STUDIES ON MARINE GAMMARIDEAN AMPHIPODA OF THE SETO INLAND SEA. IV

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With 4 Text-figures

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PART II. SOME ECOLOGICAL INFORMATIONS

1. General Remarks on the Biology of *Orchestia platensis japonica*

Orchestia platensis japonica is well known as one of the "sand-hoppers" among the gammaridean group and commonly inhabits at the high-water marks on the beach; often found in a great abundance under damp seaweed or straw-mat washed ashore, sometimes living under dead leaves in the damp places far above the sea-shore. The animal is a scavenger, showing the feeding habit of a "biting" type, and often seen crowding together and biting at the shucked meat of oyster while the animals are kept in an experimental glass-vessel in the laboratory.

The material was collected once a month from March 1962 to March 1963, at the high-water mark on the beach of Ônoura, Saeki-gun, Hiroshima Pref., where the sampling spot was located just beneath the stone wall, submerged always in the high-tide of each lunar month and covered all over with

Publ. Seto Mar. Biol. Lab., XIII (5), 327–348, 1966. (Article 17)

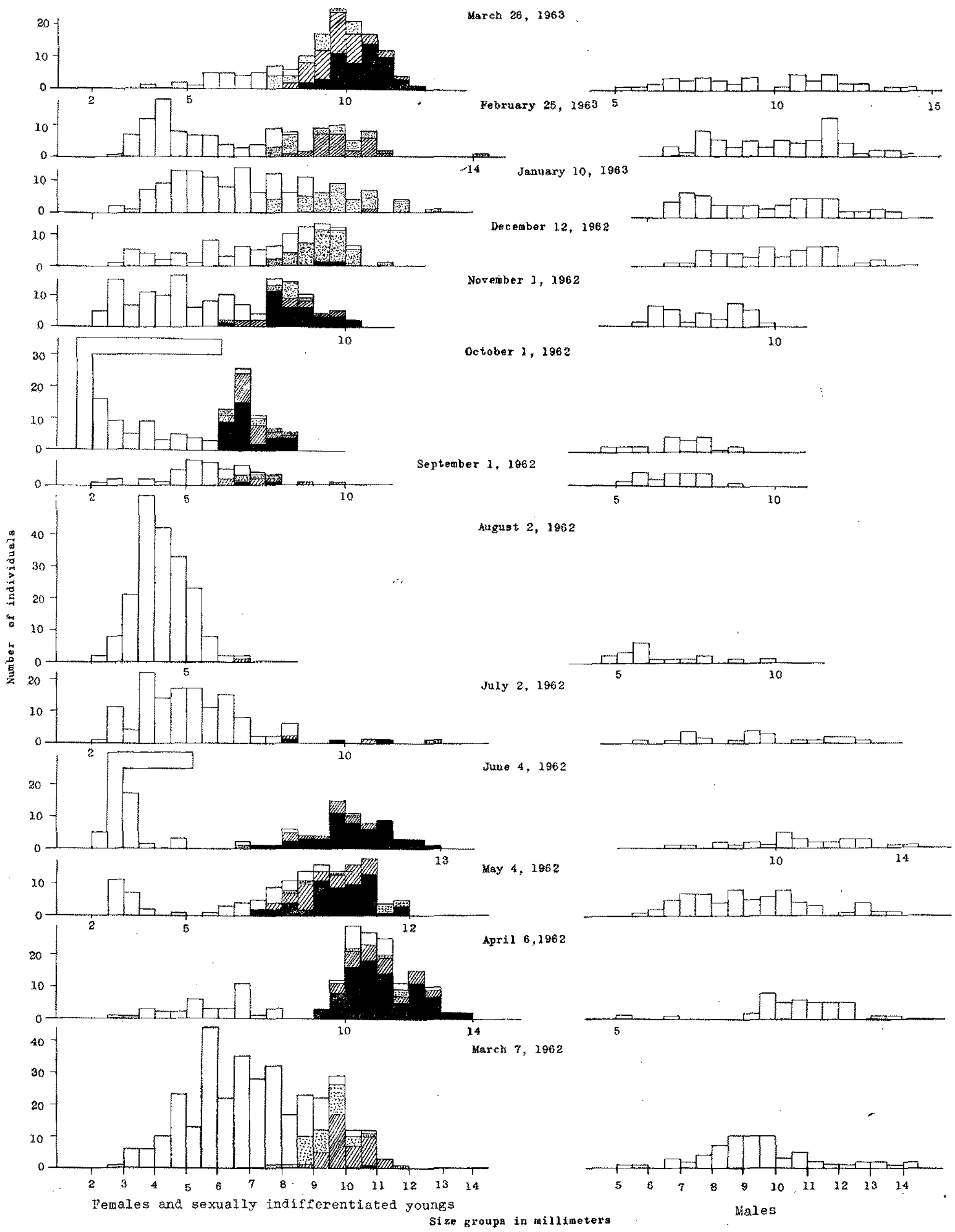

Fig. 45. Seasonal change of size-composition of *Orchestia platensis japonica.* (For female: ■ ovigerous female; ▨ females whose ovary is well developed; ▩ females bearing the empty brood pouch).

empty shells of "Asari". Sampling in each month was made in the daytime of the new moon or the full moon when the tide was outgoing, keeping a constant distance from the stone wall. The specimens were put quickly into the collecting bag by a small elliptical hand shovel.

