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Studies on Feeding Habits of Three Flatfishes, *Cleisthenes pinetorum herzensteini* (Schmidt), *Hippoglossoides dubius* (Schmidt) and *Glyptocephalus stelleri* (Schmidt)

Shigeo HAYASE* and Ikusô HAMAI**

Abstract

The gut contents in three flatfishes, *Cleisthenes pinetorum herzensteini*, *Hippoglossoides dubius* and *Glyptocephalus stelleri* were investigated in 1970–'71. The feeding types of *C. p. herzensteini* and *H. dubius* resemble each other. From spring to summer, these two species increase their amount of feeding on Pisces, mainly juvenile fish of *Theragra chalcogramma* with its occurrence, and on account of its decreasing in number or migration outwards from the inhabiting region of flatfishes from autumn through winter, they change their food to Ophiuroidea. These two species of flatfishes may be considered as fish-feeders, and on the contrary *G. stelleri* as an amphipod-polychaete feeder. Size preference was recognized in *C. p. herzensteini* in case of fish prey, but in *H. dubius* this tendency was not revealed. The amount of food eaten was most numerous in summer in *C. p. herzensteini* and *H. dubius* significantly. These two species always take a greater amount of food than *G. stelleri* does. Both *C. p. herzensteini* and *H. dubius* possess a large mouth, a larger number of gill rakers and sharp canine teeth. On the other hand, *G. stelleri* possesses a small mouth, a smaller number of gill rakers and dull incisors. Intestinal length/total length of alimentary tract ratio and upper jaw length/body length ratio are different among the three species. These types of alimentary organs are correlated with the feeding habits. It is possible to presume that there exists a competition between *C. p. herzensteini* and *H. dubius* as regards the preys, fish and ophiuroids, but they have probably a tendency to relieve the competition for the same prey by turning a prey to another or shifting the feeding times.

Three flatfishes, *Cleisthenes pinetorum herzensteini*, *Hippoglossoides dubius* and *Glyptocephalus stelleri* are generally known as important benthic fishery resources both in commercial yield and quality. For many years, the foods and the feeding habits of fishes have been studied from the points of view divided roughly into two categories, that is, Ivlev¹⁾, Ishiwata²⁾, Hatanaka et al.³⁾ and other workers studied the problems from the viewpoint of nutritional ecology of fishes in the laboratory or field, and De Groot⁴⁾ and others investigated the digestive system with food contents in the field samples and described the interrelationship between the morphology of alimentary tract and the feeding habit in flatfishes and others. These are valuable works on feeding habits of fishes, but very little information

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is available on the mutual competition for the same food items among fishes.

The authors investigated the gut contents of three flatfishes mentioned above and compared their food items among them by factors, i.e. fish species, sexes, ages and seasons, and further the competitive situations for the same prey were discussed.

Materials and Methods

The specimens of *Cleisthenes pinetorum herzensteini*, *Hippoglossoides dubius* and *Glyptocephalus stelleri* were collected by random sampling from the catch of flatfishes on the Mori fishing ground from May 1970 to April 1971.

The monthly numbers of sampled specimens of each species are shown in Table 1.

The frequency distributions of body length for each flatfish are shown in Fig. 1, being divided by sexes and ages. After the morphological measurements of the body were performed, the guts and otoliths were removed from the body and the guts were preserved in 5% formalin solution for about a month. The fish age was determined from the annual rings of the otolith by counting the number of translucent zones on the otolith. The total weight of stomach contents was reckoned as the difference between the total weight of the stomach with the contents and the proper weight of the stomach from which the contents were washed out into petri dishes. The stomach or gut contents were selected, identified, and sorted into animal species or groups as precisely as possible by a binocular microscope. The gut contents were analysed by the occurrence rate and the enumeration method.

Table 1. *Number of specimens of flatfishes with sampling date.*

Period of sampling	*C. pinetorum herzensteini*		*H. dubius*		*G. stelleri*	
	♂	♀	♂	♀	♂	♀
May 5, 1970	38	40	20	37	25	39
Jun. 8, 1970	39	53	8	29	57	34
Jul. 30, 1970	38	22	11	40	40	38
Sep. 8, 1970	2	103	43	66	9	32
Oct. 16, 1970	0	66	54	24	15	64
Nov. 17, 1970	7	54	12	8	4	15
Dec. 17, 1970	13	16	16	11	4	24
Jan. 25, 1971	12	44	17	15	8	5
Mar. 9, 1971	17	36	18	11	6	2
Apr. 22, 1971	32	46	20	29	30	26
Total	198	480	219	270	198	279

