BULL. MAR. BIOL. STN. ASAMUSHI, TÔHOKU UNIV., 17(3), 141–157, 1983

MACROBENTHIC ASSEMBLAGES IN A HABITAT OF THE RECENT LINGULID BRACHIOPOD *LINGULA ANATINA* LAMARCK AT ASAMUSHI, NORTHERN JAPAN[1)]

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Macrobenthic assemblages in a habitat of the recent linguilid brachiopod *Lingula anatina* Lamarck and grain size composition of the bottom substrate were surveyed at Asamushi, northern Japan. *Lingula* inhabited the muddy-sand bottom having large amount of fine and very fine sand with dense macrobenthos. *Lingula* were not found on the bottom having large amount of coarse sand or well sorted fine sand with the patches of the seagrass *Zostera marina* L. Relationships between the bottom substrate and distribution of macrobenthic fauna and interspecific relation between the animals are discussed.

Recent linguilid brachiopods are widely distributed in tropical and subtropical areas. In Japan, OKADA (1930) and YATSU (1902a) also reported that *Lingula* occurs chiefly along the southern coast; however, HAYASAKA (1932) studied the fauna of brachiopods in Mutsu Bay, northern Japan, and found many specimens of *Lingula* at several locations in the bay. Several reports on *Lingula* biology were given by Japanese workers. YATSU (1902a, b, c) studied embryology, histology and habits, and OHUYE (1938) also conducted a histological study. Recently, IWATA (1981) studied ultrastructure and mineralization of the shell. But in general informations on ecology of *Lingula* are greatly lacking (cf. EMIG *et al.*, 1978).

In the present paper, the macrobenthic assemblages in a *Lingula* habitat are studied with relation to the grain size composition of the bottom substrate.

STUDY AREA AND METHODS

Mutsu Bay lies at the northern end of Honshu, Japan (Fig. 1) and its northeastern corner opens into Tsugaru Strait. The water of Tsushima Warm Current, which flows to north along the coast of Sea of Japan, flows into the bay and some southern species are collected frequently. According to KYOZUKA *et al.* (1982), general oceanographic conditions around the Marine Biological Station, Tôhoku University during 1981 are as follows:

1) Contribution from the Marine Biological Station, Tôhoku University, No. 479

2) 土屋 誠, クリスチャン・エミック

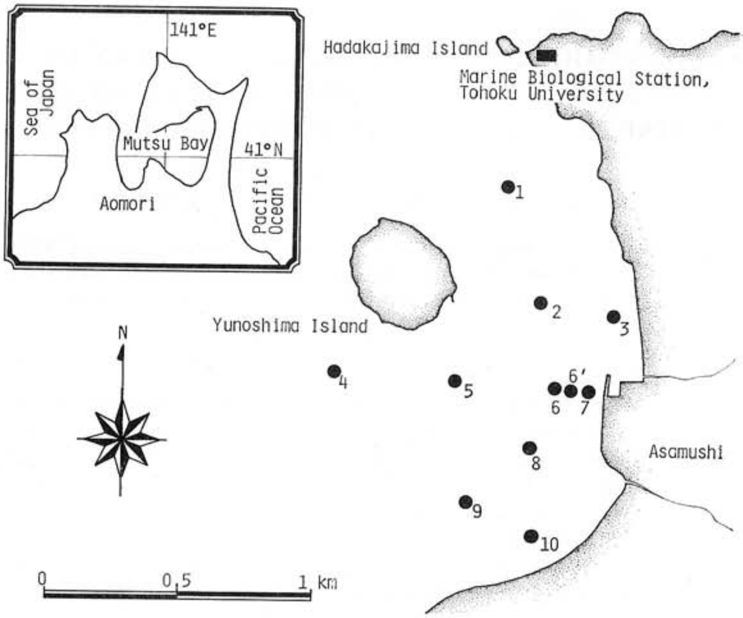

Fig. 1. Map showing the stations surveyed. Two small rivers flow into Mutsu Bay through Asamushi and there is a yacht harbor between mouths of the rivers.

	surface layer	30 m depth
maximum water temperature	22.25°C (July 25)	21.66°C (July 25)
minimum water temperature	1.90°C (Feb. 26)	4.99°C (Feb. 13)
maximum chlorinity	18.64‰ (Mar. 10 and 26)	18.78‰ (Jan. 24)
minimum chlorinity	15.78‰ (June 10)	18.04‰ (Sept. 24)
maximum dissolved oxygen	6.96 ml/1 (Feb. 13)	7.06 ml/1 (Feb. 13)
minimum dissolved oxygen	4.96 ml/1 (July 25)	4.50 ml/1 (July 25)
pH	8.2–8.4 throughout a year	

Ten sampling stations were selected (Fig. 1) for the survey which was done in late May, 1982. Firstly, direct observations on the bottom surface and counting of the number of burrows of *Lingula anatina* were conducted by SCUBA diving. At the same time, a small amount of bottom substrate was collected for analysis of grain size distribution. Two replicate samples by a Smith-McIntyre Grab (sample size: 0.1 m^2) were taken at each station. All samples were washed through a 1-mm^2 sieve and the residue was preserved in 10% formalin before sorting, identification and counting in the laboratory.

