Studies on Pelagic Amphipods in the Adjacent Seas of Japan.

Haruhiko IRIE.

I. INTRODUCTION.

1. Researches Hitherto on Amphipods in the Japanese Waters.

Many fragmental researches have been carried out on Amphipods in the Japanese waters.

Ogami (1901) enumerates 20 species collected by "Challenger" in the Japanese waters (about 260 spp. among total).

There are papers; on Gammarids by Iwasa, (15 spp. of Talitridae) (1939), on Caprellids by Utinomi (57 spp. of Caprellidae) (1937, 1943a, 1943b, 1943c, 1947), by Asimoto (16 spp. of the same) (1929, 1930, 1934), by Iwasa (2 spp. of Cymididae) (1934a) and by Utinomi (1 sp. of the same) (1938).

As regards new species, 5 spp. by Stepenisen (1932, 1933, 1938), 3 subterranean spp. by Komai (1922a, 1922b) and Akatuka & Komai (1922), and 1 sp. by Iwasa (1934b) are reported respectively. Ueno (1941) reports 2 spp. obtained at Okinosima I.

Recently, there are reports, on 241 spp. of Gammarids and 13 spp. of Caprellids in the northwestern part of the Japan Sea by Bulycheva (1957), and on 39 spp. of Hypertids and 42 spp. of Gammarids in the northwestern part of the Pacific Ocean by Vinogradov (1957, 1956).

On pelagic forms, however, there are no comprehensive studies, other than fragmental papers by the Author (1948, 1956, 1957a, 1957b, 1958a, 1958b, 1959c).

Then, putting these own papers in order, the Author firstly classified and described the pelagic Amphipods occurred at 210 stations in the adjacent seas of Japan (136 stations of open sea from the Okhotsk to the neighborhood of Formosa, and 24 stations of neritic and inshore waters from the outside of Sasebo Bay to Omura Bay). Secondly, the Author discussed their geographical distribution, selected the indicator of each water-mass or current system, and somewhat elucidated their habits.

Acknowledgements.

The investigations were carried out under the leadership of Dr. Hiroaki Akawa, Kyūsū University, who gave the Author many suggestions and continuous encouragement.

The materials, other than what the Author obtained by himself, were offered by Dr. Hiroaki Akawa (Sōyō-maru I materials), Dr. Sigeru Motoeda, Hokkaido University (Sōyō-maru II materials), Mr. Atusi Izuka, Hokkaido Regional Fisheries Research Laboratory (Tankaimaru materials), and Mr. Sigeru Fukase, Nagasaki Marine Meteorological Observatory (Sumpū-maru materials). Mr. Syōiti Nishura, especially, offered the materials obtained in his diving investigations.

Dr. Tokimi Tsuchi, Seikai Regional Fisheries Research Laboratory, Dr. Isao Machii, Simonoseki College of Fisheries, Mr. Tadashi Futa, Nagasaki Prefectural Fisheries
Experimental Station, Mr. Ititarō Sakamoto, Mie Prefectural University, and Mr. Yūzō Komaki, Tōkyō University, Dr. Fujio Utinohi, Seto Marine Biological Laboratory, Dr. T. E. Bowman, US National Museum, Dr. J. L. Barnard, University of Southern California US and Dr. M. E. Vinojovk, Institute of Oceanology USSR Academy of Science; all these men gave a great deal of benefits for reading the references.

Drs. Hiroaki Akawa and Keitarō Utida, Kyūsyū University, kindly revised the papers.
To all these men the Author returns his special thanks.


Materials and sampling methods are shown in following table.

Table 1. Date, Region, Number of Stations, and etc. of Sampling.

<table>
<thead>
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<th>No.</th>
<th>Date</th>
<th>Region</th>
<th>No. of St.</th>
<th>Collector (Vessel or Org.)</th>
<th>Sign of St.</th>
<th>Method</th>
</tr>
</thead>
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<td>'33.IX.10～'41.VI.10</td>
<td>From Okhotsk to neighborhood of Formosa.</td>
<td>86</td>
<td>Sōyū-maru I. (FES.) *1.</td>
<td>SI.</td>
<td>(A), mainly.</td>
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<td>'52.VIII.11～15</td>
<td>Tusima.</td>
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<td>8</td>
<td>5</td>
<td>Nagasaki-maru. (NUF.) *2.</td>
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<td>Southwest.</td>
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<td>* a.</td>
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<td>V.19～20</td>
<td>* b.</td>
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<td>5</td>
<td>'55.VIII.14～22</td>
<td>Central Japan Sea.</td>
<td></td>
<td></td>
<td>Sōyū-maru II. (HUF.) *4.</td>
<td>SII.</td>
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</table>

*b. Southwest of Sakito-sima I., outside of Sasebo Bay.
*c. Northern and Central Japan Sea.
*d. 2 among 15 stations were occupied in Sasebo Bay.
*e. 2 among 17 stations were occupied in Sasebo Bay.
*1. Fisheries Experimental Station, Tōkyō.
*2. Faculty of Fisheries, Nagasaki University, Sasebo.
*3. Hokkaidō Regional Fisheries Research Laboratory, Yoiti.
*4. Faculty of Fisheries, Hokkaidō University, Hakodate.
Methods

(A) 0 m horizontal hauling by larva-net.
(B) 10-0 m vertical hauling by MO-net.
(C) Vertical-20 m-interval horizontal hauling by larva-net.
(D) Vertical-Xm-interval horizontal hauling by larva-net.

