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The Distribution and Feeding Guilds of the Polychaete Community in the West Coast off Kunsan, Korea

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한국 서해 군산외해의 저서 다모류 분포와 섭식조합

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The distribution pattern of macrobenthic polychaete worms and their feeding guild structures were investigated along the coastal region off Kunsan (southeastern Yellow Sea) during the winter season. The polychaete worms, the most dominant infauna, comprised 54 species in 30 families and showed their mean density of 300 indiv./m^2 (10 to 1330 indiv./m^2). Dominant species in the study area were *Sternaspis scutata, Lumbrineris cruzensis, Notomastus* sp., *Nephtys polybranchia, Praxillella affinis.* Polychaeres were assigned to 12 feeding guilds and BMX (burrowing, motile, muscular pharynx) was the most dominant feeding guild (26%). Muddy sediments sustained more polychaete worms which showed burrowing (65%), motile (72%), and non-tentaculate strategies (92%), while sandy sediments contained more filter feeders (32%) and sessile (63%), and more tentaculate worms (49%). The sediment grain size was suggested to be the prime factor selecting the polychaete feeding guild.

황해 남서부인 군산외해역에 서식하는 저서 다모류군집의 분포특징과 그들의 섭식조합을 조사하기 위하여 van Veen grab 채집기를 사용하여 24개 장점에서 저서동물을 채집하였다. 총출현 다모류는 30개과에 속하는 54종이었고, 조사해역의 평균 서식밀도는 약 300개체/m^{2}였다. 주요 우점종으로는 *Sternaspis scutata* (10%), *Notomastus* sp. (10%). *Lumbrineris cruzensis* (9.7%), *Nephtys polybranchia* (5.6%), *Praxillella affinis* (5.2%) 등이었다. 주요 우점종의 출현은 퇴적상에 따라 차이를 보였는데 사질퇴적상에서는 *N. Polybranchia, Prionospio pinnata, Spiophanes bombyx* 등이, 니질퇴적상에서는 *S. scutata, L. cruzensis, Goniada maculata* 등이, 나머지는 혼합퇴적물상에서 그들의 주 출현량을 보였다. 다모류의 섭식조합은 12가지 유형으로 나타났으며, 그 중에서 BMX(표층하퇴적물식성, 운동성, 근육질 주둥이)가 출현빈도(19개 장점)나 출현량(전체의 26%)에 있어서 가장 높았다. 각 섭식조합별로 퇴적상에 대한 선호도를 보였는데, 니질퇴적상에서는 표층하퇴적물식성, 운동성 및 비촉수성 다모류가 우세하여 섭식조합 BMX와 BMJ 등이 많이 출현하였고, 반면 사질퇴적상에서는 여과식성, 고착성 및 촉수를 가진 FDT와 SST 등의 섭식조합이 우점하였다.

INTRODUCTION

The distribution patterns of polychaete worms have been closely related with the bottom conditions such as the grain size, the organic content and stability of sediments. Thus the trophic structure of this faunal community may also reflect the spatial and temporal variations of their habitat conditions (Sanders, 1958; Nichols, 1970; Choi and Koh, 1984). The high adaptive capacities of polychaetes on various environments make themselves the only ubiquitous dominant fauna in most soft

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bottoms (Jumars and Fauchald, 1977) and by this merit of them, polychaetes have been used as indicator of some harsh environments, especially in polluted regions (Reish, 1955; 1973).

In many previous works on the benthic community, some dominant polychaetes were olny treated in diverse but broad and general functional groupings (Woodin, 1976). These general and broad scheme on functional groupings frequently used up to recent researches were gradually criticized as being too general to apply to rather detailed and small scale investigations on biological interactions (Maurer et al., 1979; Dauer et al., 1981; Weinberg, 1984). Fauchald and Jumars (1977) attempted to construct a rather detailed but preliminary scheme on the feeding strategies of soft-bottom benthic polychaetes except carnivorous worms, and in a late they postulated the feeding guilds of polychaeteous worms based on the these attempts and an extensive review of the literature (Jumars and Fauchald, 1979).

The feeding guilds were constructed by a joint consideration of food, feeding habits and locomotory patterns. Although this concept of functional group was suggested to be important in ecological studies on the community structures or its dynamics, there were few or partial application on benthic communities (Fauchald and Jumars, 1977; Maurer and Leathem, 1981). This fact impies that practical assigning each species to a specific feeding guild is difficult because some polychaetes show diverse feeding modes depending upon the environmental conditions (Jumars and Fauhald, 1979; Taghon et al., 1980; Dauer et al., 1981), and therefore their feeding characteristics could not be divided into more detailed categories, i.e. feeding guilds.