The length of animals is measured from head to telson along the natural curve of the dorsal line. All the individuals or a part of the total collection of each month were measured and sorted into size groups. Seasonal change of size-composition may be seen by comparing one another the results of analyses of the specimens scooped by shovel in respective months (Fig. 45). The individuals less than 4.5 mm long are defined as the sexually indifferentiated youngs and treated together with the female. Adult females examined are classified into three groups according to the states, ovigerous, with fully developed ovary, or with the empty brood pouch. The number of embryos or youngs within the brood pouch is counted, when the animals are ovigerous.

The spawning appears to continue nearly throughout the year, and therefore it is difficult to define distinctively each spawning group, but it is

Table 2. Collecting data in reference to the investigation on the biology of *Orchestia platensis japonica.*

Date	Time	Age of moon in days	W.T. (°C)	Extracting rate	Material examined				
					Total	Indifferentiated young 4.5 mm>	Female 4.6~6.0 mm	Female 6.1 mm<	Male
7/III	12.00	0.7	10.7	1/4	406	23	80	236	67
6/IV	11.45	1.3	12.0	1/4	212	7	11	154	40
4/V	11.00	29.3	18.0	1/4	208	20	2	119	67
4/VI	10.40	1.6	19.2	1/2	174	75	3	68	28
2/VII	10.30	0.1	21.6	1/2	157	52	45	37	23
2/VIII	11.00	1.6	26.8	1/1	212	125	64	5	18
1/IX	11.10	2.0	27.2	1/1	66	6	20	20	20
1/X	11.50	2.3	24.2	1/1	216	118	12	63	23
1/XI	13.00	3.6	19.9	1/1	181	48	30	71	32
12/XII	11.45	14.9	12.9	2/3	146	12	13	74	47
10/I	11.00	14.2	10.2	1/2	210	19	37	88	66
25/II	11.50	1.0	6.2	1/3	189	38	22	65	64
26/III	11.20	0.6	11.0	1/2	187	1	8	134	44

probable that two active spawnings are seen in the period from spring to early summer and in the autumn season from October to November. The spawning season in spring is more prominent than that in autumn, and the total number of spawns is considered to be most abundant in this season throughout the year, although a large number of the newly hatched small specimens are not shown in the figure; this is probably on account of either the error of samling or of the operation extracting samples from the total specimens collected. Similar seasonal change of size composition and the presence of two main spawning seasons, were also observed at another station on the same beach, at a certain damp place where the kitchen residues were piled up.

Ovigerous females are 6.0–6.5 mm in length at the minimum. For the external appearances of the adult females drawing toward the spawning, the marsupial plates begin to develop at first, in time the ovary comes to mature fully so that the purplish blue mass can be seen through the dorsal chitinous cuticle of the pereion, at this time the marsupial plates have fairly developed, but not yet armed fully with the marginal setae, and then the individuals bearing embryos within the brood pouch come to appear. The moulting will be taken just before the issue of mature eggs into the brood pouch, and after this moulting the so-called "riding position" will be seen again, followed then by a copulative posture immediately before or in the middle of the issue of mature eggs. It is pretty sure that the fertilization takes place outside the body. During the breeding period with embryos within the brood pouch, the marsupial plates develop fully and are densely armed with long marginal setae. After the release of youngs or embryos, the fully developed marsupial plates remain empty for a short period and then fall off in time. Such breeding processes are repeated several times by each adult female during the spawning season. Durations for respective processes (e.g. of riding position, purplish blue state of ovary, of incubation of embryos within the brood pouch, and of retaining the empty pouch), are not made clear as yet; this requires many careful observations in laboratory in future. It is, here, to be noted that the purplish blue state of ovary has never be seen from the outside in all of 434 ovigerous specimens. The mature eggs within the ovaries may all be issued into the brood pouch in a short time.

Thus, as shown in the figure, the females defined as "females whose ovary is well developed" always indicate to be in a state prior to the ovigerous stage, and "females bearing the empty brood pouch" always in a state after the release of youngs or embryos from the brood pouch. The latter is clearly distinguished from the former in having marsupial plates fully developed, but no sign of the purplish blue mass of ovary.

The size of mature ova within the ovary is 0.32 mm–0.43 mm in diameter. The embryonal stages within the brood pouch were provisionally divided into "eggs", "medium", and "advanced" stages, respectively 0.62 mm, 0.71 mm, and 0.79 mm in diameter on an average. In the "advanced" stage, the appendages of the youngs are more or less perceptible through the chorion, and the shape is almost ovoid, 0.83–1.05 mm in longer diameter. The newly hatched young is 1.5–2.0 mm long.

More than 50 percent of ovigerous females bear 5–9 embryos within the brood pouch respectively, but 22 at the maximum in a 10.7 mm long specimen. When a few number of embryos are included within the brood pouch, they are usually consisting of only youngs or embryos of the advanced stage, while when abundant, all or most of them are the eggs of the earlier stages. And it is often met with that embryos in some different stages of development are observed within the same brood pouch. These facts seem to show the possibility that the embryos may hatch or be released from the brood pouch by and by in the order of development. On the other hand, however, it is generally said in some members of both Isopods and Tanaidaceans that the number of the fertilized eggs is reduced by the expulsion of embryos before their development is completed (Howes 1939, p. 290). Anyhow, the number of embryos within the brood pouch is very variable so far as I examined, and no significant correlation could be found between it and the season or the size of mother. If the fertilized eggs in the brood pouch could be counted exactly soon after the issue from the ovary, there might be found any relation between the egg number and some factors.