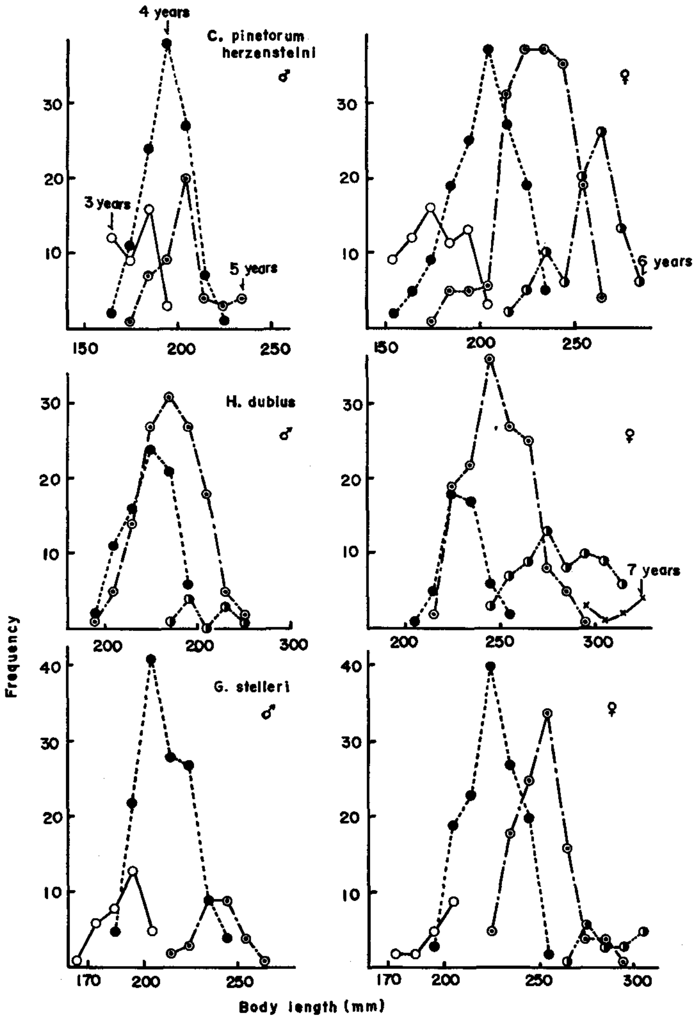

Fig. 1. Frequency distribution of body length of each age class in three species of flatfish.

Results

Food items

In Table 2, the identified food animals in the gut contents are classified into nineteen prey species or kinds, out of which the predominant species were the walleye pollock, *Theragra chalcogramma* and *Ophiura kinbergi* in both *C. pinetorum herzensteini* and *H. dubius* and Amphipoda in *G. stelleri.* Brachyura, Euphusiacea, Isopoda, Cumacea, Mysidacea and Ostracoda were not so much in quantity as these food items were brought in a lump as "other Crustacea" and all **kinds** of animals were eventually classified into seven food items, i.e. Pisces, Ophiuroidea,

Table 2. *Identified species or animal groups in the gut contents.*

Pisces	*Theragra chalcogramma* (Pallas), *Ammodytes personatus* (Girard)
Ophiuroidea	*Ophiura kinbergi* (Ljungman)
Macrura	Caridea (Shrimps), *Pandalus nipponensis* Yokoya
Brachyura	*Chionoecetes opilio* O. Fabricius ?
Euphausiacea	Genera or species unidentified.
Amphipoda	Gammaridea spp. Hyperiidea sp. Caprellidea sp.
Isopoda	*Idotea* spp.
Cumacea	*Diastylis* spp.
Mysidacea	*Mysida* spp.
Ostracoda	*Cypris* sp.
Polychaeta	Nereidae spp. Ampharetidae spp.
Mollusca	*Yoldia* (*Megayoldia*) *thraciaeformis* (Storer), *Theora late* (Hinds) *Thachrhynchus reticulatus* (Mighels)

Macrura, Amphipoda, other Crustacea, Polychaeta and Mollusca: these seven groups of food items were available for the later analyses.

Occurrence rate of food items in the gut contents and comparison of food items in the total samples

After percentages of the groups of food items in the gut contents viz. occurrence rate of the gut in which the said food item was contained were normalized by the arcsine transformation, the transformed values were analysed by the three-way analysis of variance classifying the data into three factors, viz. sexes of fish, ages of fish and the kinds of food items, in every season and every predatory fish (Table 3). Consequently, among the kinds of food items highly significant differences were shown in every season for all predatory flatfishes at the 1% level of significance, but the other two factors, age and sex, showed no significant difference in every season for every fish. This means that there are no differences in the feeding habits among the different ages and also between sexes of the same predator in the ranges here treated. Then, to make clear seasonal and specific differences, age and sex were respectively combined in a category. Thereafter, the three-way analysis of variance among the groups of food items, predatory species and seasons were performed (Table 4). In this case the percentage of food items was transformed by the angular transformation. In this calculation, especially the term of interaction between predator species and food items was highly significant, but the single factor and the other interactions were not. This fact probably means that the percentages of food items are different in relation to the predatory flatfishes. Thus lumped percentages of each food item in the gut contents and their 95% confidence intervals were calculated for every flatfish separated into four seasons (Fig. 2). From the results it was found that *C. p. herzensteini* and *H. dubius* both fed mainly on fishes, especially the juvenile of the walleye pollock, *Theragra chalcogramma*, in spring and summer. In autumn, the percentages with

Table 3. *Three-way analysis of variance on arcsine transformation values of percentage occurence of food items in each flatfish in separate seasons.*

C. pinetorum herzensteini

(Spring)

Source of variance	Sum of squares	df	Mean square	Variance ratio		Remarks
F (Food items)	9285.4107	6	547.5685	17.98	P<0.01	
A (Age)	37.3758	1	37.3758	0.43	insig.	
S (Sex)	55.1884	1	55.1884	0.64	insig.	
Collective error	1635.2583	19	86.0662			(F×A×S)+(F×A) +(F×S)+(A×S)
F×A	345.3543	6	57.5591	0.36	insig.	
F×S	324.8063	6	54.1334	0.34	insig.	
A×S	14.1290	1	14.1290	0.09	insig.	
F×A×S	950.9687	6	158.4948			
Total	11013.2332	27				

(Autumn)