We dealt with the polychaete worms collected in the eastern region of the Yellow Sea in winter season of 1985. The Yellow Sea, as a shallow epicontinental marginal sea, shows that its sedimentary environment is severely influenced by vast quantity of river discharges and also in a strong tidal regime. Thus the surface sedimentary facies and the distribution pattern of suspended materials show very complicated mozaic and a band

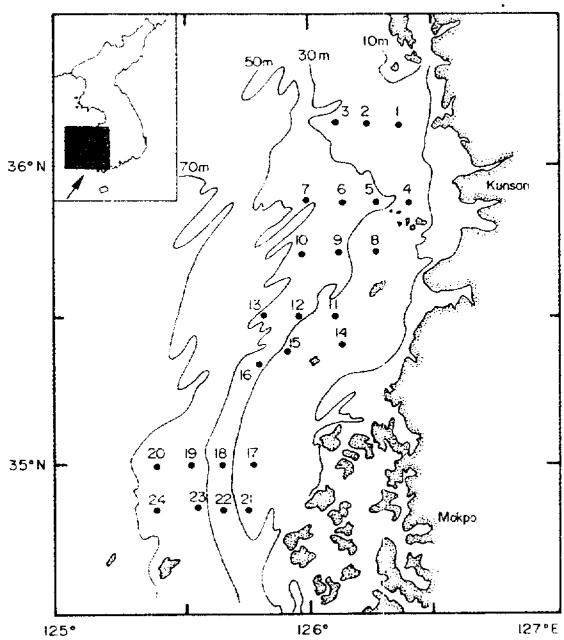

Fig. 1. The bathymetry and sampling sites in the study area.

shaped arrangement running parallel with the coastal line of Korean peninsula (Jeong et al., 1984; Park et al., 1986).

Studies on the benthic faunal communities in the subtidal region of the Yellow Sea have been conducted during recent several years (Yamashita, 1976; Liu et al., 1983; Sun and Dong, 1985; Rhoads et al., 1985; Lee, 1987; Je et al., 1988; Lee and Huh, 1988; Lee and Chin, 1989). Even though dealing with local fauna of the Yellow Sea, there are some taxonomic studies (Lee and Je, 1983;Lee, 1984; Lee and Paik, 1986) and ecological ones in the intertidal (Oh and Kim, 1976; Frey et al., 1987; Koh and Shin, 1988), and in shallow coastal regions (Lee et al., 1983; Shin et al., 1989).

In this study we primarily attempted to classify polychaete worms into feeding guilds and to relate these feeding guilds with the distribution pattern of polychaete community. In addition, the usefullness of feeding guilds in the interpretation of benthic polychaete communities was considered.

MATERIALS AND METHODS

The polychaete worms were collected at 25 sta-

Table 1. Potential feeding guilds of polychaetes in the soft-bottom

	Motile	Discretely motile	Sessile
1. Macrophagous modes Carnivores			
Unarmed pharynx	CMX	—	—
Jawed pharynx	CMJ	CDJ	—
2. Microphagous modes			
1) Filter-feeders			
Tentaculate	—	FDT	FST
Mucous devices	—	FDP	FSP
2) Surface deposit-feeders			
Unarmed pharynx	SMX	SDX	
Jawed pharynx	SMJ	SDJ	—
Tentaculate	SMT	SDT	SST
3) Burrowers			
Unarmed pharynx	BMX	BDX	BSX
Jawed pharynx	BMJ	—	—
Tentaculate	BMT	—	—

tions in the southeastern region of the Yellow Sea by using an improved van Veen grab sampler (0.1 m^2) during 4 day cruise from Feb. 25 to 28, 1985 (Fig. 1). Apart from the sediment for both grain size analysis and organic content measure, the bulk sample was sieved through 1.0 mm^2 mesh screen by *in situ* sea water and the residuals were fixed in 10% neutralized formalin solution. The fauna were sorted into major taxonomic groups and polychaetes were identified and counted.

The entire scheme on the feeding guild of polychaete worms was adopted from that of Fauchald and Jumars (1979). In the soft-bottom the feeding guilds of polychaetes could be classified into 19 caregories (Table 1). Each polychaete worm was assigned to one of this feeding guilds based on whether their gut content remained or not, and direct observation of their gut content, and on the feeding or living position and morphology of feeding apparatus, and on the available infomation on feeding modes from literatures and previous works (Choi and Koh, 1986; 1989).

Species diversity was calculated using Shannon-Wiener's index (H) and evenness by Pielou's index (J). As a species richness value the Hmax (=Ln S) was used. To display the spatial distribution pattern of polychaete worms, cluster analysis using the Bray-Curtis similarity and flexible sorting strategy ($\beta = -0.25$), and polar ordination with the

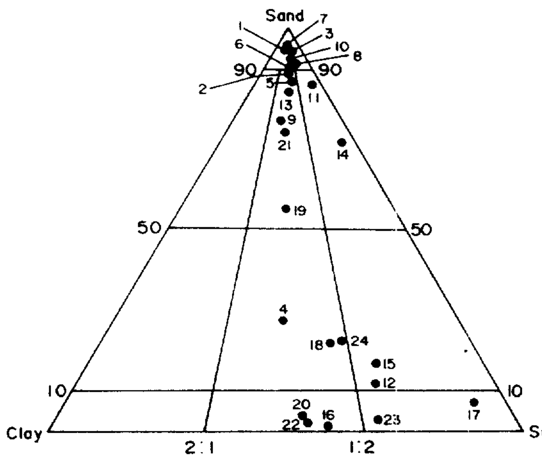

Fig. 2. The ternary diagram showing the grain size composition of surface sediments from 24 sites.

Bray-Curtis similarity were performed.