Locality of each station shown in Figs. I&II are as following tables (Tabs. 2&3).

Fig. I. Stations Occupied in the Adjacent Seas of Japan.
Fig. II. Stations Occupied in the Neighboring Waters of Sasebo

Table 2. Locality of Each Station Outside of Sasebo Bay.

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<th>St.</th>
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<th>St.</th>
<th>Locality.</th>
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<td>Long. (E)</td>
<td>Lat. (N)</td>
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<td>O</td>
<td>1  33°01.7'</td>
<td>129°49.6'</td>
<td>O</td>
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<td>&amp;</td>
<td>2  01.0</td>
<td>49.3</td>
<td>&amp;</td>
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<td>O'</td>
<td>3  00.3</td>
<td>50.3</td>
<td>G</td>
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<td></td>
<td>4  01.0</td>
<td>51.6</td>
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<td>5  01.6</td>
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<td>6  00.8</td>
<td>54.4</td>
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<td></td>
<td>7  32 58.8</td>
<td>54.5</td>
<td>G'</td>
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<td>8  58.7</td>
<td>52.7</td>
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<td>9  58.5</td>
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<td>12 56.2</td>
<td>54.7</td>
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</table>

Remarks:  
*1. Off Sukui-no-ura.  
*2. Haiki Strait.  
*3. West of Makura-sima I. (1 of 99-sima Is.) outside of Sasebo Bay.  
*4. Southwest of Sakito-sima I. outside of Sasebo Bay.

The larva-net, the Author used, is as follows.

Calibre: 1.0 m.
Side-length: 4.0 mm-meshed minnow, 1.5 m.
GG50 bolting silk, 1.5 m. Total 3.0 m.
(with a cylinder made by copper plate).

The end of hauling wire-rope was equipped a depressor (about 20 kg weight). Haulings were performed for 10 minutes with a speed of about 2 mph so as to keep the angle of rope within 45° against sea-surface (IRE, 1966a).
II. CLASSIFICATION OF PELAGIC AMPHIPODS IN THE ADJACENT SEAS OF JAPAN.

Pelagic Amphipods, both euplanktonic and tychoplanktonic occurred in the adjacent seas of Japan are listed in preceding table 4.

Order AMPHIPODA.

Order AMPHIPODA is divided into following 4 suborders.

Suborder 1. HYPERIDEA.
Suborder 2. GAMMARIDEA.
Suborder 3. CAPRELLIDEA.
Suborder 4. INGOFIELLIDEA.

Among these, 2~3 forms of the last are known as benthic only in foreign waters. Therefore, the members belonging to preceding 3 suborders occur only as euplankton and tychoplankton.

Key to Suborders.


   Suborder CAPRELLIDEA.


   Suborder HYPERIDEA.

   Suborder GAMMARIDEA.

   Suborder HYPERIDEA.

   Antennae are remarkably different in both sexes generally, especially the 2nd undeveloped and often absent in the female. Mouth parts are undeveloped, both inner lobes of maxillipeds coagulating. Gnathopods are not so remarkably different in both sexes generally. Dactyla of 3rd & 4th pereiopods direct backwards, those of the 5th~7th forwards. 2nd & 3rd urus-segments coagulate.

   Suborder HYPERIDEA are subdivided into following 3legions by the structures of eye, 2nd antenna and thoracic appendages.

   Legion 1. HYPERIDEA GAMMAROIDEA.
   Legion 2. HYPERIDEA GENUINA.
   Legion 3. HYPERIDEA ANOMALA.

Key to Legions.

1. Head not so dilate, eye comparatively small and concentric to a lateral part of head on respective sides.

   Legion HYPERIDEA GAMMAROIDEA.

   Head dilate and large, eye occupying almost all part of head.

2. 2nd antenna of the male not folded. 3rd~5th pereiopods not so remarkably different in structure and magnitude.

   Legion HYPERIDEA GENUINA.

   2nd antenna of the female folded zigzagly. Bases of 5th&6th pereiopods wider than those of others generally. 7th pereiopod very smaller than others generally.
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<td>130.6'</td>
<td>VI</td>
<td>101</td>
<td>09-23'</td>
<td>130.6'</td>
<td>VI</td>
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<td>2</td>
<td>46.8</td>
<td>139.31.2</td>
<td>VI</td>
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Table 3: Locality, Date and Region of Each Station.