Results

Bottom substrate

The observations through SCUBA diving are reported on the Table 1, while the grain size distribution curves are given on Fig. 2, for each station.

Table 1.
Observations on the bottom surface (see remarks below in text)

Stations	Depth in meters	Mean density of *Lingula*/m^2	Presence of:	
			Patinopecten	Algae
1	11	65	+	±
2	6	120	+	±
3	4	—	+	—
4	18	55	—	—
5	9	65	+	+
6	9	100	+	+
6′	7	100	+	+
7	5	150	+	—
8	10	85	+	+
9	10	140	+	+
10	6	—	+	—

The stations 1, 2, 5, 6, 6′, 8 and 9 share together strong similaritied, their depth range is from 6 to 11 m: the bottom floor is undulated, the higher parts with algal cover and the lowest mainly with linguild burrows, both have a patchy distribution on the bottom. Sediments of those stations (Fig. 2) are well-sorted sand to a muddy sand, in which the silty particle fraction (<60 μm) may reach up to 20%, as in Sts. 8 and 9. But at St. 1 coarse sands have a larger part than in the others cited stations, yet the fine sand fraction is greater than at St. 7.

At St. 7, the bottom floor is flat, without algae, and the sediment is a coarse and medium sand clogged with by fine sand, where the *Lingula* density reaches its highest value. Leeward the coarse fraction increases up to gravels and the *Lingula* fade out rapidly. Such bottom is similar to St. 10; thin shallow bottom is of medium clean sand with a coarse fraction and gravels; mollusks and ophiuroids are abundant, but *Lingula* are absent.

The deepest station is 4, a sandy mud with about 30% of silty fraction, neither with algae nor *Patinopecten yessoensis*; the particle sorting decreases with the depth (compare station curves 6, 5, 4).

Lingula do not occur in the shallow station 3, where the sediment is beach fine sand, with sparse *Zostera marina* L., similar to a sand bare; the absence of *Lingula* may be explained by a too strong hydrodynamism indicated by large ripple-marks. Westward this bottom is replaced by rocks and gravels, at about 5 m deep.

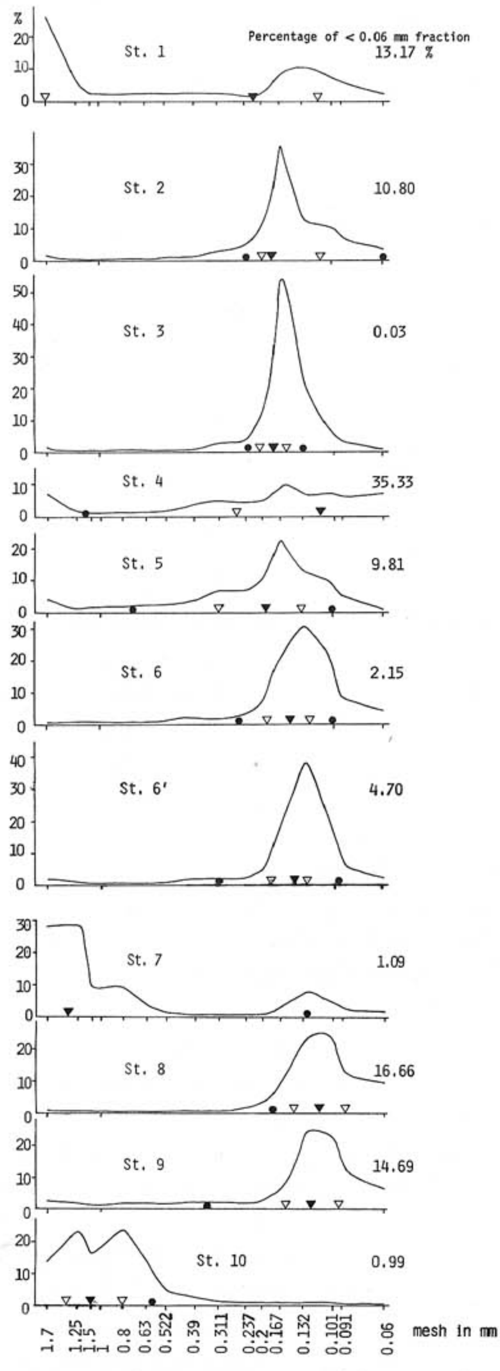

Fig. 2. Grain size distribution (frequency curves) of bottom substrate at each station. ● quartiles, 10 and 90%, ▿ quartiles, 25 and 75%, ▾ median diameter, 50%.

Macrobenthic fauna

Table 2 shows the benthic fauna (number of individuals per 0.2 m^2) collected at each station. Species diversity (H′) calculated by the method based on Shannon's index was also shown in the bottom column.