Source of variance	Sum of squares	df	Mean square	Variance ratio		Remarks
F (Food items)	9485.0238	6	1580.8373	11.04	P<0.01	
A (Age)	115.3623	2	57.6812	0.40	insig.	
S (Sex)	375.0657	1	375.0657	2.62	insig.	
Collective error	4583.9384	32	143.2495			(F×A×S)+(F×A) +(F×S)+(A×S)
F×A	1792.0934	12	149.3411	1.31	insig.	
F×S	1276.5048	6	212.7508	1.87	insig.	
A×S	153.2313	2	76.6157	0.68	insig.	
F×A×S	1362.1539	12	113.5128			
Total	14559.4352	41				

H. dubius

(Spring)

Source of vaianrce	Sum of squares	df	Mean square	Variance ratio		Remarks
F (Food items)	10167.1256	6	1694.5209	12.04	P<0.01	
A (Age)	907.0999	1	907.0999	6.45	0.01<P<0.05	
S (Sex)	0.2901	1	0.2901	0.01	insig.	
Collective error	2673.4321	19	140.7070			(F×A×S)+(F×A) +(F×S)+(A×S)
F×A	961.6606	6	160.2768	1.52	insig.	
F×S	945.4301	6	157.5717	1.50	insig.	
A×S	134.2608	1	134.2608	1.27	insig.	
F×A×S	632.0806	6	105.3468			
Total	13747.9477	27				

(Summer)

Source of variance	Sum of squares	df	Mean square	Variance ratio		Remarks
F (Food items)	9753.9099	6	1625.6517	31.70	P<0.01	
A (Age)	5.8514	1	5.8517	0.11	insig.	
S (Sex)	10.1040	1	10.1040	0.20	insig.	
Collective error	974.4345	19	51.2860			(F×A×S)+(F×A)+(F×S)+(A×S)
F×A	216.5686	6	36.0948	1.44	insig.	
F×S	540.9860	6	90.1643	3.60	insig.	
A×S	66.6514	1	66.6514	2.66	insig.	
F×A×S	150.2285	6	25.0381			
Total	10744.2988	27				

(Autumn)

Source of variance	Sum of squares	df	Mean square	Variance ratio		Remarks
F (Food items)	27710.6070	6	4618.4345	46.57	P<0.01	
A (Age)	78.3815	2	39.1908	0.40	insig.	
S (Sex)	45.8023	1	45.8023	0.46	insig.	
Collective error	3173.4908	32	99.1716			(F×A×S)+(F×A)+(F×S)+(A×S)
F×A	1542.8176	12	128.5681	2.15	insig.	
F×S	851.1178	6	141.8530	2.37	insig.	
A×S	61.9531	2	30.9766	0.52	insig.	
F×A×S	717.6023	12	59.8002			
Total	31008.2816	41				

(Winter)

Source of variance	Sum of squares	df	Mean qsuare	Variance ratio		Remarks
F (Food items)	13380.2389	6	2230.0398	9.30	P<0.01	
A (Age)	14.2657	2	7.1329	0.03	insig.	
S (Sex)	301.3929	1	301.3929	1.26	insig.	
Collective error	7674.2429	32	239.8200			(F×A×S)+(F×A)+(F×S)+(A×S)
F×A	4547.1424	12	378.9285	2.25	insig.	
F×S	885.7851	6	147.6309	0.88	insig.	
A×S	223.1472	2	111.5736	0.66	insig.	
F×A×S	2018.1682	12	168.1806			
Total	21370.1404	41				

G. stelleri

(Spring)

Source of variance	Sum of squares	df	Mean square	Variance ratio		Remarks
F (Food items)	18528. 1881	6	3088. 0314	16. 79	P<0.01	
A (Age)	372. 6514	3	124. 2171	0. 68	insig.	
S (Sex)	91. 5201	1	91. 5201	0. 50	insig.	
Collective error	8277. 9496	45	183. 9544			(F×A×S)+(F×A) +(F×S)+(A×S)
F×A	4357. 0651	18	242. 0592	1. 29	insig.	
F×S	369. 8383	6	61. 6397	0. 33	insig.	
A×S	176. 9490	3	58. 9830	0. 32	insig.	
F×A×S	3374. 0972	18	187. 4498			
Total	27270. 3092	55				

(Summer)

Source of variance	Sum of squares	df	Mean square	Variance ratio		Remarks
F (Food items)	14898. 2941	6	2483. 0490	32. 83	P<0.01	
A (Age)	59. 0151	1	59. 0151	0. 78	insig.	
S (Sex)	329. 0743	1	329. 0743	4. 35	insig.	
Collective error	1437. 0728	19	75. 6354			(F×A×S)+(F×A) +(F×S)+(A×S)
F×A	272. 1749	6	45. 3625	0. 42	insig.	
F×S	422. 7195	6	70. 4533	0. 65	insig.	
A×S	89. 6074	1	89. 6074	0. 82	insig.	
F×A×S	652. 5710	6	108. 7618			
Total	16723. 4563	27				

(Winter)

Source of variance	Sum of squares	df	Mean square	Variance ratio		Remrks
F (Food items)	22775. 7615	6	3795. 9603	17. 03	P<0.01	
A (Age)	20. 4753	2	10. 2377	0. 05	insig.	
S (Sex)	199. 8188	1	199. 8188	0. 90	insig.	
Collective error	7133. 4630	32	222. 9207			(F×A×S)+(F×A) +(F×S)+(A×S)
F×A	4441. 1882	12	370. 0990	2. 03	insig.	
F×S	342. 7661	6	57. 1277	0. 31	insig.	
A×S	163. 0201	2	81. 5101	0. 45	insig.	
F×A×S	2186. 4886	12	182. 2074			
Total	30129. 5186	41				