RESULTS

Bottom Sediments

The particle composition of surface sediment was shown in the ternary diagram, and sediments could be classified into 4 typical sediment types mainly on the basis of the proportion of sand particles (Fig. 2). From the diagram, it is clear that the fine particles have been shifted toward silt size rather than clay size. The sedimentary facies of

Table 2. Sedimentary properties of the study area

St. No.	Sand (%)	Silt (%)	Clay (%)	Mz (φ)	Sort (φ)	Org. Cont. (%)	Sediment Type
1	96.7	1.7	1.6	2.63	0.54	1.43	Sand
2	89.5	5.7	4.8	2.33	1.33	0.98	muddy Sand
3	94.0	2.3	3.7	2.33	0.80	1.21	Sand
4	27.8	38.4	33.8	6.93	3.00	2.74	sandy Mud
5	88.3	4.8	6.9	2.67	1.71	0.79	muddy Sand
6	90.1	4.6	5.3	2.57	1.15	0.91	Sand
7	96.3	1.2	2.5	2.17	0.51	0.55	Sand
8	91.9	5.1	3.0	2.53	0.76	0.88	Sand
9	78.8	9.8	11.4	3.53	2.39	1.27	muddy Sand
10	93.5	2.0	4.5	2.37	1.03	1.42	Sand
11	86.2	11.7	2.1	3.57	0.41	1.45	muddy Sand
12	11.2	62.8	26.0	6.70	2.66	4.18	sandy Mud
13	85.2	6.8	8.0	2.20	1.76	1.78	muddy Sand
14	73.0	26.4	0.6	3.87	0.41	1.55	muddy Sand
15	17.7	60.5	21.8	6.47	2.71	2.87	sandy Mud
16	0.5	58.6	40.9	7.37	2.23	4.32	Mud
17	8.8	85.1	6.1	5.12	1.27	1.75	Mud
18	21.5	48.9	29.6	7.07	2.37	4.56	sandy Mud
19	56.1	22.4	21.5	4.90	3.51	2.87	muddy Sand
20	3.3	50.3	46.4	7.97	2.43	6.13	Mud
21	75.1	11.1	13.8	3.27	3.44	3.48	muddy Sand
22	0.9	53.9	45.2	8.00	2.26	6.07	Mud
23	2.6	67.9	29.5	7.08	2.43	4.27	Mud
24	22.0	49.9	28.1	6.57	2.83	4.61	sandy Mud

the study area could be divided into 2 subregions with an approximate boundary at 35° 30'N according to the sand proportion and sorting value; northern region showed well sorted (0.5-1.5 φ) and high sand portion sediment (more than 80%) except for St.4 located near the outlet of the Keum River, while the other southern part revealed low proportion of sand grains and poorly sorted sediments (above 2.0 φ) (Table 2). This spatial pattern of sedimentary facies would be related partly to the flux pattern of suspended particulate matters toward southeast from the Keum River in winter season (Park et al., 1986).

The organic matter content within sediment reflected its grain size composition and was in the range from 0.6% at sandy to 6.1% at muddy sediments (Table 2). The sandy sediment contained the mean organic matter content of 1.17%. This value is rather higher than that of sandy delta in Kwangyang Bay (Choi and Koh, 1984). In the case of muddy sediment, however, the organic matter content was very low compared with those (higher than 10%) of other coastal or estuarine bays of Korea (Lee, 1976; Choi and Koh, 1984).

Polychaete Community

Distribution and Abundance

The polychaete worms occurred at 24 stations of the study area occupied rather higher proportion among total benthic animal groups with a mean density of 290 indiv./m^2 (Table 3). Benthic polychaete worms, together with other faunal groups such as mollusks and crustaceans, maintain the entire benthic fauna community of this study area (Lee, 1987). The polychaetes collected in the study area were identified as 54 species included in 48 genera and 30 families. The dominant species of polychaete community were *Sternaspis scutata* (11%), *Lumbrineris cruzensis* (10%), *Notomastus* sp. (9.8%), *Nephtys polybranchia* (5.7%), and *Praxillella affinis* (5.1%). Other dominant species occu-

Table 3. Benthic fauna groups collected in the study area (Unit: indiv/m^2)

Fauna group \ Station	1	3	6	7	8	10	2	5	9	11	13	14	19	21
Sediment type	Sand						muddy Sand							
Phylum Nemertinea	2							2		4				
Class Gastropoda							1							
Class Bivalvia	4						3							
Class Polychaeta	15	19	41	27	13	22	36	29	123	21	47	1	41	7
Order Isopoda	1		2						1		1			
Order Amphipoda	4	18	70	104	4	71	8	20	15	13	1	1	12	
Order Decapoda	2		13	1				1	2		2	2	1	2
Order Cumacea									14					
Class Ophiuroidea	6			1										
Total Benthos	34	37	126	133	17	93	48	52	155	38	51	4	54	9
Percent of Polychaeta	44	51	32	20	76	23	75	55	79	55	92	25	75	77