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1. NL0° off Notori. 2. NE0° off Omura. 3. NW0° off Suyzanburi. 4. W0° off Midare. 5. NW0° off the estuary of Isikari River. 6. N23° off Hurubira.
<table>
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<th>Genus</th>
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Legion Hyperidea Anomala.

Legion Hyperidea Gammaridea.

Key to Families.

1st antenna lanceolate. Dactylus of 7th pereiopod talon-shaped, distal end pointing.
Fam. Scindidae.

1st antenna spatulate. Dactylus of 7th pereiopod finger-shaped, distal end round.
Fam. Vibiliidae.

Legion Hyperidea Genuina.

Key to Families.

1. Head cubic. 
   Head conic. 
   Head spherical.

2. 5th pereiopod not so large and robust, basis not so dilate and wide.
   Fam. Hyperiidae.

5th pereiopod large and robust, frontal margin of carpus with massive serration.
   Fam. Anchylomeridae, (Phronimidae)

5th pereiopod of the male very narrow and long, in the female moderate.
   Fam. Lycaeopsidae.

Legion Hyperidea Anomala.

Key to Families.

1. Head elongate forwards, frontal end pointing. Basis of 5th pereiopod somewhat dilate and wide.
   Fam. Oxycephalidae.

   Head almost spherical, with a beak-shaped rostrum. Basis of 5th pereiopod remarkably dilate and laminate.

2. Basis of 6th pereiopod not so dilate as to cover all other legs.
   Basis of 6th pereiopod so dilate as to cover almost all other legs.

3. Rear margins of carpus and propodus in both gnathopods with serration.
   Fam. Brachyscelidae.

   Rear margins of carpus and propodus in both gnathopods without serration.
   Fam. Lycaeidae.

4. Telson not coagulated with urus.
   Telson coagulated with urus.

5. Distal several articles in both gnathopods chelate or prehensile.
   Both gnathopods simple.

   Fam. Typhidae, (Platyscelidae)

Suborder Gammaridea.

Both antennae and gnathopods, severally, are not so remarkably different in general, but, if different, the 2ndrobuster than the 1st severally in general. Mouth parts are well-developed, both inner lobes of maxillipeds isolating. Dactyla of 3rd&4th pereiopods direct backwards, those of the 5th~7th forwards but in some pairs of them often backwards. 2nd&3rd urus-segments liberate generally.

Key to Families.

1. 1st peduncular article of 1st antenna remarkably larger and thicker than others. 2nd
gnathopod narrow and long, ischium remarkably narrower and longer than merus.

Fam. **LYSIANASSIDAE.**

1st peduncular article of 1st antenna not so large and thick. 2nd gnathopod not so narrow and long, ischium small.

2. Head elongate, almost conic, frontal end truncate. Eye divided into more than 1, standing abreast on respective lateral sides.

Fam. **AMPELISCIIDAE.**

Head not conic. Eye 1 and concentric on respective lateral sides.

3. Rostrum very projected.

4. Rostrum not so projected.

5. Rostrum flattened, frontal end round.

6. Rostrum somewhat bended downwards, frontal end pointing.

7. Both eyes contacted on pate with each other. 2nd gnathopod chelate.

Fam. **OEDICEROTIDAE.**

Both eyes isolated on respective lateral sides. 2nd gnathopod non-chelate, both gnathopods being almost similar.

8. Rear margin of carpus in both gnathopods projecting slenderly between merus and propodus. Each urus-segment liberated. Telson not split.

Fam. **AMPHILOCHIDAE.**

Rear margin of carpus in both gnathopods not projecting. 2nd&3rd urus-segments coagulated. Telson split.


Fam. **MELPHIDIPPIDAE.**

Both gnathopods prehensile. Pereiopods not so narrow and long.

10. Both gnathopods almost similar in structure and magnitude, rear margin of propodus remarkably projecting round rearwards, covering almost all part of rear margin of carpus.

Fam. **EUSINIDAE.**

Both gnathopods somewhat different with each other, rear margin of propodus not so projecting.

11. 1st antenna with a accessory flagellum. 3rd uropod larger than the 2nd.

12. 1st antenna without a accessory flagellum. 3rd uropod smaller than the 2nd.


Fam. **GAMMARIDAE.**

Telson not split.

Fam. **PHOTIDAE.**


Fam. **DEXAMINIDAE.**

Dorso-median end of no pleon-and urus-segment pointed. 2nd&3rd urus-segments liberated.

15. Both antennae almost similar in thickness, flagella with many articles.

Fam. **AMPHITHOIDAE.**

2nd antenna robust than the 1st, both flagella with few articles.