The gammaridean animal is usually said to live on for about a year. The present specimens fully grown up attain nearly to 15.0 mm long in both sexes. The spawning group seen in March 1963 is likely to belong to the group hatched in the season April to June 1962. Now, taking it into account that the size of the newly hatched specimens is 1.5–2.0 mm long, the average growth rate per a month may be roughly estimated to be about 1.0 mm, although the growth rate naturally differs according to the water temperature. Sex-ratio indicates no positive relation with the season, even though the specimens less than 6.0 mm are excluded.

2. An Observation on the Nocturnal Migration of Benthic Gammaridean Amphipods

The nocturnal migration of gammaridean amphipods inhabiting the sea floor or among seaweeds is one of the most interesting phenomena. The object of this observation was first to obtain the general outline of the upward movement at night, and second to distinguish the species migrating up to the surface waters at night from many benthic amphipods living abundantly both in number of individuals and species on the *Zostera* belt near the low-water mark.

It was planned to see successive changes in the number of individuals at different hours of obsesvation from nightfall to dawn. The result is represented graphically in Figure 46. The "number of individuals" is represented by the number of gammarideans per horizontal haul of a plankton

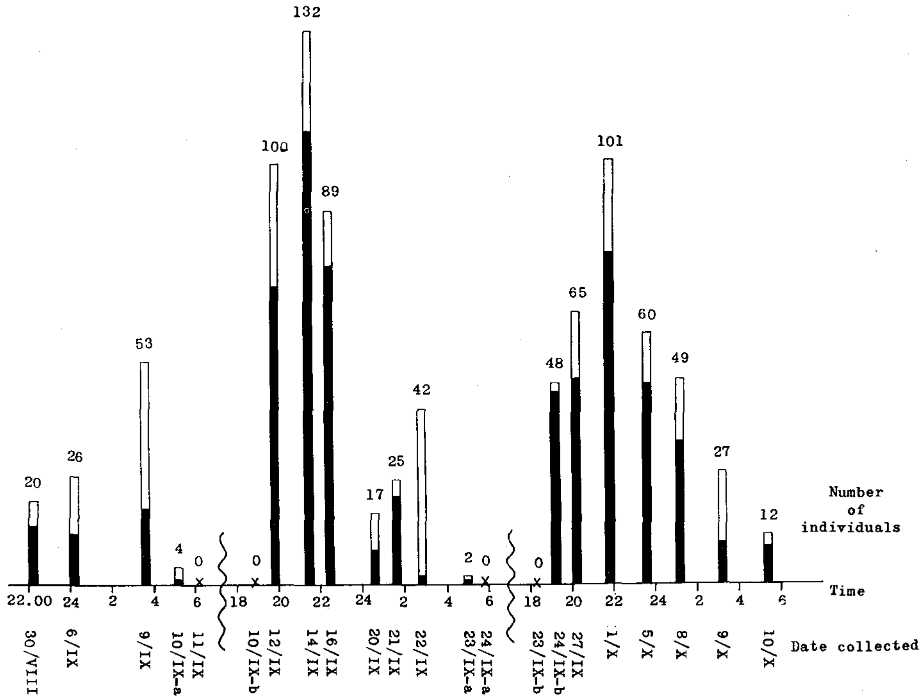

Fig. 46. Diagram showing the diurnal change of number of individuals of the benthic gammarids per sample obtained by the horizontal towing of plankton net in the surface waters on *Zostera* belt near the low-water mark. The solid column indicates the proportion of *Paradexamine barnardi* to the total sample.

net (stretched with GG 40, mesh 39/inch), towed by a return sailing of a distance of about 250 meters in the surface water above the *Zostera* belt off the Ôno-Branch of our laboratory, Ônoura, Saeki-gun, Hiroshima Pref.

In the Seto Inland Sea, the tide range is fairly prominent, and the tidal flow is very fast, particularly in "Seto" (strait). This *Zostera*-belt is facing Ôno Seto, and narrowly spreads outside the inlet in the direction along the tidal flow; therefore, it is desirable to collect at the time when the tidal flowing is dead. Moreover, the *Zostera*-belt is very shallow being about 0.5 meter in depth in low water at the spring tide. Thus, the collecting was always done in the slack water just before the high water, and then it was impossible to carry out successive observations in the same day.

As seen in Table 3, the samples of both series A and C were collected after the moondown, while the series B was taken after the moonrise. No distinctive relations, however, could be seen between the migration and the moon light so far as the present collections were concerned. In general, the number of individuals rapidly increases as soon as it becomes completely dark after the nightfall, reaching to the maximum just before 22.00, then

Table 3. Data of the observations on the nocturnal migration of benthic gammarids.