Fauna group \ Station	4	12	15	18	24	16	17	20	22	23	Total
Sediment type	sandy Mud					Mud					
Phylum Nemertinea	3				1	2					14
Class Gastropoda	3										4
Class Bivalvia	2	10	1	19		133	3	3	6		184
Class Polychaeta	40	37	40	13	32	40	21	10	16	10	701
Order Isopoda	1										6
Order Amphipoda	3	3	1	1	9					2	360
Order Decapoda	1			1			5			1	34
Order Cumacea		6		3		2					25
Class Ophiuroidea	1				10						18
Total Benthos	54	56	42	37	52	177	72	13	22	13	1346
Percent of Polychaeta	74	66	95	35	61	22	72	76	72	76	52

Table 4. Dominant polychaete worms occurred in the study area (Unit: indiv/m^2)

Fauna group \ Station	1	3	6	7	8	10	2	5	9	11	13	14	19	21
Sediment type	Sand						muddy Sand							
Sternaspis scutata			2	1			2	1	2		2		1	
Lumbrineris cruzensis			7			1	1		8	1	1			4
Notomastus sp.					2				25	1	23		3	
Nephtys polybranchia	1		7	2		3	1	3	10	2	3		1	
Praxillella affinis		3			1		1	8	19		2			
Prionospio pinnata	3	2	4	5		1	6	5	2					
Amphisamytha japonica	4	1			4		5	3	9	1				
Clymenella sp.						3							5	
Magelona japonica				1			3		3	8				
Glycera chirori			8						5	2	2			
Spiophanes bombyx	1	3		11	2				2					
Tharyx sp.				3					3		6		4	1
Nereis surugaensis									2				7	
Goniada maculata						2					3		1	
Terebellides horikoshii									8				2	
Sternaspis scutata	5	12	12	2			20	9		7				
Lumbrineris cruzensis	7	7	11	2			5	5	2	3	5			

Table 4. (continued)

Station / Species \ Sediment type	4	12	15	18	24	16	17	20	22	23	Total
	sandy Mud					Mud					
Notomastus sp.		4	8	1		2					
Nephtys polybranchia	5	1	1								
Praxillella affinis		2									
Prionospio pinnata										1	
Amphisamytha japonica				1							
Clymenella sp.					14						
Magelona japonica	6			1							
Glycera chirori		1				2	1				
Spiophanes bombyx											
Tharyx sp.			1								
Nereis surugaensis		2		1	3				3		
Goniada maculata						9				1	
Terebellides horikoshii		1			3				1		

pied more than 3.0 % were *Prionospio pinnata*, *Amphisamytha japonica*, *Clymenella* sp., *Magelona japonica and Glycera chirori*. These ten species comprised 59.0% of total specimens (Table 4).

The most dominant species in this study, *Sternaspis scutata* occurred at 14 stations and showed its highest density (120-200 indiv./m^2) at sandy mud or muddy sediments within 30 m water depth (e.g. St. 12, 15, 16, 17). It was reported that this species showed its large population at fine sediments of Korean coasts (Yi *et al.*, 1982; Hong and Lee, 1983). *Notomastus* sp. showed an extreme patchy distribution. This species occurred at 9 stations, but showed very high density of 230 indiv./m^2 and 250 indiv./m^2 at only 2 stations (St.9 and St.13), where sediment is coarse and represented by muddy sand (Mz=3.53ϕ and 2.20ϕ respectively). *Lumbrineris cruzensis* was most frequently met species (occurred at 16 sts.). *L. cruzensis* showed its maximum density of 110 indiv./m^2 at sandy mud (St.15) and high density at muddy sediment. *L. cruzensis* has not been found as dominant species in Korean coasts until Lee (1987) reported it as one of dominant polychaetes in the Yellow Sea. Some polychaete worms which showed high population density at coarse sediment such as sand were *Prionospio pinnata* and *Spiophanes bombyx*, and at muddy sand *Nephtys polybranchia*, *Amphisamytha japonica*, and *Praxillella affinis* were found abundant. These species are active burrowers or tube dwellers which seems to be adapted or suitable at sandy sediment environment.

The maximum density and species richness in this area were shown at St. 9 where sediment was muddy sand, and organic content within sediment was very low (only 1.3%). This high density seems to be related with the co-occurrence of 3 dominant species: *Nephtys polybranchia*, *Praxillella affinis*, and *Notomastus* sp., all occupied this station with high density. At St.14, though its sediment type was muddy sand, only one polychaete worm was collected and other benthic fauna were also scarse. The remained stations showed their densities in the range of 70 to 460 indiv./m^2, and the overall mean density was estimated as 290 indiv./m^2. The species diversity was different along depth and grain size or facies (Fig. 3). The maximum diversity value was at muddy sand facies, while mud or sand facies showed lower diversity value. At each sedimentary facies the maximum diversity was at intermediate water depths.

The spatial distribution pattern of polychaete worms was analysed by clustering and polar ordination. The study area was composed of two station groups, one from sandy dominant stations and the other from mud dominant stations (Fig. 4). The result of polar ordination also showed a similar pattern to that of cluster analysis (Fig. 5). Station groups are arranged along an oblique direction of two component axis.