Many species and individuals of animals were found in this survey. At St. 5, the spionid *Spiophanes bombyx* showed the maximum density among all animals collected in this survey (96/0.2 m^2), but no or a few specimens of this species was found at the other stations. The maldanid *Praxillella gracilis* was abundant at many stations and the maximum density was 39/0.2 m^2 at St. 8. Another maldanid *Maldane cristata* was also found at many stations. The eunicid *Eunice longicirrata* occurred at all stations except St. 9 and was abundant at St. 1 (33/0.2 mm^2). The pectinarid *Lagis bocki* was found at all stations except St. 3, but its density was low. The paraonid *Paraonis gracilis minute* was collected only at St. 7 where is located near a yacht harbor and large amount of coarse sand was included in the bottom substrate.

The pennatulid *Scytalium sprendens* were common in many stations except Sts. 3 and 10, the absence may be as for *Lingula* (see above). All colonies were small (<7 cm long).

Number of individuals of each mollusca was not so many. The scaphopod *Episiphon makiyamai* was common at many stations except Sts. 3 and 10 and the small bivalve *Nitidotellina* spp. shows a similar trend. In St. 10, there were many large mollusks (SCUBA observations). The scallop *Patinopecten yessoensis* (Jay) were cultured on shallow bottom in Mutsu Bay. The scallops were not collected by the grab smapler, but many individuals were seen on the bottom surveyed (Table 1).

Many amphipods were collected at many stations. *Cirolana japonensis*, *Orchomenella* spp. and *Ampelisca brevicornis* were common. *Cypridina hilgendorfii* was abundant at St. 3. *Orchomenella pinguis* was the most abundant and 33 individuals per 0.2 m^2 were collected at St. 1. The leptostracan *Nebalia bipes*, which is an indicator of an organic matter rich environment, was found only at St. 3.

The ophiuroids were found at many stations except Sts. 3 and 4. Density of *Ophiopeltis œstuarii* was high and its maximum density was 27/0.2 m^2 at St. 8. By SCUBA diving, it was observed that two or three arms of the ophiurans appear on the bottom surface and the brittle-stars were seen to shake their arms.

The small ascidian *Eugyra glutinans* was abundant at St. 8 (11/0.2 m^2).

Species richness and individual density were comparatively lower at Sts. 3 and 10 (20 and 19) than at the other stations (30–46 species). Species diversity index was also low at these two stations. There were no stations exclusively demoinated by one or a few species; and many species having the density more than average frequency were found at each station. So, Pielou's equitability index (J′) showed comparatively high values (0.79–0.91), except St. 5 (0.71).

Table 2.
Macrobenthic animals collected at each station (Number of individuals per 0.2 m^2)

Sampling stations	1	2	3	4	5	6	7	8	9	10
Coelenterata										
1. *Cavernularia abesa* Milne Edwards et Hailme					1					
2. *Anemonactis mazelii* (Jourdan)									1	
3. Actiniaria sp.								1	3	
4. *Scytalium sprendens* (Thomson et Henderson)	20	9		1	6	4	1	3	1	
5. Pennatulida sp.	2	5			1	1				
Plathelmintes										
1. Plathelmintes sp.					1				3	
Nemertinea										
1. Nemertinea sp.	1		2			1	1	1	1	
Sipunculoidea										
1. Sipunculoidea sp.	1			1	1	1				2
Annelida										
1. Sigalionidae sp.					1					
2. *Eteone longa* (Fabricius)						1				
3. *Eumida sanguinea* (Oersted)					1					
4. *Anaitides* sp.	1				2			1		
5. Phyllodocidae sp.							1			
6. *Syllis* sp.							1			1
7. *Typosyllis* sp.										1
8. *Nephtys polybranchia* Southern		1					2	1		
9. *Nephtys ciliata* (O.F. Müller)									1	
10. *Nephtys* sp.								1		
11. *Sigambra tentaculata* (Treadwell)							1			
12. *Neanthes succinea* (Frey et Leuckart)					1					
13. *Nereis grayi* Pettibone				1						
14. *Nereis* sp.				1				1		
15. *Platynereis bicanaliculata* (Baird)	3				1	8	3		5	
16. *Dorvillea matsushimaensis* Okuda et Yamada						2	3		1	2
17. *Eunice longicirrata* Webster	33	6		9	18	3		2		
18. *Lumbrineris japonica* (Marenzeller)	1									
19. *Lumbrineris* sp.						1		1		
20. *Glycera capitata* Oersted	2	3	1	3	3	1	1	3	1	1

Table 2. Continued.