Series	Date	Time	Age of moon in days	Moon- rise	Moon- set	Sun- rise	Sun- set	Depth (m)	W.T. (°C)
A	30/VIII	22.05	29.6	5.30	18.55	5.42	18.40	3.5	25.4
	6/IX	0.01	7.0	11.51	22.38	5.46	18.31	2.4	24.7
	9/IX	3.20	10.0	14.41	0.07	5.48	18.26	2.3	25.6
	10/IX-a	5.08	11.0	15.36	1.01	5.49	18.25	2.6	24.6
	11/IX	5.58	12.0	16.28	2.02	5.50	18.25	2.5	24.2
B	10/IX-b	18.35	11.0	15.36	1.01	5.49	18.25	3.0	25.4
	12/IX	19.35	13.0	17.16	3.07	5.50	18.23	3.0	25.0
	14/IX	21.15	15.0	18.42	5.28	5.52	18.20	3.7	25.0
	16/IX	22.15	17.0	20.01	7.50	5.53	18.17	3.2	25.5
	20/IX	0.30	21.0	22.55	12.19	5.56	18.11	3.0	24.8
	21/IX	1.35	22.0	23.45	13.18	5.56	18.10	2.6	24.5
	22/IX	2.45	23.0	—	14.12	5.57	18.08	2.4	25.0
	23/IX-a	4.50	24.0	0.39	15.00	5.58	18.07	2.2	25.1
	24/IX-a	5.45	25.0	1.34	15.43	5.59	18.05	2.6	25.1
C	23/IX-b	18.15	24.0	0.39	15.00	5.58	18.07	2.3	25.3
	24/IX-b	19.00	25.0	1.34	15.43	5.59	18.05	2.5	25.0
	27/IX	20.00	28.0	4.19	17.28	6.01	18.01	3.0	23.8
	1/X	21.45	2.3	7.55	19.29	6.04	17.56	3.2	23.4
	5/X	23.25	6.3	11.37	22.02	6.07	17.51	2.5	22.2
	8/X	1.00	9.3	14.17	—	6.10	17.46	2.1	22.5
	9/X	3.00	10.3	15.06	0.48	6.10	17.45	2.1	22.5
	10/X	5.15	11.3	15.51	1.54	6.10	17.44	2.6	22.8

gradually decreases towards the dawn, and animals wholly disappear while the sky is turning gray before dawn. The result of series A seems unusual.

Nevertheless, these observations made only in high water of different days are considered to accord with the day of lunar month. The results indicate, thus, the number of migrating individuals increases in the spring tide of the full moon or new moon. Similar phenomenon is also observed in the nocturnal migration of members of amphipod genus *Bathyporeia* carried out in the intertidal waters of Kames Bay, open to the Firth of Clyde, by WATKIN (1939). He says there, "when the samples are related to the day of lunar month it is shown that the numbers increase in the tidal waters in the periods immediately preceding the full moon and preceding and partly overlapping the new moon." My results show that the animals stop migrating upwards in the day time, even in the twilight. It is still questionable if the numbers always show the maximum at about 22.00 at night, although this time corresponds just to the high water of the new moon or full moon as it was so in my observations. In future, the nocturnal change of the number of migrating individuals throughout the same night will be clearly explaind by further investigations made at the location in a certain much deeper inshore area, deep enough even in the low water of neap tide and without any prominent tidal flow in neither spring nor neap tide, which will disturb the towing of plankton net.

The total number of individuals of each species obtained is given below, together with the frequency of occurrences shown by the number of samples for each species:

	(Number of individuals)	(Frequency)
Paradexamine barnardi	607	18 (all)
Aoroides columbiae	45	10
Ericthonius pugnax	41	11
Corophium uenoi	39	6
Synopia ultramarina	23	7
Pontogeneia rostrata	21	7
Corophium sp. (juv.)	19	8
Byblis japonicus	16	8
Pontocrates altamarinus	11	8
Gitanopsis vilordes	10	4
Maera serratipalma	8	5
Grandidierella japonica	6	5
Stenothoe gallensis	4	4
Melita koreana	4	4
Orchomenella littoralis	4	3
Corophium acherusicum	4	2
Eriopisella sechellensis	2	2
Melita sp. (juv.)	2	2
Jassa falcata	2	2
Ampelisca miharaensis	1	1
Aoroides secunda	1	1
Ampithoe lacertosa	1	1
Microjassa cumbrensis	1	1

Paradexamine barnardi occurred most abundantly nearly in all samples, showing 69.6 percent of the total individuals of all species. It is noticeable that such groups as the burrowing or tubicolous forms often appear in surface water at night. These facts seem to show that nearly all of the benthic gammarideans act the nocturnal migration. Unfortunately, the present observations were made in the season when the gammarideans were rather scarce, and so it is very desirable that further investigations will be carried out in the season when much larger numbers of individuals are available, for instance in spring to early summer.

There has been discussions by some authors on the factors causing this nocturnal migration, and the influence of the tide is regarded as an important factor in the tidal area. This may be supported also in the present observation by the increase of individual number in the high tide of the new and full moon. The migration may really have something to do with the breeding cycle for each species. Nearly all the individuals obtained were small specimens; further detailed analyses are needed on the size and age compositions and sex-ratio.