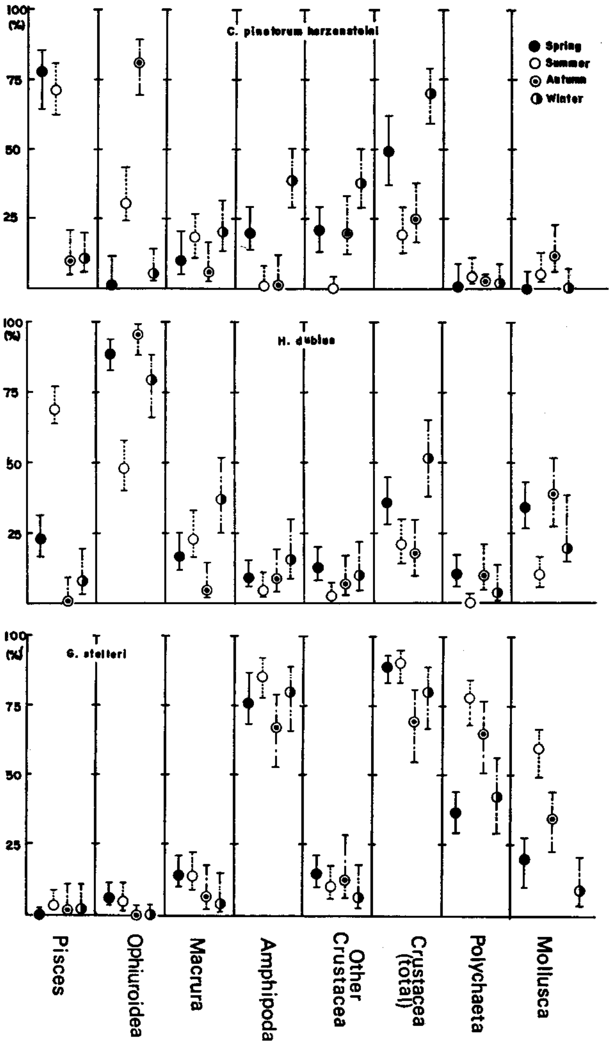

Fig. 2. Seasonal percentage occurrences of food items in gut contents and 95% confidence intervals.

which they fed on fishes decreased and in their place Ophiuroidea predominated.

In *G. stelleri*, the percentage occurrence of food items seemed unchangeable throughout a year. This flatfish feeds on Amphipoda, small Mollusca, Polychaeta and so on, out of which Gammaridea is predominant. The numerical composition of food items in the total specimens of a predatory fish, which is calculated as the ratio of the number of individuals of particular food animals to the total number of all food animals in all the predator specimens separated into four seasons, showed a similar tendency to the occurrence rate of food items (Fig. 3).

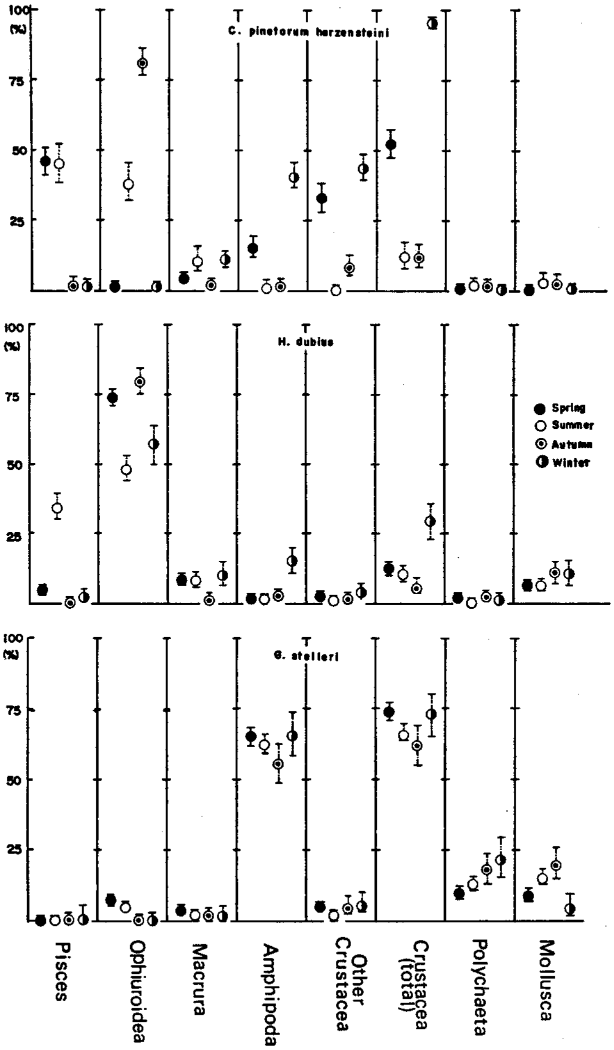

Fig. 3. Composition of food-item groups in total specimens of predators separated in seasons.