	1	2	3	4	5	6	7	8	9	10
21. *Glycera* sp.	1	1			1					
22. *Glicinde nipponica* Imajima	2	1	5		1	1	1	1		
23. *Haploscoloplos* elongatus (Johnson)		7	1		1	1	2		1	
24. *Spio borealis* Okuda										1
25. *Spio filicornis* (O.F. Müller)						1		1	1	
26. *Spio* sp.				2	2					
27. *Nerinides* sp.				1						
28. *Spiophanes bombyx* (Claparéde)	3	2		1	96		1	1	1	
29. *Paraprionospio pinnata* (Ehlers)				10						
30. *Laonice cirrata* (Sars)	3	4			2		1			
31. Spionidae sp.									1	
32. *Paraonis gracile minute* Hartmann-Schröder							16			
33. *Paraonides nipponica* Imajima			1							
34. Paraonidae sp.										2
35. *Polycirrus medius* Hessle					1					
36. *Cirriformia tentaculata* (Montagu)		2			2	2	1	2		
37. *Capitella* sp.				2	2					
38. *Notomastus letericeus* Sars	3			4	6			1	1	6
39. *Magelona japonica* Okuda	1			3	3			2		
40. *Maldane cristata* Treadwell	3			19	5	3		3		
41. *Praxilella gracilis* (Sars)	9	11		8	10	13		39	11	
42. *Lagis bocki* (Hessle)	6	5		5	7	7	3	8	15	2
43. *Brada villosa* (Rathke)									3	1
44. *Pherusa plumosa* (Müller)							1			
45. *Amage auricula* Malmgren						1		1		
46. *Terebellides stroemii* Sars				1				1		
47. *Asabellides sibirica* Wiren	1			2	2				5	
48. *Ampharete arctica* (Malmgren)		4								
49. *Ampharete* sp.				1						
50. *Mellina* sp.	2									
51. *Streblosoma japonica* Hessle					1					
52. *Owenia fusiformis* Delle Chiaje										1
53. *Euchone analis* (Kröyer)	2					1				
54. *Chone teres* Bush		2			3	1				
55. Sabellidae sp.			1							
56. *Thelepus japonicus* Marenzeller						1			2	
57. *Pista* sp.	1									
58. unidentified polychaete (fragment)									1	
59. *Ikeda taenioides* (Ikeda)								3		

Table 2. Continued.

	1	2	3	4	5	6	7	8	9	10
Lophophorata										
1. *Lingula anatina* Lamarck	3			3	7	3	2	3	11	
Mollusca										
1. *Lepidopleurus* (*s.s.*) *hakodatensis* Thiele							10			3
2. *Philine argentata* Gould	1	1	1		3	3		4		6
3. *Hermaea dentritica* (Alder et Hancock)		2								1
4. *Reticunassa beata* (Gould)		1								
5. *Ringicula* (*Ringiculina*) *doliaris* Gould							1			
6. *Cylichnatys yamakawai* (Yokoyama)	3	5					2			
7. *Fronsella fujitanaiana* (Yokoyama)	1							2		
8. *Nitidotellina minuta* (Lischke)		1		3	2	2	2	2	1	
9. *Nitidotellina* sp.	1	4		1	1	1	1	2	1	
10. Veneridae sp.	1			2	1	1				5
11. *Trigenothracia pusilla* (Gould)	1							1		
12. *Macoma* sp.	5	2			1		1			5
13. *Lyonsia ventricosa* Gould	1									
14. *Raeta* (*Raetellops*) *rostralis* (Reeve)								1	2	
15. *Anisocorbula venusta* (Gould)	2									
16. *Clinocardium buellowi* (Rolle)							1			
17. *Mantellum hakodatensis* (Tokunaga)			1							
18. *Mactra chinensis* Philippi			1							
19. *Pillucina pisidium* (Dunker)	2			6	4		2	1		3
20. *Dentalium* (*Paradentalium*) *octangulatum* Donovan	1				1				1	
21. *Episiphon makiyamai* (Kuroda et Kikuchi)	11	6		5	6	7	1	9	2	
Arthropoda										
1. *Ascorhynchus auchenicus* (Slater)		2								
2. *Nebalia bipes* Fabricius			5							
3. *Eucuma* sp.		1								
4. *Gynodiaslylis* sp.							1			
5. *Cypridina hilgendorfii* G.W. Muller			22		2		1	2		
6. *Cirolana japonensis* Richardson	4	8		4	6	3		3	3	
7. *Dynoides dentisinus* Shen									1	
8. *Symmius candatus* Richardson			2				2			
9. *Orchomenella pinguis* (Boeck)	33	6	4	2	13	4	4	3		5
10. *Orchomenella* sp.	2	3	1			1	3	2		
11. Lysianassidae sp.		1	3			1				

Table 2. Continued.