Fam. **JASSIDAE.**

Both antennae almost similar in thickness. 1st-7th coxal plates remarkably higher than the 5th-7th overlapping little by little with each other.

Fam. **TALITRIDAE.**

2nd antenna robust than the 1st. Each coxal plate not so different in height, isolating with each other.

Fam. **COROPHIDAE.**
There are no remarkable difference in antennae in both sexes, but between both antennae the 1st is larger than the 2nd generally. Mouth parts are well-developed, both inner lobes of maxillipeds isolating. In general, 1st gnathopod is not so remarkably different in both sexes, but the 2nd, especially in the male, is larger and robust than the 1st.

Suborder **Caprellidea** have 2 families; i.e. Families *Caprellidae* and *Cymidae*. The latter, however, is parasitic, therefore only the former occurs in plankton.

III. **Animal Geography of Pelagic Amphipods in the Adjacent Seas of Japan.**

1. **General Distribution in the Adjacent Seas of Japan.**

Investigations were carried out on materials obtained in oceanic open seas in the neighborhood of Japan, with the exceptions of those obtained in Ḫomura Bay, in the neritic and inshore waters semienclosed by islands outside of Sasebo Bay, and those obtained outside of Sasebo Bay in the daytime and in the night.

Frequency occurrences of each genus in every 5° latitude and in 5 main regions (i.e. the Northern North Pacific, the Central North Pacific, the Okhotsk Sea, the Japan Sea and the China Sea) are as Tab.5.

From the table, the population of pelagic Amphipods in the adjacent seas of Japan are divided into following 4 categories.

A. Genera which have wider distribution, but their centers lie

1. in cold-water region of high latitudes:
   - *Vibilia, Phronima, Themisto, Hyperoche, Primno, Amphithoe*, etc.,

2. in warm-water region of low latitudes:
   - *Hyperia, Anchylomera, Tetrathyrs, Platyscelus, Brachyscelus, Lycaea, Oxycephalus, Amphilochoi*, etc.

B. Genera which have rather narrower distribution and occur

3. only in cold-water region of high latitudes:
   - *Thamnus, Tmetonyx, Paraphoix, Nototropis, Leptocheurus*, etc.,

4. only in warm-water region of low latitudes:
   - *Paraphroniina, Phronimella, Phronimopsis, Hyperioides, Phrosina, Lycaeopsis, Parascelus, Amphithyrs, Eupronoe, Sympronoe, Leptocotis, Rhabdosoma, Pleoneses, Sunamphithoe, Hyale, Corophium*, etc.

Distributions of main members belonging to these 4 categories (underlined above) are shown in Fig. III.

From occurrence of each genus in every region, followings are said.

1. *Tmetonyx* and *Nototropis* occur only in the Okhotsk Sea. These 2 genera are probably characteristic to this region.

2. *Scina, Paraphronina, Thamnus* and *Leptocotis* occur only in the North Pacific. If a boundary is placed at 35° N, however, there occurs no member in the north of the boundary, and 3 genera other than *Scina* occur only in the south of it, namely these

* The boundary between Northern and Central North Pacific was placed at 35° N voluntarily.
Table 5. Frequency Occurrences of Genera in Every 5° Latitude and in 5 Main Regions.

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Ch.-China Sea.
are probably characteristic to this region.

3. *Paraphoxus* occurs only in the Japan Sea, and *Hyperioides*, *Lycaeopsis* and *Rhabdosoma* only in the China Sea. In the combined area of these 2 regions, *Primno,Glossoccephalus*, *Pleonexes*, *Sunamphithoe* and *Hyale* are added besides 4 genera mentioned above. These 9 genera are probably characteristic to the domain of the Tusima Current.

Generic and specific numbers in each suborder occurred in every 5° latitudes and in 5 main regions severally are shown in Table 6.

From the table, it is seen that the area from the Central North Pacific to the China Sea (35°~25° N) has larger number of genus and species, especially in holoplankton Hyperiids, being not only due to the larger number of collections, but also probably to a general tendency in geographical distribution (Ishizuki, 1948).

Furthermore, from the general view, occurrences of Gammarids and Caprellids are largely confined to the very neritic region and, if not, to the insular or "tide-rips" regions (Ishizuki, 1956, 1957a, 1957b, 1958a, 1958b, 1958c). This suggests that many members of these suborders are not euplanktolic but rather tycho-planktolic.

Table 6. Generic and Specific Numbers in Each Suborder Occurred in Every 5° Latitude and in 5 Main Regions.

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<th>45°~40°</th>
<th>40°~35°</th>
<th>35°~30°</th>
<th>30°~25°</th>
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<th>N.NP.</th>
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<td>12 (15)</td>
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<td>20 (29)</td>
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Remark: Numbers put in brackets showing the number of species.
2. Distribution in the Western Sea of Kyūsyū.