3. A Note on the Comparison of Species Composition Between Two Different Areas

Nearly all of the species described in this paper are found in relatively shallow waters, from the *Zostera*-belt near low-water mark to about 60 meters deep; and the bottoms of the localities are in most cases composed of silt, mud, or sandy mud. Unfortunately, no detailed analyses of the nature of the bottom inhabited by animals have been made, so that the relations between the animals and the important factor, the soil grade, are almost unknown. But there is an interesting difference between the species obtained from *Zostera*-belt near low-water mark and those collected from the deeper area. The '*Zostera*-belt near low-water mark' mentioned here is the place where the tide dose not completely go out even in the spring tide and about 5 meters at the deepest place in low-water. Such a *Zostera*-belt usually offers a habitat suitable for many young fishes as well as for small crustaceans important as prey-animals. Particularly gammarideans are very rich there in the number of both individuals and species, and occupies 60–90 percent of small crustaceans on the *Zostera*-belt of Mihara Bay (NAGATA 1960). The abundant occurrences of gammarideans on the *Zostera*-belt is obviously shown also by the stomach contents of fishes caught there (KITAMORI, NAGATA, and KOBAYASHI 1959).

The species of gammarideans very commonly found on the *Zostera*-belt near low water mark are listed below:

1) *Paradexamine barnardi*
2) *Pontogeneia rostrata*
3) *Ampithoe lacertosa*
4) *Ampithoe valida*
5) *Grandidierella japonica*
6) *Ericthonius pugnax*
7) *Pleustes panopla*
8) *Cerapus tubularis*
9) *Jassa falcata*
10) *Corophium acherusicum*
11) *Byblis japonicus*
12) *Eriopisella sechellensis*
13) *Pontocrates altamarinus*
14) *Orchomenella littoralis*
15) *Aoroides columbiae*
16) *Eurystheus japonicus*
17) *Corophium uenoi*

Of the above-listed species, species 11, 12, and 13 are found abundantly and species 14–17 are found occasionally also in the area more deeper than the *Zostera*-belt near low-water mark. While the species 1–10 are mostly limited to the *Zostera*-belt. On the *Zostera*-belt of Mihara Bay (Area IV), species 1-5 were found very abundantly in net-collections, while species 6 was unexpectedly rather scarce. The list of the species living very abundantly on the inshore *Zostera*-belt is based on the materials obtained from Mihara Bay in

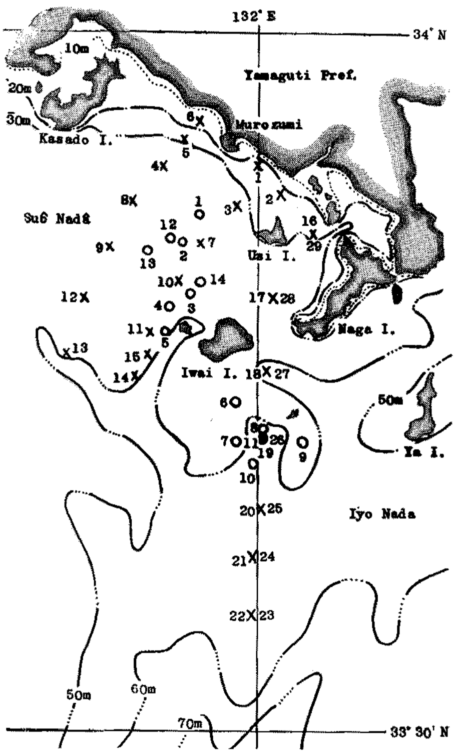

Fig. 47. Map showing station localities in two surveys of "Area XI". Marks ○ and × indicate respectively stations in 1959 (Area-a) and 1960 (Area-b). Sts. 16–22 in 1960 nearly coincide with Sts. 29–23, and so does St. 11 in 1959 with Sts. 19 and 26 in 1960.

the Seto Inland Sea and near Asamushi in Mutsu Bay. On the *Zostera*-belt of the latter locality, species 1, 3, 6–9, and 13–16 were very rich.

On the other hand, general aspects of their occurrences in the area deeper than the *Zostera*-belt near low-water mark are well represented in Tables 4 and 5 (see also Figs. 1 and 47). The collections in this area were made by drawing a bottom-layer net (NAGATA 1960, fig. 1) on the soft sea floor for 1.5–4 minutes at each station, but the drawing can never be done under the constant conditions throughout the stations and therefore the collections are not to be estimated quantitatively. However, several common species widely distributed in the littoral areas below the level of the low-water mark may be clearly shown in the catches of these two surveys. More than 90 percent of total individuals in each catch is occupied by the following 10 species: all the 7 species of Ampeliscidae, *Pontocrates altamarinus*, *Eriopisella sechellensis*, and *Bathymedon longimanus*. Most of them have often been found in the stomach contents of benthos-feeding fishes, too. J. L. BARNARD started in the opening of his paper of 1954b, "Amphipoda of the family Ampeliscidae form an important component of any littoral marine soft-bottom fauna", and this appears to be the fact common to all amphipod faunas of the littoral sea floor along the Japanese coast deeper than about 10 meters. *Eurystheus utinomii*, *Anonyx nugax pacificus*, and two species of the genus *Photis* have been collected most abundantly at the three stations deeper than 10 m in Mihara Bay (NAGATA 1960, fig. 2), but not so numerously as expected in the two surveys.

As mentioned above, a prominent difference in their occurrences was noted between the species commonly found in respective areas, but other species occur comparatively less abundantly and less frequently, and thus it is unable to show definitely for each species the area of the richest occurrence.

Table 4. Species composition at each station, based on the bottom-layer net catches made in the east area of Suô Nada (Area XI–a) in the period June 12–16, 1959.
Total: 5673 specimens. Depth: 32–56 m. (see Figs. 1 and 47).