Size preference

Out of seven food item groups, only the prey-fish were chosen to confirm the size preference in *C. p. herzensteini* and *H. dubius* which had fed much on fish. In order to determine the size preference to fishes, it is necessary to investigate the mouth size of the predator and the body height of the prey, because the predator swallows a prey in the direction from head to tail. Fig. 4 shows the relation between the mean body height of prey-fish and the mouth size of the predators. In *C. p. herzensteini*, a significant correlation is observable (the correlation coefficient $r=$

Table 4. *Three-way analysis of variance of percentage occurrence of food items among predator species, food items and seasons.*

Source of variance	Sum of squares	df	Mean square	Variance ratio		Remarks
F (Food items)	2351.7630	6	391.9605	1.03	insig.	
S (Species)	542.8309	2	271.4155	0.72	insig.	
G (Season)	80.0100	3	26.6700	0.07	insig.	
Collective error	27250.4773	72	378.4788			(F×S×G)+(F×S) +(F×G)+(S×G)
F×S	17915.6653	12	1492.9721	11.41	P<0.01	
F×G	3965.0484	18	220.2805	1.68	insig.	
S×G	659.9959	6	109.9993	0.84	insig.	
F×S×G	4709.7677	36	130.8269			
Total	30225.0812	83				

0.96, $P<0.01$) excluding an extraordinary point, consequently there exists a tendency in which the predator with a larger mouth size might prefer preys with larger body heights. But in *H. dubius*, no correlation was recognized between the predator's mouth and the size of the prey ($r=-0.61$, $P>0.05$).

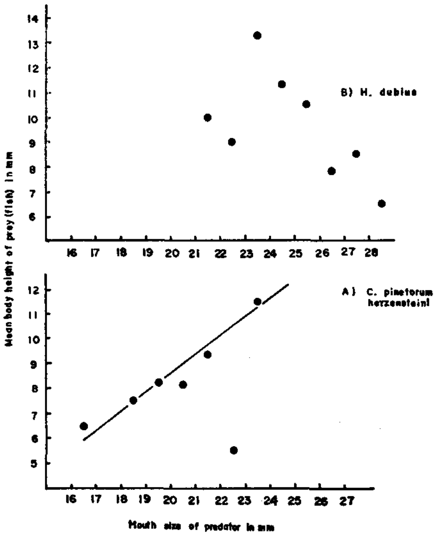

Fig. 4. Relation between the mean body height of prey fish and the mouth size of predator flatfish.

Amount of eaten food

For the quantitative analysis of the stomach contents in the flatfish species the following index was adopted according to Yasuda5):

$$k=\frac{SCW}{BL}\times 10^5$$

where k is the index of the amount of food eaten, SCW is the weight of stomach contents in gram and BL is the body length of the predator in mm.

The frequency distribution of k skewed to the right, so that the logarithmic values of k were available for normalization (Fig. 5). Both *C. p. herzensteini* and *H. dubius* have a similar tendency in which the female has a greater amount of food in stomach than the male does, and both species have taken the greatest amount among three species throughout a year (Table 5 and 6). The upper limit of rejection for log k was calculated by Smirnov's method at the 1% significance level. This value may be reliable while taking account of the maximum amount