Based on the materials collected 3 times (August, October, and December) in 1962 in the neighborhood of Tusima I., from February to March in 1954 and from January to February in 1956 in the neighborhood of Satun, severally, the western open sea of Kyūsyū were divided into following 3 regions voluntarily:

a. Tusima-region (north of the line from Hirado I. to the south end of Korea: 9 stations).

b. Gotō-region (south of the line mentioned above, north of 30° N: 42 stations), and
c. Southwest-region (south of 30° N: 31 stations),

and the general distribution of pelagic Amphipods in oceanic open sea and their characteristics in every region were discussed.

Occurrence in every region is as follows.

a. Tusima-region.

(1) Gammarids were very rare but Hyperiids dominated. Members of the latter have rather wide distribution in the adjacent seas of Japan (Iri, 1968). Among them, 2 species of Gen. Hyperia (i.e. H. schizogeneios & H. latissima) were overwhelmingly abundant in every month. The Author surmised that the stomach-contents of scomber caught by purse-seine in the eastern waters of Tusima I. in spring 1952 were almost composed probably of them (Iri, 1955, 1957b).

(2) There was no collection of Themisto japonica in August at all, a few in October but very abundant in December. This species has also wider distribution but its center lies in colder region (Iri, 1946).

(3) 1 species of Gen. Caprella was obtained in August. Specimens were too broken and small to identify easily, but the Author surmised them C. linearis, being also abundant in northern cold waters, though being reported from Kominato Bay, Tiba Prefecture (Utigom, 1947). Caprellid members are mostly attaching or tube-building to a substratum in stead of free-living, accordingly they play only a secondary role as plankton (Schellenberg, 1929). Specimens the Author obtained in this region were mostly released from the floating algae converged at remarkable “tide-rips” area at that time (Iri et al., 1962).

(4) Gammarid members were also rare in epipelagic occurrence generally, but the Author obtained 1 species in August and 2 species in December. These were also very much broken. The Author, however, surmised them Allorchestes aquilinus and Corophium acutum.

b. Gotō-region.

(1) There occurred abundantly not only Hyperiids (17 species) but also Gammarids (3 species), Caprellids being only 1 species in this region.

(2) Themisto japonica and 2 species of Gen. Hyperia (i.e. H. schizogeneios & H. latissima) dominated also in this region generally. These dominated also in Tusima-region, where was no subsurface collection, so being not to be compared with, but have a tendency to occur abundantly in rather lower layers than in surface in this region, especially Themisto japonica were collected from surface for the first time in colder months in Tusima-region and, on the other hand, there are a tendency not
to occur so densely in layers less than 50 m deep in this region, being probably due to collections in warm month. Motoda & Anraku (1954) also pointed out such vertical distribution of this species. They surveyed to which extent the diurnal vertical migrations of zooplankton were performed in each region in the adjacent seas of Japan, and explained Primno sp. & Themisto sp. mostly distributed in layers more than 150 m deep both in the daytime and in the night, these refraining warmer water or preferring colder water, and being rare in layers from 150 m deep to surface in the daytime but abundant in the night. Tab. 7 shows the numbers of main zooplankton Amphipods collected by Sōyō-maru II in various layers of the Central Japan Sea (north off Noto Peninsula, west off Yamagata Prefecture) in August 1965.

Table 7. Diurnal Vertical Occurrences of Main Zooplankton Amphipods at Each Station in the Central Japan Sea.

<table>
<thead>
<tr>
<th>St. (SII)</th>
<th>Date</th>
<th>Hour</th>
<th>Depth (m)</th>
<th>Themisto japonica</th>
<th>Primno macroproa</th>
<th>Leptocotis ambobus</th>
<th>Glossocephalus milne-edwardsi</th>
<th>Allorchestes malleolus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1955, VIII-12</td>
<td>4:29-6:19</td>
<td>335</td>
<td>286 (9)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>2</td>
<td>&quot; &quot;</td>
<td>20:17-3:43</td>
<td>800</td>
<td>165 (1)</td>
<td>579 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>3</td>
<td>&quot; &quot;</td>
<td>14:06-3:10</td>
<td>0</td>
<td>173 (1)</td>
<td>67 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>4</td>
<td>&quot; &quot;</td>
<td>15:06-5:56</td>
<td>87</td>
<td>467 (0)</td>
<td>36 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>5</td>
<td>&quot; &quot;</td>
<td>22:34-16:03</td>
<td>169</td>
<td>72 (15)</td>
<td>2 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>6</td>
<td>&quot; &quot;</td>
<td>22:13-4:06</td>
<td>0</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1 (0)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

From the table, specific number occurred was large in Hyperiids, especially Themisto japonica and Primno macroproa were large in number of individual. The former has comparatively wide distribution, having its center in higher latitudes (Irri, 1948) but increasing number in colder months also in middle latitudes, and that having a tendency to be abundant in deeper layers. The latter is also similar to the former. It indicates clearly the inclination of upward-migration in the night that they are abundant overwhelmingly in surface of St. 3 from mid-night to early morning (3:08 ~ 6:10).