Station No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Ampelisca brevicornis	212	318	334	230	150	19	120	8	30	128	196	127	136	109	2117
Pontocrates altamarinus	106	127	96	28	37	79	150	22	129	30	41	26	64	56	991
Eriopisella sechellensis	29	29	38	17	24	38	138	22	31	59	39	17	8	39	528
Byblis japonicus				4	14	35	105	12	80	86	115				451
Bathymedon longimanus			31	7	26	47	49	24	36	48	45	5	9	3	330
Ampelisca naikaiensis					7	41	63	33	42	44	79				309
Ampelisca bocki			1	1	79	1	45	1	22	37	79	2		1	269
Ampelisca miharaensis					9	24	15	11	20	20	33				132
Ampelisca misakiensis				1	37	10	8	2	8	28	33				127
Photis longicaudata						3	3	11	53	7	29				106
Photis reinhardi							1		42	9	7				59
Eurystheus utinomii		2	1			11	9	17	9	1	6				56
Melphidippa globosa	1	2	4	3	3	9	4	3	5	4	7				45
Liljeborgia japonica	1	2		2			6			4	5	11	1	1	33
Corophium uenoi				1		3	2	14							20
Melita tuberculata					1	3	5	1		3		1		1	15
Idunella curvidactyla	1	2	4	2	1		1		1			2			14
Melphidippa borealis						3	1	1	4		2				11
Liljeborgia serrata						1	2		1	3	3				10
Corophiidae undet. sp. (B)					1				1		5				7
Ampelisca cyclops									5		1				6
Ceradocus capensis								5							5
Maera serratipalma								4							4
Aristias pacificus		1						2			1				4
Idunella chilkensis							2	1							3
Corophium kitamorii						2			1						3
Argissa hamatipes									1				2		3
Leptamphopus novaezealandiae									3						3
Orchomenella littoralis											2				2
Melphidippella sinuata						2									2
Melphisana japonica						2									2
Podoceropsis nitida					1			1							2
Endevoura mirabilis						1									1
Harpinia miharaensis										1					1
Eurystheus japonicus								1							1
Podocerus inconspicuus						1									1

Table 5. Species composition at each station, based on the bottom-layer net catches made in the east area of Suô Nada (Area XI-b) in the period Sept. 2-5, 1960.

Total: 3689 Specimens. Depth: 10-56 m. (see Figs. 1 and 47).

Species \ Station No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Total
Ampelisca brevicornis	4	23	103	306	127	10	65	237	123	298	3	117	17	95	122	54	147	3	101	24					3	23	1	95	61	2162
Ampelisca bocki	24	6	19	1		19		1	6	15		39	14	37	63		49		67	26				1	9	14	1	17		428
Ampelisca misakiensis			4								1	9	1	64	45		6	3	20	38	11	23	11	5	12	6	1	16		275
Byblis japonicus										3		28	12	51	45		8	15	30	34	1	1		2	4	22	6	1		263
Pontocrates altamarinus		3	1	14	9	4	4	7	4	1		14		7	5	2	25		9	13	1	11	8	1		11	1	7	1	163
Ampelisca naikaiensis						1				3	1	2	4	15	9		1		27	31	1	3	2	7	7	22		4		141
Ampelisca miharaensis									1			3	1	2	4		1	4	22	20	2	3	4	5	1	6		4		83
Eriopisella sechellensis	3		3	7	1		1	3	1	1		1		2	2		1		2	1		1		1		1		3		35
Ampelisca cyclops																				16					7	8				31
Bathymedon longimanus							3										9	3										1		16
Melphidippa globosa												1						5					2	1						9
Photis longicaudata														1				1	2			3	1		1					9
Melphidippella sinuata																				1	2	1	3			1				8
Unciolella lunata																		6			2									8
Orchomenella littoralis																						5	1							6
Megaluropus agilis																						5								5
Photis reinhardi																		1			2		2							5
Corophium crassicorne																				5										5
Endevoura mirabilis																					2	1	1							4
Urothoe pulchella																						3	1							4
Eurystheus japonicus																					1		2							3
Eurystheus utinomii																		2					1							3
Ericthonius pugnax																									3					3
Scopelocheirus bopei																											1	1		2
Liljeborgia serrata																									1	1				2
Maera serratipalma																		2												2
Maerella tenuimana																		2												2
Podoceropsis nitida																						1	1							2
Grandidierella japonica																		2												2
Paraphoxus oculatus																		1												1
Harpinia miharaensis																		1												1
Anonyx nugax pacificus																		1												1
Leucothoe incisa																		1												1
Liljeborgia japonica																										1				1
Idunella chilkensis						1																								1
Melphisana japonica																		1												1
Aoroides columbiae						1																								1

4. Gammaridean Amphipods as Prey-animals, with Special Relation to the Triglid Fishes Caught in the Seto Inland Sea

As previously mentioned again and again, amphipods are important prey-animals often found abundantly in the stomach contents of many benthos-feeding fishes. To make clear the trophic relations between higher consumers and their preys, our laboratory carried out the collecting of benthic fishes by the experimental two-boat trawler (30 tons & 80 H.P.), which had eight cruises over eleven "Nada"-areas around the coast of Shikoku in the period from Sept. 1957 to Sept. 1960 and obtained enormous catches of benthic fishes. And I have had an opportunity to observe the stomach contents of nearly all of the benthic fishes, but piscivorous fishes and plankton feeders.