	1	2	3	4	5	6	7	8	9	10
12. *Pontocrates altamarius* (Bate et Westwood)								1		
13. *Stegocephalus inflatus* Kröyer								1		
14. *Ampelisca brevicornis* (Costa)	7	1		5	3	3		1		
15. *Ampelisca* sp.			1							
16. *Jassa falcata* (Montagu)		1					4			
17. *Harpinia miharaensis* Nagata			3							
18. *Corophium* sp.			1							
19. *Eriopisella* sp.								1		
20. Gammaridae sp.								1		
21. *Caprella (Caprella) eximia* Mayer						2	1			
22. *Metapaeopsis dalei* (Rathbun)						1				
23. *Pinnixa rathbuni* Sakai	3								1	
Echinodermata										
1. *Ophiopeltis æstuarii* (Matsumoto)	2	11			3	14	5	27	24	16
2. *Ophiophragmus japonicus* Matsumoto		4			4	1	1	4		
3. *Ophiura kinbergi* (Ljungman)	3					2	1		1	
4. *Ophiopholis mirabilis* (Duncan)							1			
5. *Ophiopholis* sp.		2								
6. *Astropecten scoparius* Valenciennes	2	1		1						
7. *Asterias amurensis* Lütken		1					1			
8. *Luidia quinaria* von Martens		1								
9. *Echinocardium cordatum* (Pennant)			2				1	3	4	
10. *Scaphechinus brevis* (Ikeda)			1							
11. *Labidoplax dubia* (Semper)	1							3	1	
12. *Cucumaria chronhjelmi* Theel									1	
Protochordata										
1. *Corella japonica* var. *asamusi* Oka				1						
2. *Styela clava* Herdman								1		
3. *Eugyra glutinans* (Moeller)						4		11		
Number of species	44	38	20	30	44	38	40	46	34	19
Number of individuals	191	129	59	108	239	108	89	167	112	64
Species diversity (H′)	4.42	4.80	3.43	4.33	3.88	4.65	4.70	4.39	4.15	3.70
Pielou's equitability index (J′)	0.81	0.91	0.79	0.88	0.71	0.89	0.88	0.79	0.82	0.87

Similarity of faunal composition

Similarity of species composition between each two sampling stations was calculated using Kimoto's C_{Π} index, degree of overlap (Kimoto, 1967):

$$C_{\Pi} = \frac{2\sum_{i=1}^{S} n_{1i}\cdot n_{2i}}{(\sum \Pi_1{}^2 + \sum \Pi_2{}^2)\, N_1 \cdot N_2} \qquad 0 \leqq C_{\Pi} \leqq 1$$

$$\sum \Pi_1{}^2 = \frac{\sum_{i=1}^{S} n_{1i}{}^2}{N_1{}^2}, \qquad \sum \Pi_2{}^2 = \frac{\sum_{i=1}^{S} n_{2i}{}^2}{N_2{}^2}$$

n_1: number of individuals at St. 1, n_2: at St. 2
N_1: total number of individuals at St. 1, N_2: at St. 2

If overlap is complete, the index is 1, and if there is no overlap, it is 0. The results are shown in Fig. 3.

	1	2	6	8	9	10	4	5	7	3
1		0.577	0.464	0.297	0.191	0.233	0.443	0.298	0.194	0.104
2			0.731	0.632	0.525	0.376	0.344	0.223	0.280	0.057
6				0.827	0.764	0.503	0.430	0.163	0.300	0.044
8					0.726	0.456	0.362	0.163	0.187	0.060
9						0.587	0.244	0.144	0.283	0.014
10							0.125	0.095	0.317	0.051
4								0.211	0.091	0.014
5									0.094	0.044
7										0.093
3										

<0.1 0.1-0.3 0.3-0.5 0.5-0.7 >0.7

Fig. 3. Similarity index (Kimoto's C_{Π} index) of faunal composition between sampling stations.

Species composition between Sts. 2, 6, 8 and 9, which were located about 300–400 m offshore, was very similar. Dominant species were the pectinarid *Lagis bocki*, the maldanid *Praxillella gracilis*, the ophiuran *Ophiopeltis æsturaii*, the nereid *Platynereis bicanaliculata* and the brachiopod *Lingula anatina*.

Fauna at St. 3 did not look like the fauna at the other stations. Many species appear only at this station: the paraonid *Paraonides nipponica*, the amphipod *Harpinia miharaensis*, the bivalve *Mantellum hakodatensis*, the bivalve *Mactra chinensis*, the leptostracan *Nebalia bipes* and the heart urchin *Echinocardium* *cordatum* etc., and density of the myodocod *Cypridina hilgendorfii* was high only at St. 3. Even common species obtained in this survey had a trend not to be found frequently at St. 3. Growths of the seagrass *Zostera marina* were observed around St. 3, as well as the sand dollar *Scaphechinus brevis*, and the substrate was well sorted fine sand. These may affect the faunal composition as well as strong wave movement.

The similarity index between Sts. 1 and 2 was relatively high (0.577) but faunal composition of these stations was not resemble to the other stations.

Distribution of Lingula anatina

Living specimens of *Lingula anatina* were collected at many stations and their size distribution was shown in Fig. 4. Dead shell or shell fragments were also seen on and in the bottom substrate. The density sampled with the grab sampler was slightly different from the data obtained by direct counting (SCUBA diving). By grab sampling, living specimens were not collected at Sts. 2, 3 and 10, but it was observed by SCUBA diving that many *Lingula* inhabit at St. 2. *Lingula* has long burrow and gets quickly in the deeper part of the burrow under some stimuli, e.g. approaching of predators or a shock of grab. This is a sampling problem and applicable to other species too.