From horizontal and vertical occurrences of Themisto japonica, Hyperia schizogeneios & H. latissima in Gotō-region, and vertical occurrence of Themisto japonica in the Central Japan Sea, the Author surmised Gen. Themisto is rather the open-sea mesozonal form, while Gen. Hyperia the neritic mesozonal one. For example, the latter occurs even in Omura Bay but the former does not.

(3) All the members of Gammarid and Caprellid were obtained only from surface
layer, and stations almost confined to the very neritic or offshore insular regions.

c. Southwest-region.

Specific number of Hyperiid occurred was larger than in Gotô-region, while only 2 species were obtained among Gammarids.

Occurrence of each species in every region is shown in Fig. IV, and generic and specific numbers in each suborder occurred are summarised in Tab. 8.

Table 8. Generic and Specific Numbers in Each Suborder in 3 Regions of the Western Sea of Kyûsyû.

<table>
<thead>
<tr>
<th>Region</th>
<th>Subord.</th>
<th>HYPERIDEA</th>
<th>GAMMARIDEA</th>
<th>CAPRELLIDEA</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tusima</td>
<td></td>
<td>12</td>
<td>(14)</td>
<td>2</td>
<td>(2)</td>
</tr>
<tr>
<td>Gotô</td>
<td></td>
<td>14</td>
<td>(17)</td>
<td>5</td>
<td>(9)</td>
</tr>
<tr>
<td>Southwest</td>
<td></td>
<td>18</td>
<td>(23)</td>
<td>2</td>
<td>(2)</td>
</tr>
</tbody>
</table>

Remark: Numbers put in brackets showing the number of species.

From the table, it is known that, as in general distribution in the adjacent seas of Japan, the more we go southwards the more abundant we get them also in confined “Western Sea of Kyûsyû”.

From the figure, the occurrence of each genus is as follows.

1. 9 genera are common to 3 regions: i.e. Phronimopsis, Themisto, Hyperia, Primno, Lycaeopsis, Tetrathyrsus, Parascelus, Brachyscelus & Lycae. Among these, 6 genera: Themisto, Hyperia, Primno, Tetrathyrsus, Brachyscelus & Lycae, have wider distribution, and members other than 2 genera: Themisto & Primno, have the center of distribution rather in warm-water region. Furthermore, 3 genera: Phronimopsis, Lycaeopsis & Parascelus, are purely warm-water forms.

Fig. IV. Specific Occurrence in 3 Regions of the Western Sea of Kyûsyû.
2. From the consideration of season obtained,
   a. in warm months, 3 genera; *Hyperia*, *Lycaea* & *Tetrathyarus*, and
   b. in cold months, 2 genera; *Hyperia* & *Brachyscelus*,
      are common to 3 regions severally.
3. Regionally,
   a. 1 genus; *Corophium*, occurred only in Tusima-region,
   b. 5 genera; *Rhodosoma*, *Pleonexes*, *Sunamphithoe*, *Jassa* & *Hyale*, occurred only in Goto-region, and
   c. 5 genera; *Vibia*, *Hyperioideis*, *Phrosina*, *Sympronoe* & *Leptocotis*, occurred only in Southwest-region.

From the above mentioned, in the western sea of Kyushu, followings are summarised.
1. There are seen almost the holoplankton only in southern part, i.e. pure Kurusio Area, but the tychoplankton takes its place in the neighborhood of Goto Is., and then the holoplankton increases again in the neighborhood of Tusima I.; namely it is characteristic to the western sea of Kyushu that there occurs larger number of Gammarid member in Goto-region compared with other 2 regions. This suggests that the oceanic water dominates both in Tusima- and Southwest-regions, while the neritic water does in Goto-region, severally.
2. Occurrence of Gen. *Themisto* in upper layer in Tusima-region suggests the prosperity and decay of the Warm Current or the dominance of cold water-mass.
3. Gammarids and Caprellids are tychoplankton and, accordingly, their pelagic occurrences are generally confined in the very neritic and, if not, insular or "tide-ripples" regions in open sea.
4. From the occurrence of each genus, it is suggested that the western sea of Kyushu is somewhat influenced by the cold current or water-mass, although lies in domain of the Warm Current, being characteristic to this region.
5. From the consideration of vertical distribution, Gen. *Themisto* is rather the open-sea mesozonal form, while Gen. *Hyperia* the neritic mesozonal one, especially Gen. *Hyperia* having wider distribution both horizontally and vertically in the western sea of Kyushu all the year round.