For an example, a qualitative analysis of their feeding frequency by food-group of the fishes caught during the fourth cruise made in May-June 1958 is given in Table 6. Here, the feeding frequency is shown by the percentage of the number of fish feeding on a respective food-group to the total number of the fish examined. The total number of fishes examined here amounts to 2880 individuals, including 75 species, but in this table, only the results for 31 species are given, the species represented by less than 10 individuals being omitted. As seen on this table, main food items of those benthic fishes except for piscivors in the Seto Inland Sea are shrimps, small crustaceans, annelids, and fishes; although the proportions of these food animals are different with feeders, nearly all of fishes are known to show a fairly high percentage of shrimps in the stomach contents. Fishes or squids which all the feeders listed in this table preyed upon are small in size and not so significant quantitatively so far as concerned with those found in the Seto Inland Sea. Strictly saying, all the values in the table may be swayed to some extent by the number of feeding individuals examined, variation of their size, and also by the seasonal change of prey-animals themselves; although they may be available to get the general view of the food organisms of the fishes.

Relatively high percentages of small crustaceans are seen in flatfishes and triglid ones. Especially it is noteworthy that unexpectedly large amount of small crustaceans including gammaridean amphipods are eaten by the latter. Particularly as to *Lepidotrigla microptera*, a large number of individuals were examined so that the above-mentioned trend seems to be unsuspecting. It is supposed that triglid fishes bear some resemblance to flatfishes in their feeding habits. In feeding they usually lie prostrate on the bottom and feel the sea floor by means of their long finger-like pectoral filaments.

Of course, like other feeders, triglid fishes show some changes in the composition of food animals with growth. Table 7 shows the percentage of

Table 6. Feeding frequency of the benthic fishes caught during May-June 1958, by food-group.

Feeding fish \ Food group	Range of T.L. (cm)	Number of feeding individuals examined	Fish	Squid	Shrimp	Crab	Stomatopod	Small crustacean	Annelid	Molluscan	Echinoderm	Undet. contents
Triglidae												
Lepidotrigla abyssalis	8–15	11	—	9	73	—	—	64	18	—	—	—
L. guntheri	9–21	12	—	—	83	—	—	8	17	—	—	—
L. japonica	8–19	30	—	20	80	7	—	57	10	7	—	—
L. microptera	7–30	287	2	7	89	1	—	39	7	3	—	2
L. kishinouyei	14–24	37	—	3	100	—	—	27	—	3	—	—
Pachytrigla alata	11–22	15	7	—	94	7	—	—	—	—	—	—
Flatfishes												
Laeops lanceolata	8–13	41	—	—	—	—	—	—	100	—	—	—
Areliscus sp.	12–17	31	—	—	—	—	—	3	90	—	—	16
Poecilopsetta plinthus	6–11	22	—	—	—	—	—	73	64	—	—	9
Pleuronichthys cornutus	9–17	20	—	—	5	—	—	5	75	5	—	25
Limanda yokohamae	14–21	19	—	—	32	—	—	26	63	16	—	32
Areliscus interruptus	6–10	39	—	—	5	—	—	21	54	—	—	28
Psettina ijimai	5– 8	115	—	2	2	1	—	96	45	—	—	—
Scidorhombus pallidus	5– 6	13	—	—	23	—	—	92	8	—	—	—
Eopsetta grigorjewi	12–19	41	—	2	61	7	—	44	—	—	—	—
Arnoglossus japonicus	7–10	57	14	—	60	—	—	74	—	—	—	—
Pseudorhombus pentophthalmus	6–13	100	25	6	44	1	—	47	2	—	—	—
Sparidae												
Chrysophrys major	12–35	16	—	—	69	—	—	—	—	—	6	25
Branchiostegidae												
Branchiostegus spp.*	11–32	55	29	6	33	4	—	16	22	—	4	11
Nemipteridae												
Nemipterus spp.**	9–47	39	41	3	56	18	—	5	10	—	—	—
Sciaenidae												
Argyrosomus argentatus	9–23	274	37	—	68	—	—	12	1	—	—	7
Platycephalidae												
Kumococius detrusus	14–26	22	27	—	59	5	—	5	—	—	—	5
Suggrundus meerdervoorti	14–23	32	25	—	91	—	—	3	—	—	—	—
Cociella crocodila	20–44	18	33	6	50	28	33	—	—	6	—	—
Lamnina												
Mustelus griseus	42–85	11	27	—	55	36	18	9	—	—	—	—
M. manazo	40–77	63	16	—	81	41	11	6	—	—	—	—
Rajina***												
Holorhinus tobijei	13–35	28	—	—	82	—	—	—	—	75	—	—
Raja kenojei	9–24	58	14	—	86	3	—	2	—	—	—	5
Dasyatis akajei	15–32	27	30	—	85	4	—	7	4	—	—	4

*) Comprising two species *B. argentatus* and *B. japonicus japonicus*.
**) Comprising two species *N. virgatus* and *N. bathybus*.
***) Measured by 'Body Length'.

Table 7. Feeding frequency of *Lepidotrigla microptera* caught during June 1959, by size and by food-group.