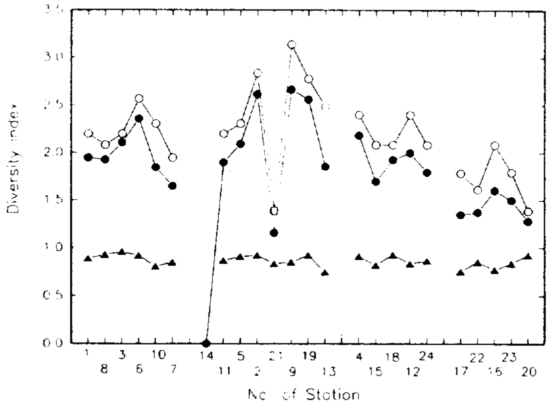

Fig. 3. Species diversity of each site in the study area. Sites were first arranged according to sediment types and next to water depth (from left toward right: sand facies, muddy sand, sandy mud and mud facies; in each facies, from shallow to deep sites). (Diversity (H'): ●, Hmax: ○, Evenness (J): (▲)

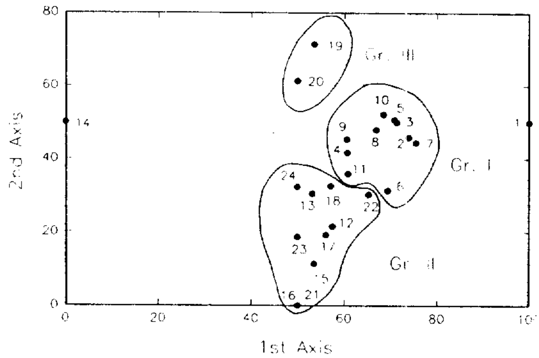

Fig. 5. Polar ordination of 24 sites based on polychaete abundance data. The site gorups classified by cluster analysis were enclosed by solid lines.

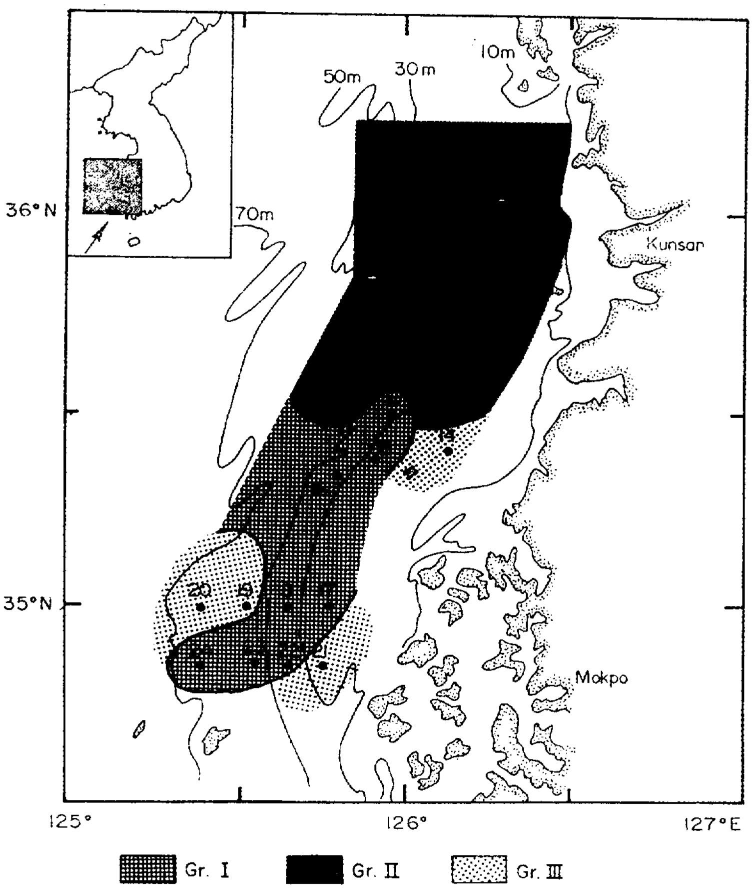

Fig. 4. Spatial distributions of 3 site groups clustered by fexible sorting strategy ($\beta = -0.25$) and Bray-Curtis disimilarity based on the polychaete abundance data in the study area.

Table 5. The spatial distribution of 12 feeding guilds of polychaete worms (uint: indiv./ 0.1 m^2)

St. No.	Sed. type	Feeding Guilds CDJ	CMJ	CMX	SST	SDT	SMT	SMX	BSX	BMJ	BMX	FDT	FST
1	S		2		6			1			1	4	
3	S				4		2		3	1	1	8	
6	S	11	7		2					8	7	4	2
7	S	2	4			4					1	16	
8	S			1	5				1		2	3	1
10	S	2	4		1				3	1		12	
2	mS	1	6	2	8	3	3	1	1	1	3	6	1
5	mS		3	2	3	1	1		8		1	5	5
9	mS	5	12	2	26	6	1	1	19	17	30	5	
11	mS	4	2	1	1	8	3			1	1		
13	mS	5	3			6			2	1	29		
14	mS			1									
19	mS	4	8		2	4	1		5	2	12		
21	mS	1	1			1				4			
4	sM	2	6	1		6	3	1		7	13		1
12	sM	2	3		1	1			2	8	21		
15	sM	6	1			2				11	20		
18	sM	5	1		1	1				2	12		
24	sM	5	3		8				14	1			1
16	M	12	1							5	22		
17	M	5		1	3		1			5	9		
20	M		3		1					6			
22	M	5					1			3	7		
23	M	1					1			5	2	1	
FREQ.		18	18	8	15	12	10	4	10	19	19	10	6
INDIV.		78	70	11	72	43	17	4	58	89	186	64	11
%		11	10	2	10	6	2	1	8	13	26	9	2
SPP.		8	7	2	7	5	3	2	2	6	7	4	1