To elucidate the distribution of pelagic Amphipods in neritic and inshore waters, investigations were carried out at 18 stations in Omura Bay (among them 2 were in Sasebo Bay near Omura Bay) 6 times (May, July, August, September, October 1954 and March 1955) at 17 stations in Omura Bay (among them 2 were in Sasebo Bay near Omura Bay) 4 times (April, June, August and December 1956), at 4 stations in semienclosed waters outside of Sasebo Bay 3 times (May, July and November 1956) and at 2 stations outside of Sasebo Bay once (May 1956).

A. Occurrence in Waters Outside of Sasebo Bay.

*1 Horizontal hauling of the larva-net at surface.
*2 Horizontal hauling of the larva-net every 10 m depth.
*3 The waters from the outside of Sasebo Bay to Upper Goto Is., north being enclosed by Hirado I. and south by Osima, Sakito, Enosima and Hirasima Is.,-Hokusyo-Kamigoto Region.
Specific number in each suborder occurred in total and in every month are as following table.

Table 9. Specific Number in Each Suborder Occurred in Total and in Every Month in Hokusyō-Kamigotō Region Outside of Sasebo Bay.

<table>
<thead>
<tr>
<th>Suborder</th>
<th>Species</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>May</td>
<td>July</td>
<td>November</td>
</tr>
<tr>
<td>HYPERIDAEA</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>GAMMARIDAEA</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CAPRELLIDAEA</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7</strong></td>
<td><strong>5</strong></td>
<td><strong>3</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

From the table, it is known that specific number occurred is very small generally in this region. There occurred more abundantly in lower layers than in the upper vertically, and Caprellids were dominant generally.

B. Occurrences in the Daytime and in the Night.

Investigations were carried out at the west of Makurasima I., (1 of 99-sima Is.) 3 times (1956-05~16, 05~19, 31~00) 2~3 May 1956 and at the southwest of Sakitosima I. 3 times (1956-05~15, 10~12, 20~22) 19~20 May 1956. Results are as follow.

Table 10. Generic and Specific Numbers in Each Suborder Occurred at 2 Stations Outside of Sasebo Bay.

<table>
<thead>
<tr>
<th>Suborder</th>
<th>G'St. 1.</th>
<th></th>
<th>G'St. 2.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Genus</strong></td>
<td><strong>Species</strong></td>
<td><strong>Genus</strong></td>
<td><strong>Species</strong></td>
</tr>
<tr>
<td>HYPERIDAEA</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GAMMARIDAEA</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>CAPRELLIDAEA</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4</strong></td>
<td><strong>7</strong></td>
<td><strong>14</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

From the table, it is clearly seen that Gammarids are abundant overwhelmingly. Hyperiids and Caprellids were obtained at surface both in the daytime and in the night, 13 species among 14 of Gammarid being obtained only in lower layers and being confined in the night.

C. Occurrence in the Neighborhood of Ōmura Bay.

Generic and specific numbers in each suborder occurred in the neighborhood of Ōmura Bay are as following table.
Table 11. Generic and Specific Numbers in Each Suborder Occurred in Ōmura Bay.

<table>
<thead>
<tr>
<th>Suborder</th>
<th>Genus</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperidea</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Gammaridea</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>Caprellidea</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14</strong></td>
<td><strong>24</strong></td>
</tr>
</tbody>
</table>

From these and the considerations on hydrographical conditions hitherto observed (Ishizuka, 1954, etc.), followings are summarized in Ōmura Bay.

1. Hyperiids were very poor, while Gammarids dominated. Taking into consideration of stations occupied, Gammarids occurred in the eastern part from the middle to the innermost having depths less than 15 m and the water being proper to the Bay, while Hyperiids did in the western part having depths more than 20 m and being influenced strongly by the water outside of the Bay. These Hyperiid members are of Genera Hyperia and Hyperoche, having rather wider distribution both geographically and vertically.

2. In a year round, there occurred in abundance from the middle to the mouth from April to June, this region having “tide-rips” and converging various floating organisms almost constantly. The Author surmised this results in these occurrences.

3. Among Gammarids,
   (1) Gen. Amphithoe, in general, dominated, especially A. japonica having compartively wide distribution also vertically and being released also from floating algae.
   (2) Biancolina sp. was only released from floating algae, but no eupelagic collection.
   (3) Amphilochoerus brunneus, Amphithoe rubricata and Corophium acutum were obtained both from floating algae and free living state.
   (4) Among members released from floating algae, Amphithoe japonica and Corophium acutum dominated, especially the latter being overwhelmingly abundant and occurring also in free living state.
   (5) Jassa dentex, Erichthonius brasiliensis and E. hunteri were the dominant members at the “wakame” grounds of Simabara, Nagasaki Prefecture (Ishizuka, 1964). The Author is of opinion that they may not essentially be pelagic, but they have comparatively high frequency occurrence in this region.

Taking a general view of occurrence of each species in western every region of Kyūsyū, followings are summarized.