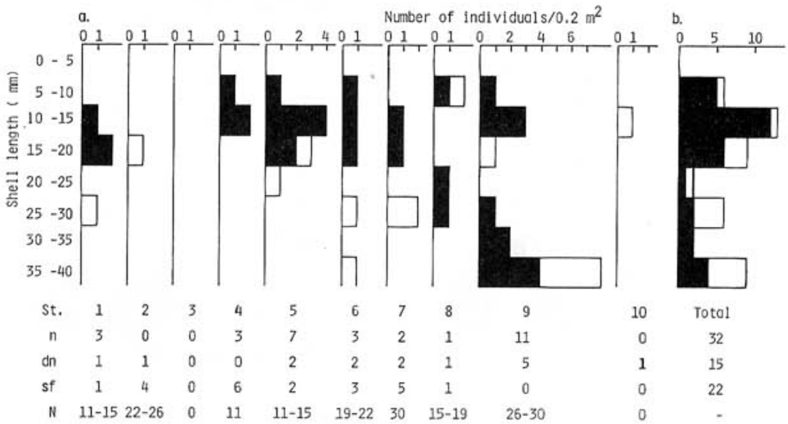

Fig. 4. Shell length of living *Lingula anatina* (black histograms) and the dead shells (white histograms) collected at each station (a) and that of whole specimens (b). n: number of living individuals per 0.2 m², dn: number of dead shells, sf: number of shell fragments, N: number of living individuals per 0.2 m² (SCUBA observation).

Large specimens (>30 mm long) were collected only at Sts. 8 and 9. At St. 3, living specimen, dead shells and shell fragments were not found and only one small dead shell was found at St. 10.

Fig. 4b shows the size distribution of whole *Lingula* specimens collected in this survey. There may be two or more cohorts. One is younger group having

5–20 mm shell length and another is larger group which can be divided into two sub-groups according to colour of their shells: light and dark brown according to their age.

Effect of bottom substrate on distribution of macrobenthos

Fig. 5 shows the relations between grain size composition of the bottom substrate and distribution of benthic animals. Fig. 5a shows a sand type diagram of the stations surveyed. All stations have small amount of silt-clay fraction (<0.06 mm) and content of larger particles was different from each other.

Three types of benthic animals were recognized. First group is the animals which were distributed within wide range of bottom substrate conditions from the

