$ 0.40 mm median width) organisms (table 2). The differences between the catches of the zooplankton in the Gulf III and bongo samplers, fitted with nettings of 0.366 mm apertures, probably result from the extrusion of the smaller copepods and other small zooplankters through the meshes of the Gulf III when towed at high speeds equal to or greater than 366 cm per second (6 knots).

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Table 1. Sizes of the major zooplankters and copepod species collected in the bongos and Gulf III samplers, winter and summer 1968. Friedman Xr2 and Mann-Whitney U values and probabilities are listed for each of the zooplankters.

	Median width (mm)	Median no/100m^3 Port	Starboard	Gulf III	Xr^2	Probability value
ppendicularians	0.16	940	341	166	4.2	> 0.10
. longiremis	0.27	1,482	1,451	74	10.4	< 0.01
. clausi	0.31	584	534	55	9.6	< 0.01
. herdmani	0.31	2,008	1,358	606	12.6	< 0.01
. hamatus	0.35	2,129	2,212	634	15.0	< 0.001
. discaudatus	0.36	384	381	273	3.2	> 0.20
. minutus	0.36	3,026	1,858	297	10.4	> 0.01
. longicornis	0.38	1,013	1,209	839	5.4	> 0.05
. minutus (W)[1/]	0.38	NS[2/]	687	19	4	< 0.001[3/]
riped larvae	0.40	89	142	250	2.5	> 0.20
opod larvae	0.40	612	590	501	0.0	> 0.99
. Temoridens	0.43	2,799	2,889	2,099	1.4	> 0.30
Indocerinus	0.44	1,114	387	1,392	10.6	< 0.01
rustacean nauplii	0.45	641	715	701	2.2	> 0.30
Peroguis	0.47	481	556	266	2.6	> 0.20
ntropod eggs	0.69	1,051	666	14	15.4	< 0.001
. Temoridens (W)	0.79	NS	2,670	2,796	66	0.052[3/]
ish eggs	0.85	1,001	1,083	82	1.6	> 0.30
ushpuma larvae	1.92	324	413	795	9.8	< 0.01

1/ W = winter

2/ No sample

3/ Mann-Whitney U, and probability values

Table 2. Friedman analysis of variance values (Xr^2) for the pooled small (median width < 0.38 mm)[1/] and large (median width > 0.40 mm)[2/] zooplankters collected in the bongo and Gulf III samplers, summer 1968.

Tows	Small zooplankters median no's/100m^3			Large zooplankters median no's/100m^3		
	Port	Starboard	Gulf III	Port	Starboard	Gulf III
1	4,362	4,551	1,377	7,084	5,995	5,242
2	6,755	13,329	2,574	7,420	5,670	6,680
3	5,987	5,270	2,180	7,530	8,498	7,310
4	12,223	9,246	2,788	10,718	9,140	4,991
5	10,896	7,038	2,489	10,012	7,568	8,873
6	3,169	2,703	2,800	3,950	3,773	9,883
7	18,121	9,327	4,693	11,648	12,691	12,189
8	16,132	33,007	2,718	13,948	12,178	6,044
9	16,450	19,742	4,435	10,895	12,505	8,226
10	16,651	17,296	7,067	13,579	9,576	16,276
		Xr^2 12.2, P < 0.01			Xr^2 1.4, P > 0.03	

1/ Includes: brachyuran larvae, Calanus finmarchicus, cladocerans, cirriped larvae, crustacean nauplii, decapod larvae, fish eggs, gastropod eggs, and pteropods.

2/ Includes: Acartia clausi, Acartia longiremis, Centropages hamatus, Eurytemora herdmani, Pseudocalanus minutus, Temora longicornis, and Tortanus discaudatus.