1. In oceanic open sea, the more we go southwards the more abundant we get them even in the confined area, “the western sea of Kyūsyū”, reflecting the general tendency of geographical distribution.

2. Gammarids and Caprellids are generally neritic, the more going into the neritic inshore waters the more being abundant; i.e. they are tychoplanktonic, especially Gammarids are mostly nyktiplankton, while Hyperiids are generally holoplankton.

3. Towards neritic and inshore waters from oceanic region, holoplankton becomes to be poor gradually, while tychoplankton takes his place almost entirely in the
innermost of inlet. In bay, however, there occurs holoplankton which has wide
distribution both geographically and seasonally at the time and in the region
strongly influenced by oceanic water. The Author surmises accordingly that
holoplankton is important as the indicator of oceanic water, while tychoplankton as
that of neritic water.

4. In population, transition from dominance of oceanic form to that of the neritic and
invasion of adaptable oceanic form into bay may probably be a index showing the
effect of oceanic water to the inshore.

APPENDICES : Significance of Amphipods in Natural Economy.

A. Amphipods as Food of Important Fishes.

The Author roughly examined stomach-contents, by precipitation, of about 23 mackerels
(Pneumatophorus japonicus) caught by purse-seine in the eastern sea of Tusima in spring
1952, resulting in that 8~10 % of those, presumably, were occupied by 1~2 species of
Amphipod (probably be Hyperiid), with the exception of the fish sated with the
Euphausiids. The Author, furthermore, knew the surf-fish (Ditrema tenmineckii) which
were caught by a small set-net in Sasebo Bay were wellfed by Caprellids probably.

Many authors; Utonokita et al (1954), Izuka et al (1964), Takano (1954), Takano & Hanado
(1957), Madra et al (1956 & 1958) and Ogawa (1955) report respectively that Amphipods are
comparatively important as the food of perch (Lateolabrax japonicus), Alaska pollack
(Theragra chalcogramma), mackerel (Pneumatophorus japonicus) and horse mackerel
(Trachurus japonicus) and may be able to become a indicator showing a speciality of the
inhabiting domain from their food-composition, although it changes according as age,
season and ground.

Watari (1956b) reports, furthermore, that Nikuti Trout-farm, Yamagata Prefecture, are
given a satisfactory result mainly to brook-trout by throwing down living Amphipods (a
species of fresh-water Gammarid : Echinogammarus annandalei) which thrive abundantly
in neighboring spring waters.

B. Indirect Damage to Useful Algae by Amphipods.

Irie, 1966b).

It is not only well-known that Amphipods bore wood in water and eat algae untidily,
but also benthic forms consolidate the mud covering substrata to which the algae attach
and consequently often obstruct attachment and growth of the algae very much.

Simabara Peninsula, Nagasaki Prefecture, facing to Ariake Kai (Simabara Bay), from
Mie to Kazusa has been the most productive area of “wakame” (a species of brown algae:
Undaria pinnatifida) in the Prefecture for last 80 years. In 1960, rocks and stones were
thrown for the purpose of the increase of crop. Probably consequence of this process
attained twice of the ordinary harvest.

Near the end of harvest time (June) in 1954, however, the yield fell away abruptly. In 1956 again, from the beginning of February, the symptome of remarkable decrease was
noticeable. To elucidate the cause, diving investigations were done in April and June at
the neighboring area of Simabara City, producing about 30 % of the yield of the Peninsula
by Mr. Syōiti Nishimura, Nagasaki Prefectural Fisheries Experimental Station.

According to the observations, the grounds at north of Dōzaki were not only accumula-
ted by mud about 10 cm thick but also the tube-building Amphipods were abnormally thrive. It seems that these display some obstacles to the growing of the alga. Following 2 species were identified from the mud-sample; the first about 90%, the second about 10% and almost nothing else.

*Erichthonius brasiliensis.*
*Corophium acherusicum.*

Members other than the above were very few; they were

*Erichthonius hunteri.*
*Jassa dentex.*
*Caprella spp.*

If the Author is allowed to surmise, the flood in June 1953 might have conveyed the mud from the opposite side of Ariake Kai and accumulated at the neighboring area of the Peninsula. Thus it gave favorite inhabitable places for the tube-building Amphipods.

Lastly, it was observed by a glass-box that the mud accumulation had almost disappeared. On the other hand, mullets (*Magil cephalus*) were caught in remarkably large quantities in this area by angling. The mullet-angling is ordinarily opened in June-July, but in 1953 it continued till September.

Dominated 2 species are rather cosmopolitan in neritic muddy bottom in warm waters, and they were also dominant in samples of oyster-bed at the same area in July 1954, i.e. they seem to be residents in this area. They often occur in neritic and inshore waters as tychoplankton.

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(48) " 1954c.
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(49) " 1954d.
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(50) " 1956.
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(52) " 1932.
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(53) " 1937.
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(58) Pluot, J. M. 1939.
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