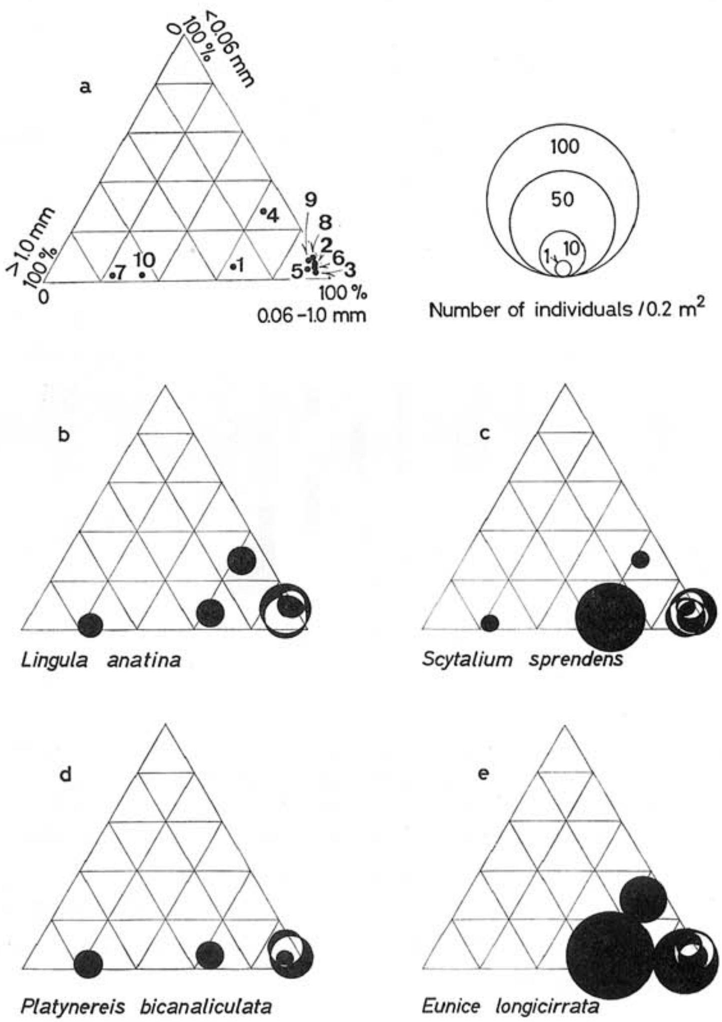

Fig. 5–1

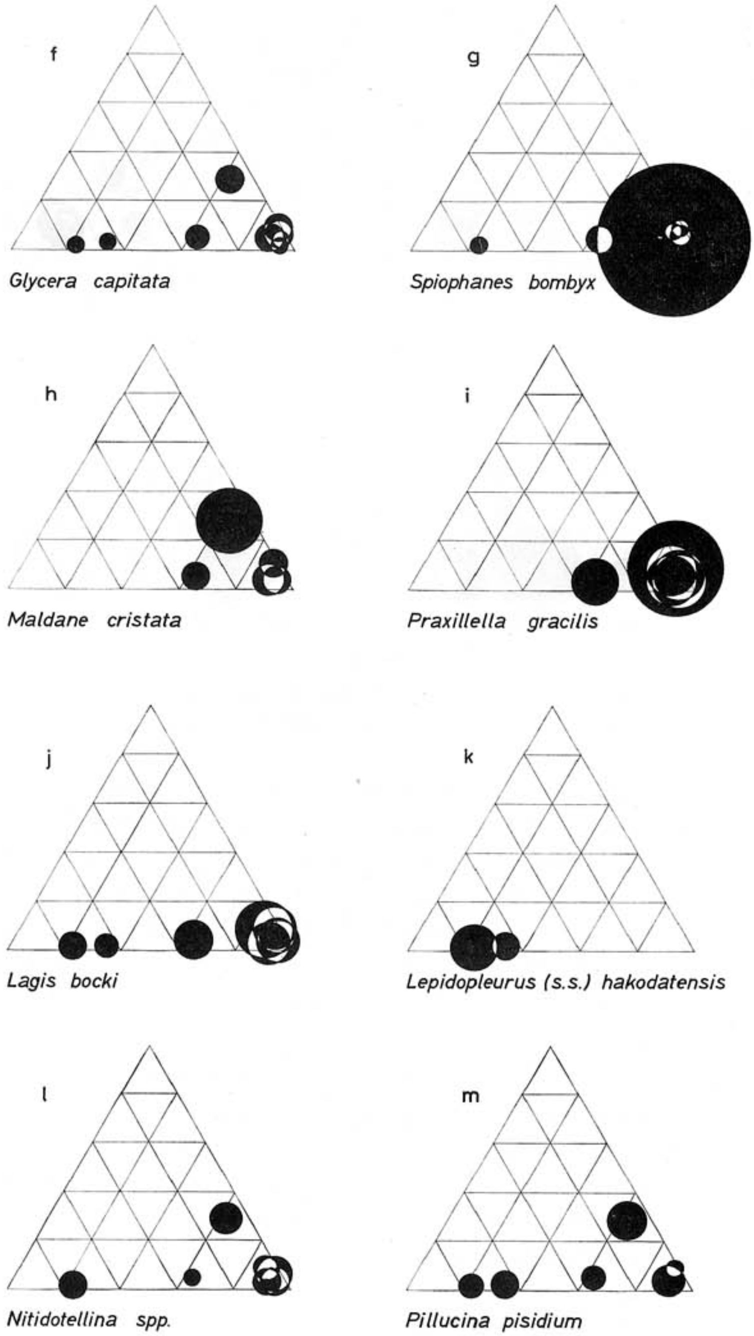
f
Glycera capitata
g
Spiophanes bombyx
h
Maldane cristata
i
Praxillella gracilis
j
Lagis bocki
k
Lepidopleurus (s.s.) hakodatensis
l
Nitidotellina spp.
m
Pillucina pisidium

Fig. 5–2

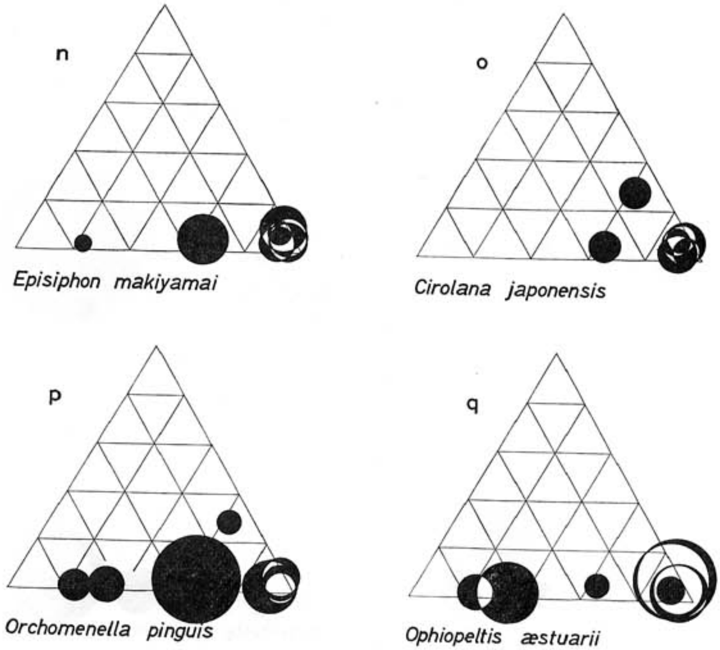

Fig. 5-3

Fig. 5. Sand-type diagram of the sampling stations (a) and relations between bottom substrate and distribution of main benthic animals (b-q).

locations having larger amount of large particles and to ones with a little >1 mm fraction. The brachiopod *Lingula anatina*, the pennatulid *Scytalium sprendens*, the nereid *Platynereis bicanaliculata*, the glycerid *Glycera capitata*, the spionid *Spiophanes bombyx*, the pectinarid *Lagis bocki*, the bivalve *Nitidotellina* spp., the bivalve *Pillucina picidium*, the scaphopod *Episiphon makiyamai*, the amphipod *Orchomenella pinguis* and the ophiuran *Ophiopeltis æstuarii* are included in this group. The spionid *Spiophanes bombyx* was exclusively abundant at St. 5 where the amount of larger fraction (>1 mm) was very few.