T.L. (mm)	<120	<160	<200	<240	<280	<320	Total
Number of feeding individuals	1	12	103	69	35	5	225
Fish	—	—	3.8	5.7	11.4	—	5.3
Squid	—	—	5.8	2.9	2.9	—	4.0
Large shrimp	—	41.6	43.6	50.7	71.4	80.0	50.6
Small shrimp	100.0	66.6	56.3	55.0	71.4	40.0	58.6
Crab	—	—	0.9	—	—	—	0.4
Amphipod	—	75.0	43.6	26.0	22.8	20.0	36.0
Cumacean	—	—	1.9	—	—	—	0.9
Polychaete	—	16.7	4.9	2.9	5.7	—	4.9
Molluscan	—	—	3.9	2.9	5.7	—	3.6

the feeding frequency by food-group and by size in *Lepidotrigla microptera* caught during the cruise in June 1959. With the increase in size, the percentages of large shrimps and fishes grow higher, while those of small shrimps and amphipods gradually decrease. Small crustaceans were represented by only two groups of gammaridean amphipods and cumaceans.

Table 8. Feeding frequency of triglid fishes caught during Sept. 1957 to July–Aug. 1958, by season and by food-group.

	Sept. '57	Dec. '57	Jan.–Feb. '58	May–June '58	July–Aug. '58
Fish	5.5	11.0	2.9	1.8	9.1
Squid	6.3	1.3	—	7.3	2.5
Shrimp	70.8	91.9	80.9	87.9	84.4
Crab	3.3	2.3	10.3	1.5	3.6
Stomatopod	1.4	3.9	1.5	—	0.4
Small crustacean	19.6	13.3	19.1	37.1	13.8
Polychaete	1.4	6.1	—	6.6	1.8
Molluscan	0.3	6.1	—	3.0	—
Echinoderm	—	0.3	—	—	0.4
Others	—	1.0	—	0.5	—
Undet. contents	7.2	—	2.9	2.3	8.7
Numbers of feeding individuals	363	235	53	396	275

On the other hand, the feeding frequency of triglid fishes caught in the period from Sept. 1957 to July–Aug. 1958, by season and by food-group, is shown in Table 8. The feeding frequency for shrimps was highest throughout, and that of small crustaceans was always relatively higher than those of other prey-groups excepting shrimps. Figure 48 shows the seasonal change of the feeding frequency for small crustaceans given in Table 8, together with that for gammaridean amphipods eaten by various fishes living on the

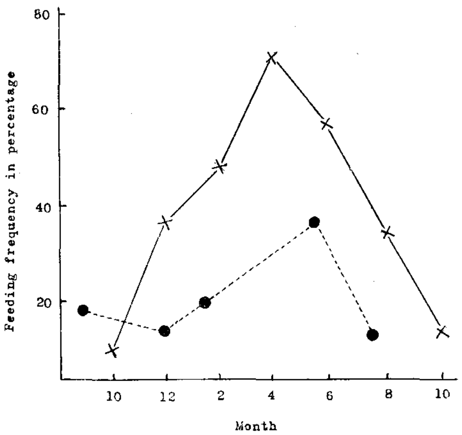

Fig. 48. The seasonal change of the feeding frequency for small crustaceans (---) and for gammaridean amphipods (—). The dotted line refers to that of triglid fishes given in Table 8, while the solid line concerns that of the various fishes living on the *Zostera* belt near the low-water mark in Mihara Bay.

Zostera-belt of Mihara Bay (KITAMORI, NAGATA et KOBAYASHI 1959, fig. 8). Amphipods are the largest component of small crustaceans found in the stomach of triglid fishes treated in Table 8, and therefore it is very interesting that the two curves shown in Figure 48 indicate a similar tendency; one refers to the offshore areas, while the other concerns the inshore region near the low-water mark. Results of many surveys in Mihara Bay indicate that the seasonal change of the feeding frequency for gammaridean amphipods agrees fairly well with the seasonal variation in the quantity of the amphipods themselves in that habitat. And this means nothing but that triglid fishes in the Seto Inland Sea feed relatively well on small crustaceans.

Now throughout the five-month data shown in Table 8, the percentage composition of the total small crustaceans found in the stomach contents of triglid fishes is given as follows:

Amphipoda	
Gammaridea	54.1
Caprellidea	5.4
Cumacea	24.4
Ostracoda	9.6
Mysidacea	5.6
Brachyura & Macrura larvae	5.6
Isopoda	0.09
Nebaliacea	0.09

More than half of small crustaceans consist of gammaridean amphipods, of which several dominant species are given below together with the percentage composition:

Ampelisca brevicornis *Ampelisca cyclops* *Ampelisca bocki* *Ampelisca misakiensis* *Ampelisca miharaensis* *Ampelisca naikaiensis*	23.2
Byblis japonicus	17.5
Pontocrates altamarinus	11.7

Eurystheus utinomii / *Eurystheus japonicus*	37.5
Photis longicaudata / *Photis reihardi*	0.3
Liljeborgia japonica	0.4
Podocerus inconspicuus	3.4
Other species	5.9

It is seen that 89.9 percent of the total are occupied by 10 species of the genera *Ampelisca, Byblis, Pontocrates*, and *Eurystheus*. The conjecture that these species important as prey-animals must be inhabiting abundantly on the offshore floor is supported actually by two benthos-collections shown in Tables 4 and 5, namely the above 10 species account for 78.6 percent of the total individuals in Area XI-a (Table 4) and for 96.2 percent in Area XI-b (Table 5).

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