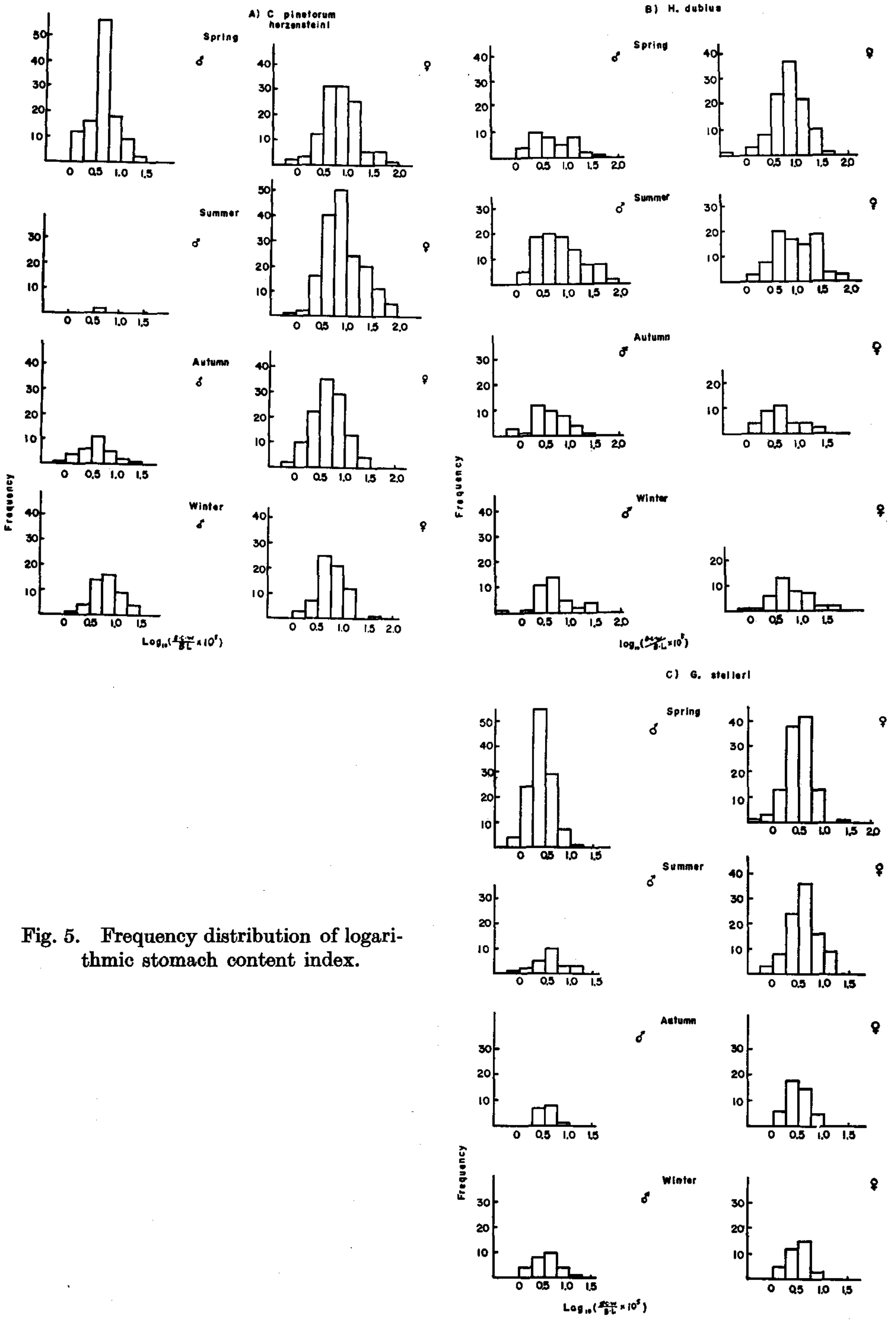

Fig. 5. Frequency distribution of logarithmic stomach content index.

Table 5. *Upper limit of rejection for log k* ($P=0.01$), *mean log k and variance of the mean. Figures in parentheses show antilogarithm of the above value.*

Species	Season	Male				Female			
		N	Mean	V	U.L.	N	Mean	V	U.L.
C. pinetorum herzensteini	Spring	113	0.6275 (4.24)	0.0706	1.3267 (21.22)	113	0.8606 (7.25)	0.1100	1.7336 (54.15)
	Summer					168	0.9373 (8.65)	0.1469	1.9388 (86.87)
	Autumn	29	0.6035 (4.01)	0.1050	1.5143 (32.68)	113	0.6871 (4.87)	0.0975	1.5090 (32.29)
	Winter	47	0.8266 (6.71)	0.0720	1.5548 (35.89)	69	0.7513 (5.64)	0.0850	1.5292 (33.82)
H. dubius	Spring	38	0.7209 (5.26)	0.1369	1.7385 (54.77)	105	0.8586 (7.22)	0.0893	1.6466 (44.32)
	Summer	95	0.8434 (6.97)	0.1938	2.0075 (101.74)	89	0.9852 (9.67)	0.1643	2.0581 (114.31)
	Autumn	42	0.5960 (3.95)	0.0981	1.4517 (28.29)	34	0.6441 (4.41)	0.1129	1.5758 (37.65)
	Winter	95	0.7000 (5.02)	0.1011	1.5758 (37.65)	39	0.7684 (5.87)	0.1180	1.7155 (51.46)
G. stelleri	Spring	116	0.4224 (2.64)	0.0434	0.9706 (9.35)	107	0.5189 (3.30)	0.0578	1.1529 (14.22)
	Summer	24	0.5584 (3.62)	0.0747	1.3413 (21.94)	93	0.6049 (4.03)	0.0596	1.2507 (17.81)
	Autumn	16	0.5401 (3.47)	0.0217	0.9874 (9.72)	44	0.4891 (3.08)	0.0409	1.0402 (10.97)
	Winter	35	0.4741 (2.98)	0.0399	1.0268 (10.64)	27	0.5288 (3.38)	0.0524	1.1765 (15.01)

Table 6. *Result of the test of significance for the mean of log k between flatfish species.*

Interspecific relation	Spring		Summer		Autumn		Winter	
	♂	♀	♂	♀	♂	♀	♂	♀
C. p. herzensteini–H. dubius	insig	insig	—	insig	insig	insig	insig	insig
H. dubius–G. stelleri	**	**	**	**	insig	**	**	**
G. stelleri–C. p. herzensteini	**	**	—	**	insig	**	**	**

insig: $P>0.05$, **: $P<0.01$, — No test because of insufficient number of individuals.

of feeding. As seen from this value and the mean value of log *k*, the amount of food may be the greatest in *C. p. herzensteini* and the smallest in *G. stelleri*. The seasonal changes of food amount are also detectable especially in *C. p. herzensteini* and in the female of *H. dubius*, whereas no change is significantly found in *G. stelleri* (Table 5).

Relationship between alimentary tract of the predator and its feeding habits

To make researches on the types of feeding habits, physical factors were measured, namely the relationships among intestinal length, total length of alimentary tract and body length were elucidated. The ratio of intestinal length to the total length of alimentary tract is the largest in *C. p. herzensteini* (about 73% on the average), the smallest in *H. dubius* (about 70%) and intermediate in *G. stelleri* (about 72%) (Table 7). In other words, the length of the stomach, according to the size of the stomach in proportion to its length, is the largest in *H. dubius.* Generally, it may be true that the size of the stomach is one of the factors deciding the type as a fish-feeder. Investigating the frequency of the rotation of the intestine, it became clear that *C. p. herzensteini* had the most complex intestine, but there might be little relationship between the intestinal and the feeding types in the three flatfishes treated here.