Second is the animals which appeared at 0.06–1.0 mm fraction dominated locations: the eunicid *Eunice longicirrata*, the maldanid *Maldane cristata*, the maldanid *Praxillella gracilis* and the isopod *Cirolana japonensis*.

The chiton *Lepidopleurus* (*s.s.*) *hakodatensis* showed a different type of distribution. This gravel loving species was found only two stations where had larger amount of >1.0 mm fraction.

Discussion

It was confirmed that many individuals of *Lingula anatina* inhabit shallow bottoms with a dense number of macrobenthic fauna. The *Lingula* habitat may be characterized by a certain grain size composition of bottom substrate which has large amount of fine and very fine sand. EMIG (1981) reported that *L. reevei* inhabit similar conditions of bottom substrates in Kaneohe Bay, Hawaii. These substrates may be suitable for burrowing and suitable amount of foods may be supplied in such environments.

There were many faunal composition types in this area and *Lingula* inhabited at all stations except Sts. 3 and 10; these stations have each several species which did not occur in the other ones, in regard to the shallow depth and water motion (St. 3) and to the coarse substrate (St. 10). These marked conditions may also be unsuitable for *Lingula*. At Sts. 1, 4 and 7, large amount of very coarse sand was recognized but fine sand was also in existence. Since many *Lingula* were seen at these stations, it was suspected that fine sand plays an important role for living conditions of *Lingula*. In both stations, 3 and 10, there was a conspicuous lack of *Nitidotellina* spp., *Episiphon makiyamai* and *Scytalium sprendens*, which were only present in the stations which *Lingula* occurred. This may be also related to the difference in grain size compositions between the stations.

In Sts. 4 and 5, large population of *Spionidae* spp. occurred: they indicate the presence of fine suspended organic material highly degraded. *Capitalla* and *Paraprionospio*, which are indicators of organic matter rich environments, also occurred at these stations. Organic materials may be accumulated here. On the other hand, Sts. 1 and 2 appear to be the most "clean" sands according to the grain size curves (Fig. 2). In conclusion, community of Sts. 3 and 10 may be related to a low depth sand and all the others to a muddy-sand bottoms. Arrival of organic matter by small rivers through Asamushi, that matter decants through Sts. 6–9 up to 5 and 4, and as Sts. 1 and 2 are the "cleanest", it may be suggested that there is a bottom current north-south surrounding Yunoshima island.

In Japan, many studies on the macrobenthic fauna have been done (MIYADI, 1940a, b; YAMAMOTO, 1950, 1952; HORIKOSHI, 1962, 1970; KIKUCHI and TANAKA, 1978; HAYASHI, 1978; NAKAO, 1982, etc.). In comparison with these studies, the macrobenthic community in this area may be characterized by the high values of species diversity index (H′) and Pielou's equitability index (J′). It is uknown why there are no exclusive dominant species. KIKUCHI and TANAKA (1978) and NAKANO (1982) reported the seasonal changes in the values of species diversity index. The macrobenthic assemblages have to be surveyed several times in a year.

One of interspecific relation between *Lingula* and the other animals is suspected to be on the supply of suspended foods. It is suspected that suitable a amount of suspended material was supplied as food for *Lingula*. The suspended material was supplied by bottom currents or bioturbation by some deposit feeding animals. Many deposit-feeding polychaetes, e.g. the pectinarid *Lagis*, the maldanids *Praxillella* and *Maldane*, were found in the *Lingula* habitat. According to the feeding behaviour of these benthic animals, sediments of bottom surface may be to become easy to be re-suspended by tidal current or waves and utilized as food for *Lingula*. Ophiurans may also cause re-suspension of sediments by shaking arms. Similar role of sediment reworking by the holothurian *Molpadia oobitica* for some suspension feeders was reported by RHOADS and YOUNG (1971). In order to check the interspecific relation, micro-distribution of these animals has to be surveyed and the relations between these animals have to be clarified in future.

The authors wish to express their gratitude to Dr. T. Numakunai and the technical staff members of the Marine Biological Station, Tôhoku University, for their assistance on the survey and advice, and to Dr. T. Habe for his identification of some molluscs. Dr. B.A. Thomassin provided helpful commentary on the manuscript.

This research was partly supported by grants-in-aid from the Centre National de la Recherche Scientifique and the Japan Society of Promotion of Science.

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