Feeding Guilds

Assigning each polychaete worms to a feeding guild resulted in total 12 feeding guilds. The spatial distribution of each feeding guild was shown in Table 5. According to the feeding modes, four types were first recognized: i) carnivorous, ii) surface deposit feeding, iii) subsurface deposit feeding, and iv) filter feeding. For carnivores, three kinds of feeding guilds could be identified in terms of degree of mobility and feeding apparatus, and these were abbreviated as CDJ (carnivorous-descretely mobile-jaw), CMJ (carnivorous-mobile-jaw) and CMX (carnivorous-mobile-other feeding apparatus). For the same manner, surface deposit feeders and subsurface deposit feeders were assigned into four and three feeding guilds respectively, and abbreviated as follows: SST, SDT, SMT, SMX and BSX, BMJ, BMX. Filter feeders were assigned two feeding guilds, FST and FDT.

Polychaete worms categorized in the feeding guild of BMX occurred at 19 stations and showed the highest abundance (26.4%), and comprised 7 species in the study area. The feeding guilds of SST, BMJ and CDJ each showed also rather high abundance and included 7 or 8 species, whereas CMX, SMX and FST showed relatively very few species (1 or 2 species) and very low abundance (less than 2% of total individuals).

Apart from the stations with very low density, each station showed at least 5 or 6 feeding guilds. All feeding guilds (12 kinds) were found at St.2 and 10 feeding guilds except FST were occurred at St. 9 where polychaetes showed the most abun-

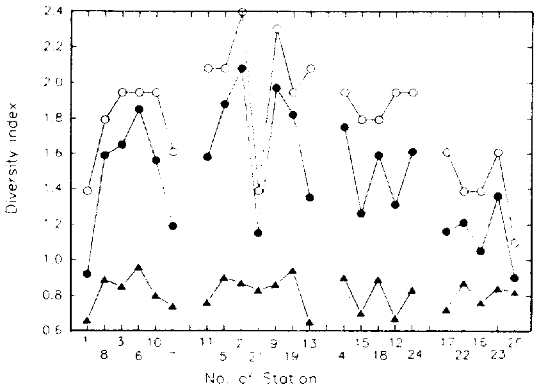

Fig. 6. Diversity index of each site based on the abundance data of feeding guilds. (Diversity (H'): ●, Hmax: ○, Evenness (J): ▲)

dant and richest species. The feeding guild of BMX (burrowing, motile, other feeding apparatus) showed its dominance at 7 stations (St.4, 9, 12, 13, 15, 16, 19), showing their density of more than 100 indiv./m^2. At three stations (St.9, 15, 16), there are a trend to indicating co-existence of 2 or more feeding guilds together with BMX. For example, 5 feeding guilds (CMJ, SST, BSX, BMJ, and BMX) co-occurred with high density at St.9, and high occurrence of BMJ-BMX and CDJ-BMX showed at St.15 and St.16 respectively. For some other feeding guilds each also showed its dominance at a specific station (e.g., CDJ at St.6; SST at St.7; SDT at St.10; BSX at St.24). We calculated the diversity index based on the feeding guild data to see the spatial composition of guilds (Fig. 6). From sandy bottoms to muddy sediments feeding guild diversity gradually declined; the maximum value appeared at muddy sand, and the minimum value at mud substrates.

Mud content may be a convenient factor reflecting the sedimentary property of habitat conditions of benthic infauna. The proportion of each component of feeding modes, position and organ was plotted against mud content (Fig. 7). Carnivores showed no clear correlation with mud content, but burrowers are abundant at high mud content whereas surface deposit feeders and filter feeders showed their high density at sediments with low mud content or at high sand content. The distribution trend between mobility or feeding organ

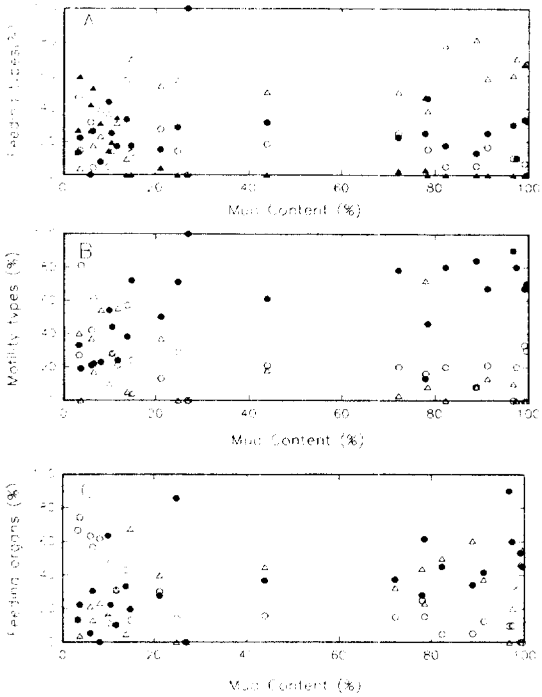

Fig. 7. The proportion of each component of feeding guild strategy along mud content of sediment. (A) Feeding modes; carnivores (●), burrowers (△), surface deposit-feeders (○), filter-feeders (▲). (B) Motility; motile (●), discretely motile (○), sessile (▲). (C) Feeding organs or morphology; jaw (●), tentacles or palps (○), proboscis or others (△).

and mud content was similar to the feeding modes: worms mobile and with proboscis were abundant at sediments with high mud content, while those sessile or with tentacles abundant at sediments with lower mud content.