Table 7. *Comparison of mean percentage ratio of intestinal length to total alimentary tract length between flalfish species.*

Species	Mean (%)	Variance	Significance level
C. pinetorum herzensteini	72.69	8.3484	0.01
H. dubius	69.73	4.1988	0.05
G. stelleri	72.16	4.6506	0.01

Table 8. *Comparison of mean values of upper jaw length/body length ralio between flatfish species.*

Species	Mean (%)	Variance	Significance level
C. pinetorum herzensteini	8.45	0.3090	0.01
H. dubius	9.33	0.1881	0.01
G. stelleri	3.23	0.1259	0.01

In order to investigate the relationship between the mouth size and the feeding type, the ratio of the upper jaw length to the body length was examined (Table 8). From the results it is clear that *H. dubius* has the highest ratio (9.3% on the average), the intermediate is for *C. p. herzensteini* (8.4%), and the lowest for *G. stelleri* (3.2%). These facts show that both *H. dubius* and *C. p. herzensteini* have a large mouth, and furthermore they have many sharp canine teeth in their mouths. On the contrary the mouth size of *G. stelleri* is very small and it has small incisors. From the above evidences it is suggested that the former two species may belong to a type of fish-feeder, whereas *G. stelleri* may be likely a type of benthos-feeder.

The number of gill rakers on the hypobranchial arch ranges from 16 to 23

(19.01 on the average) in *C. p. herzensteini*, from 10 to 15 (13.23 on the average) in *H. dubius*, and from 7 to 10 (8.15 on the average) in *G. stelleri*, that is, clear differences in the number of gill rakers are recognized between the flatfish species.

Competition for the same preys

It is observed that three species of flatfish feed on the same kinds of food items although different in quantity. Consequently in order to ascertain the existence of competition for the same preys among three flatfish species, the index of competitive independence adopted by Richards[6)] was used in the present case:

i.e.
$$\mathrm{C.I.} = \{(\mathrm{P}i)^2/(\Sigma\mathrm{P}i \times \Sigma\mathrm{R}i)\} \times 10^3$$

where C.I. is the index of competitive independence, P*i* is the individual number of a given prey (food item) found in the stomach contents of a given predator-species, ΣP*i* is the individual number of the same prey found in all predators, and ΣR*i* is the individual number of all prey taken by a given predator under consideration. In addition to C.I. the degree of resemblance of the prey between the predator-species was estimated by the Spearman rank correlation coefficient (Siegel[7)]):

$$r_s = 1 - \frac{6\sum_{i=1}^{N} d_i^2}{N(N^2-1)} \qquad (-1 \leqq r_s \leqq 1)$$

where r_s is the rank correlation coefficient, N is the number of prey, and d_i is the difference of the ranks for the same prey (food item) which is availed by the oppositional predators. For both C.I. and r_s twelve groups of food items were taken into account. *C. p. herzensteini* and *H. dubius* showed together high values of C.I. for several groups of food items, viz. Pisces, Ophiuroidea and Macrura,

Table 9. *Rank of food items and their index of competitive independence* (C.I.).

Food items	*C. p. herzensteini*		*H. dubius*		*G. stelleri*	
	Rank	C.I.	Rank	C.I.	Rank	C.I.
Pisces	2	120	2	46	11	0
Ophiuroidea	1	62	1	500	4	3
Macrura	5	24	4	36	5	5
Brachyura	11	1	11.5	0	10	2
Euphausiacea	4	186	9	0	12	0
Amphipoda	3	32	5	1	1	511
Isopoda	12	0	11.5	0	7	8
Cumacea	8	3	7	3	6	4
Mysidacea	6	45	8	1	8	1
Ostracoda	10	1	9	0	9	2
Polychaeta	9	0	6	1	2	113
Mollusca	7	1	3	27	3	76

Table 10. *Spearman rank correlation coefficients (r_s) of food items between the predator species.*

Interspecific relation	r_s	Significance level (for a one-tailed test)
C. p. herzensteini–H. dubius	0.785	$>\rho_s\begin{pmatrix}N=12\\P=0.01\end{pmatrix}=0.712$
C. p. herzensteini–G. stelleri	0.098	$<\rho_s\begin{pmatrix}(N=12\\P=0.05\end{pmatrix}=0.506$
H. dubius–G. stelleri	0.456	$<\rho_s\begin{pmatrix}N=12\\P=0.05\end{pmatrix}=0.506$

and therefore these flatfishes should have a tendency of competition for these same preys (Table 9). Between *C. p. herzensteini* and *G. stelleri*, and between *H. dubius* and *G. stelleri* a little high value of C.I. in both species is only shown respectively in Amphipoda and Mollusca. These relationships are also observable in the value of r_s; i.e. only r_s between *C. p. herzensteini* and *H. dubius* is significant at the 1% level (Table 10). Therefore supposing the competition for food, it may occur only between *C. p. herzensteini* and *H. dubius*, and the competitive preys may mainly be Pisces, Ophiuroidea and Macrura.

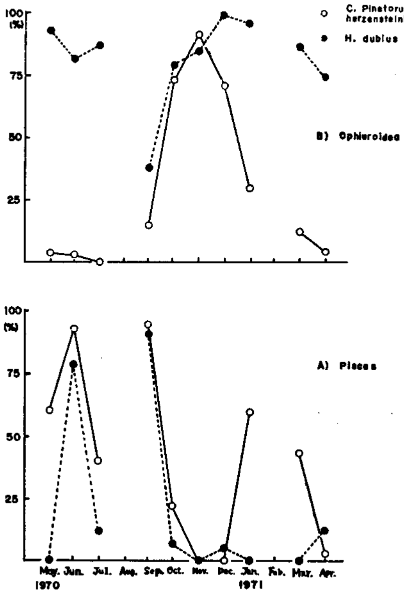

Fig. 6. Monthly change of the percentage occurrence of fish and Ophiuroidea in the gut contents.