The distribution pattern of feeding guilds in relation to the sediment types was shown in Table 6. Except for sandy sediment, polychaete feeding guild of BMX showed the highest density at mixed and fine sediments (muddy sand to mud). At sandy sediment FDT was the most dominant feeding guild. In the case of muddy sediment only CDJ, BMJ and BMX showed rather higher density; other feeding guilds showed very low density less than 10 indiv./m^2. In terms of the distribution pattern of each feeding guild among sediment types, most feeding guilds showed their highest density at muddy sand (i.e. 34% of total mean density), but some feeding guilds showed their specific rela-

Table 6. The composition of polychaete feeding guilds with relation to sediment types. Figures show the mean density of each feeding guilds at each sediment type (unit: indiv./m^2)

Sediment type	St. No.	Spp.	Fedding Guilds CDJ	CMJ	CMX	SST	SDT	SMT	SMX	BSX	BMJ	BMX	FDT	FST
Mud	5	18	46	8	2	8		6			48	80	2	
sandy Mud	5	30	40	28	2	20	20	6	2	32	58	114		4
muddy Sand	8	43	25	44	10	50	39	11	3	44	33	95	20	8
Sand	6	31	25	28	2	30	7	3	2	12	17	22	78	5
Sum	24	54	136	43	81	139	126	26	7	88	156	311	100	24

Table 7. The relationships between feeding strategies and sediment types. Figures represent the mean density of each item in all categories. (unit: indiv./m^2)

Sediment	Feeding types				Mobility			Feeding apparatus		
types	Car.	Sur.	Bor.	Filt	Ses.	Des.	Mot.	Jaw	Ten.	others
Mud	56	14	130	0	8	48	144	102	16	82
sandy Mud	70	48	204	4	56	60	210	126	50	150
muddy Sand	79	100	171	28	101	81	195	101	128	148
Sand	73	42	50	83	46	110	92	70	123	56
Sum	278	204	555	115	211	299	641	399	317	435
%	24	18	48	10	18	26	56	35	27	38

tions with sediment types. CDJ (carnivorous, discretely motile, jawed) showed high density at fine sediment whereas CMJ and CMX distributed at a rather coarse sediment. The mean density of SST was high at coarse sediment such as muddy sand and sand. FST also exhibited the same trend as SST.

The numerical compositions of three categories in feeding guilds in relation to the sediment types was estimated as those in Table 7 and summarized as follows.

(1) Feeding types: Carnivores showed no preference to sediment types. Surface deposit feeders and filter feeders showed higher densities at coarse sediment (e.g. muddy sand or sand) than at fine sdiment. However, though lower density at sandy sediment, burrowers did not show so clear trend as surface deposit feeders or filter feeders did to the grain size composition of sediment.

(2) Mobility: Sessile polychaetes occurred with high density at sand or muddy sand, while motile worms showed their minimum density at sand sediment. Most motile species are also burrowing worms, so the density change of motile worms in relation to sediment type showed the same trend as that of burrowers.

(3) Feeding apparatus: The worms with jaws in proboscis showed an inverse pattern in density change to sediment types with those using tentacles when feeding. The former showed high density at fine sediment, but the latter abundant at sand or muddy sand.

DISCUSSION

Distribution

The faunal composition of the benthic community in the study area was very similar to the result of Lee and Chin (1989). The representative species of polychaete worms in the Yellow Sea were different from the typical species of coastal regions. They were reported as follows: *Spiophanes bombyx*, *Ampharete arctica*, *Goniada maculata*, *Nephtys caeca*, *Nothria iridescens*, and *Lumbrineris cruzensis*. The faunal dominance of polychaete worms within benthic community was high (52%). Lee and Chin (1989) also reported high proportion of polychaete worms in a whole benthic community in the range of 35.1% in spring, 1985 to 46.4% in the summer of 1983.

The mean density of polychaete worms was 290 indiv./m^2. This value is in the similar level from the continental shelf of the East Sea (Sea of Japan) (Choi and Koh, 1990), and is rather higher than the overall density of polychaetes of the southwestern Yellow Sea reported by Lee and Chin (1989) to be in the range of 169 indiv./m^2 in Aug., 1983 to 244 indiv./m^2 in Nov., 1984. Compared with those of Kwangyang Bay (490 indiv./m^2) located at southern coast of Korea in summer season (Choi and Koh, 1984), however, the mean polychaete density of this study area is very low.

The maximum density of polychaetes according to the sediment type appeared at muddy sand (mean density of 380 indiv./m^2), whereas lower densities at mud and sand sediments (212 to 231 indiv./m^2). This distribution trend of higher density at mixed sediment than at fine or coarse sediments was also shown in the coastal regions (Choi and Koh, 1984) and in the broad shelf area (Choi and Koh, 1990). This sediment-animal density relation has been well known (Gray, 1974).

The orgnaic matter content of fine sediments was lower than those of other coastal regions; maximum value of 6.13% at muddy sediment of 46.4% clay. This low organic content of fine sediment may be partly explained by the source of particles and their longer suspension time before settling on the bottom sediment. The proportion of clay or sand particles showed no clear relationship with the mean density of species richness in contrast to the results from Sanders (1958) and Nichols (1970); only at low values less than 10% of clay, the density showed a weak positive relation with the proportion of clay particles. This suggests that the polychaete worms, except those in the sandy sediment containing less than 10% of clay, should be more suffered from the substratum instability by physical factors such as waves and tidal currents rather than biological or other factors like food, competition and predation especially in winter season.

Feeding Guilds

The feeding guilds of polychaete worms in this study comprised 12 guilds among total 24 kinds of feeding guilds (Fauchald and Jumars, 1979), which including 5 feeding types (herbivore, carnivore, filter feeder, surface deposit feeder, subsurface deposit feeder), 3 mobility patterns (mobile, descretely mobile, sessile), and 4 morphological structures used in feeding (jaws; pumping apparatus; tentacles; eversible sac-like pharynges). Among them 3 herbivorous feeding modes are excluded in our feeding scheme because herbivores are typical worms dominant at hard bottoms or seagrass beds where algal species or seagrass is abundant as their food items, and because there are no marine macroflora and only planktonic and benthic microflora are predominate.

Among 12 feeding guilds in this area, BMX (burrowing; motile; muscular pharynx, not using jaws or tentacles when feeding) was the most dominant feeding guild (26.4%). *Sternaspis scutata* and *Notomastus* sp. were main contributors to this BMX guild. The main habitat of these two species was muddy sediments with high total organic matter. Thus the BMX guild seems to be associated with fine sediments (Table 6) and this fact showes a similar trend with the result of Maurer and Leathem (1981) though dominant species and species composition are different. Other four polychaete feeding guilds which occupied more than 10% of total density were CDJ, CMJ, SST, and BMJ. However, considering that sandy or muddy sand prevailed overall the study area, it is a remarkable phenomenon that filter feeding modes such as FDT and FST are found with very low density (Table 4).

Maurer and Leathem (1981) reported high density of CMJ was associated with coarse grained sediment, and suggested that the movement of motile carnivores would be enhanced by a large volume of pore space between coarse grains and therefore this relationship would give some functional advantage to the CMJ guild. The sedimentary preferences of CDJ and CMJ is different; polychaete worms of CDJ guild possess tubes and their movements are restricted within very short distances and thus they will require stable substrata and sufficient food. The high density of CDJ at muddy sediment in this study (Table 6) may reflect above statements.

The spionids are considered to be ditrophic (Jumars and Fauchald, 1979; Maurer and Leathem, 1981). They feed on detritus of surface deposit in a calm condition, but change their feeding mode to the suspension feeder when high particulate fluxes exist or current velocity increases (Taghon *et al.*, 1980; Dauer *et al.*, 1981). Thus Maurer and Leathem (1981) assigned the spionids to the new feeding guild of F-SD-SDT (filtering and surface deposit feeding; sessile or discretely motile; tentaculates). We assigned the spionids to the FDT guild; the spionids build sandy tubes or make mucus-lined burrows, and they mainly occurred at sandy sediment where tidal current probably predominate other physical environmental factors. Therefore the main feeding mode of them may be suspension feeder and this feeding mode will be more advantageous to the spionids than surface deposit feeding.

The relationship between functional groups of benthos and bottom substrata was one of earlier focuses of benthic ecologists. Woodin (1976) distinguished three functional groups of infauna: (1) non-tubicolous, mobile, deposit feeders; (2) filter feeding bivalves; and (3) tube-builders of various trophic types. A functional group includes all organisms which use and affect their environment in approximately similar ways whereas a guild is defined solely on the basis of modes of exploitation of resoures (Woodin and Jackson, 1979). In recent researches on the benthic ecology, above functional grouping classification were criticized to be too general to apply to detailed and small scale investigations on the biological interactions (Weinberg, 1984).

First we can consider the within-sediment comparison of each parameter of feeding strategies, that is, feeding types, motility, and feeding apparatus. From Table 6, it is clear that muddy sediment sustain more polychaete worms which show burrowing (65%), motile (72%), and non-tentaculate(jawed+pharynx) strategies (92%), while sandy sediment contain more filter feeders(33%) and sessile (tube building) (63%), and more tentaculate forms (49%). This result of our data is rather different to those of other researches; as Fauchald and Jumars (1979) and Maurer and Leathem (1981) assumed, sessility is generally associated with less dynamic, more stable sedimentary conditions encountered in deeper water. In this study area, however, the sediment of deeper water was represented by mud, where low sessility but high motility was shown in contrast to their predictions. From these facts, it seems that sediment grain size may be the prime factor selecting polychaete feeding guild.

Next, considering the between-sediment comparison of them (Table 7), it can be concluded that at fine mud, macrophage with jaw or non-selective microphage with muscular parynx may be dominant feeding strategy whereas at coarse sediment, selective microphage with tentacles or palps may be the most dominant feeding strategy.

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