But concerning the competition on Pisces and Ophiuroidea, it seems that these two flatfishes have a tendency to avoid competition as much as possible. For example, from winter to spring generally a greater quantity of Pisces were fed by *C. p. herzensteini* than by *H. dubius*, but in this period Ophiuroidea are more frequently fed by *H. dubius* than *C. p. herzensteini* (Fig. 6).

The dredge samples from the habitat area of the flatfishes

To examine the relationship between the benthic community in the environment and the food items in the gut contents, the benthos were sampled by dredging inside the habitat of flatfishes (Fig. 7 and Table 11). By the identification of these samples it was shown that the environmental community resembles the composi-

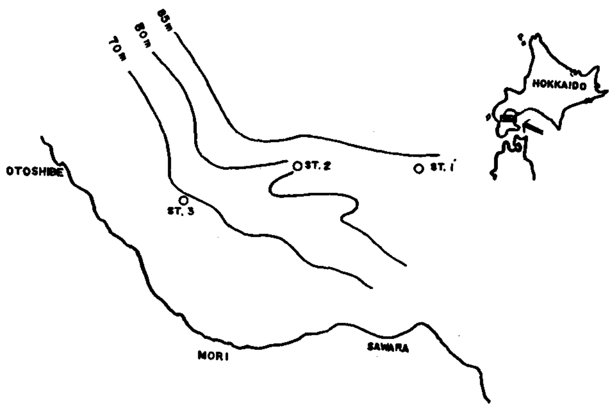

Fig. 7. Map showing the sampling stations by Niino's dredge.

Table 11. *Benthic animals with their individual number in the samples by Niino's dredge.*

Date, station and dredge net	Oct. 6, 1971 St. 1		Jul. 15, 1970 St. 2				Oct. 6, 1971 St. 3	
Kinds of organisms	Minnow net 30 mm mesh	Canvas	Minnow net 30 mm mesh		Canvas		Minnow net 30 mm mesh	Canvas
Schizaster lacunosus (Linnaeus)	1	-	1	1	1	1	-	-
Ophiura kinbergi (Ljungman)	20	5	4	1	5	5	4	1
Gammaridea	-	10	1	-	3	1	-	2
Cumacea	-	-	-	-	1	-	-	-
Cypris sp.	-	-	-	-	1	-	-	-
Ampharete arctica	-	4	-	3	2	1	-	-
Nereidae	-	7	-	1	-	1	-	2
Yoldia (*Megayoldia*) *thraciaeformis* (Storer)	-	-	-	3	-	1	-	-
Tachrhychus reticulatus (Mighels)	1	3	-	-	-	1	-	-
Theora lata (Hinds)	-	3	-	-	-	3	-	-

tion of food items qualitatively (Table 2). Therefore these flatfishes should be also benthos-feeders feeding in the area of their habitat.

Discussion

The important object of the field observation by sampling is to obtain some evidences regarding the natural feeding habits of fishes. The three species of flatfishes were collected by sampling from the catch of flatfishes on the Mori fishing ground, therefore in this way no larva or no juvenile is contained in the sample. So the results from these samples are referred to the fish more than 3 years of age (Fig. 1). As shown in Fig. 2, many juveniles of the walleye pollock were found out in the guts of *C. p. herzensteini* and *H. dubius* during the season from spring to summer. On the other hand, there was a fact that many juveniles of the walleye pollock were caught by set nets from May to June in the same water area. Joining together with these two facts, it is presumed that *C. p. herzensteini* and *H. dubius* prefer the juveniles of the walleye pollock to the other organisms. The walleye pollock juveniles of suitable size for food occur usually from spring to summer in this water area, but during the seasons from autumn to winter they migrate from here to some other area, or they grow too large to be eaten by *C. p. herzensteini* and *H. dubius*, which may substitute Ophiuroidea for the walleye pollock. The problem of size preference has been investigated by Saishu et al.[8] regarding the gurnard, *Chelidonichthys spinousus* (McClelland), and they concluded that there existed a size preference in the gurnard to prey-fish excluding some kinds of shrimps. Also in *C. p. herzensteini* a similar result has been obtained except a case of 22–23 mm mouth size, which comprised only one prey-fish in the stomach of a predator (Fig. 4).

The interrelationship between the morphology of the alimentary tract, food and feeding behaviour has been investigated by De Groot[4] about flatfishes. He concluded that gill rakers were indispensable to fish-feeders, since they prevent the grasped alive prey to struggle out of the mouth. Therefore they have to be large, and on each raker one observes a series of small teeth. Polychaete feeders do not need such large gill rakers, for once their prey has been sucked in, it easily passes on to the stomach. On the other hand, concerning to the stomach, for fish feeders, there need be large stomachs which grasp their relatively large prey at once and swallow it intact. According to this discussion, it may be appropriate to consider *C. p. herzensteini* and *H. dubius* to be likely fish-feeders in view of their alimentary tract, their foods and feeding habits. On the contrary *G. stelleri* is likely a polychaete or amphipod-feeder. In every species although the food items comprise many kinds of prey animals which reflect the benthic community in the habitat, the most important, main preys are restricted to a few groups of animals (Table 3).

The maximum amount of food taken into a gut was estimated by the upper rejection limit of log *k* (Table 5), whose value was highest in summer in every flatfish especially in *C. p. herzensteini* and *H. dubius*. This evidence is also shown in the mean value of log *k*. Consequently summer is the period of the most prosperous feeding, and the depression from autumn to winter may be related to reproduction. The amount of food is greater in *C. p. herzensteini* and *H. dubius* than in *G. stelleri* almost throughout a year (Table 6). There may be no sexual difference of food-amount in every species.

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