On the Development and Growth of *Neocaridina denticulata* De Haan

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I Introduction

In Kyusyu, the many fresh water shrimp had lived in the paddy-field and pool, and these shrimp was maked use of the live-bait or in some regions was used as food. But after the war, it disappeared rapidly since the farmers has emploied the insecticides -Folidol and so on — at the paddy-firld. In the present time, it is not discovered at the paddy-field and pool entirely, but it has lived sometimes in the pond among the mountains which has no connection with the paddy-field. This fresh water little shrimp is *Neocaridina denticulata* De Haan and in japanese is Taebi which means the shrimp of the paddy-field. In this days, the other live-bait for the fishing in the sea commence to disappear and the fishing to sport has been popular among the people, so the demand to this shrimp which is the most desirable live-bait in the sea has increased. We has studied on the propagation of this fresh water shrimp and in this paper we report about the development and growth of this shrimp.

We are grateful to Dr. S. Yokoya and Prof. S. Miyake of Agriculture department of Kyusyu University for the effective advice to us.

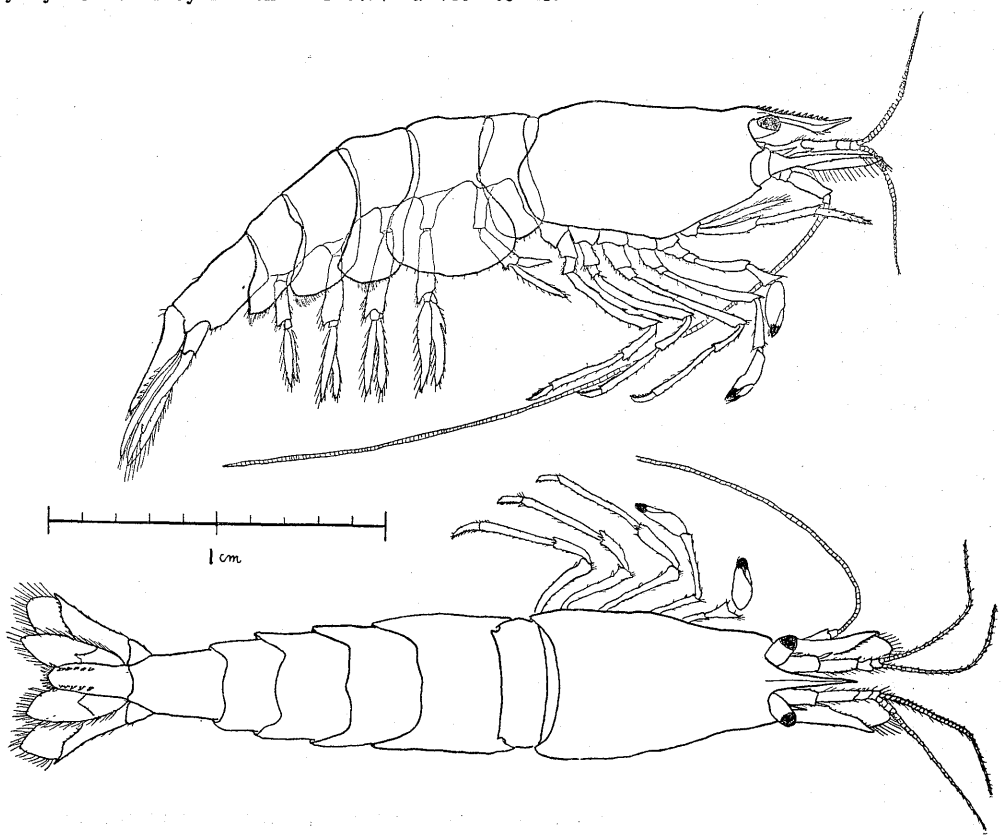

Fig. 1 *Neocaridina denticulata* De Haan (female)

II Method and Material

This shrimp has been described in *"ILLUSTRATED ENCYCLOPAEDIA OF THE FAUNA OF JAPAN"* and *"ENCYCLOPAEDIA ZOOLOGICA ILLUSTRATED IN COLOURS"*. By these literature its distribution in Japan extends broadly throuout the south-west since N 30° and it is very common species. The sketch of our shrimp is shown in Fig. 1. Our species is very similar to *Caridina denticulata* De Haan (this is tipical form, Japan — from the neighbourhood of Lake Biwa) in S. Kemp's original work (1918). And then he introduced the *Caridina denticulata sinensis* Kemp in this work, but our species is different from the *Caridina denticulata sinensis* on the point of the number of rostral teeth and of the shape at the endopodite of first maxilliped. In 1938, Prof. I. Kubo had prepared a new genus — *Neocaridina* — and separated from *Caridina* by three characteristics, and he reported about the *Neocaridina denticulata* De Haan at Nagasaki, Unzen, Beppu, Huzan, Hukuyama, Hukuoka, Kyoto, Yaizu etc. And then after the war Mr. H. Yaguchi described about *Neocaridina denticulata* De Haan of Chiba pref., but the shrimp of Chiba pref. is different from our species on the point of the shape of rostrum and the number of rostral teeth. Prof. T. Kamita described about the *Neocaridina denticulata* De Haan in following prefecturs—Shimane, Yamaguchi, Oita, Kagoshima, Kumamoto, Wakayama, Tottori etc. in 1956. These treatises has been treated on the taxonomic problems mainly and has not been studied on the development and growth except the Kamita's work.

We collected this shrimp from the pools among the mountains in the neighbouring of Sasebo city, and we had breeded since autumn of 1958 in the outdoor concrete breeding pool (360cm×370×32) and in the columnar glass water tank (30cm×40) in the room with *Eichhornia crassipes*.

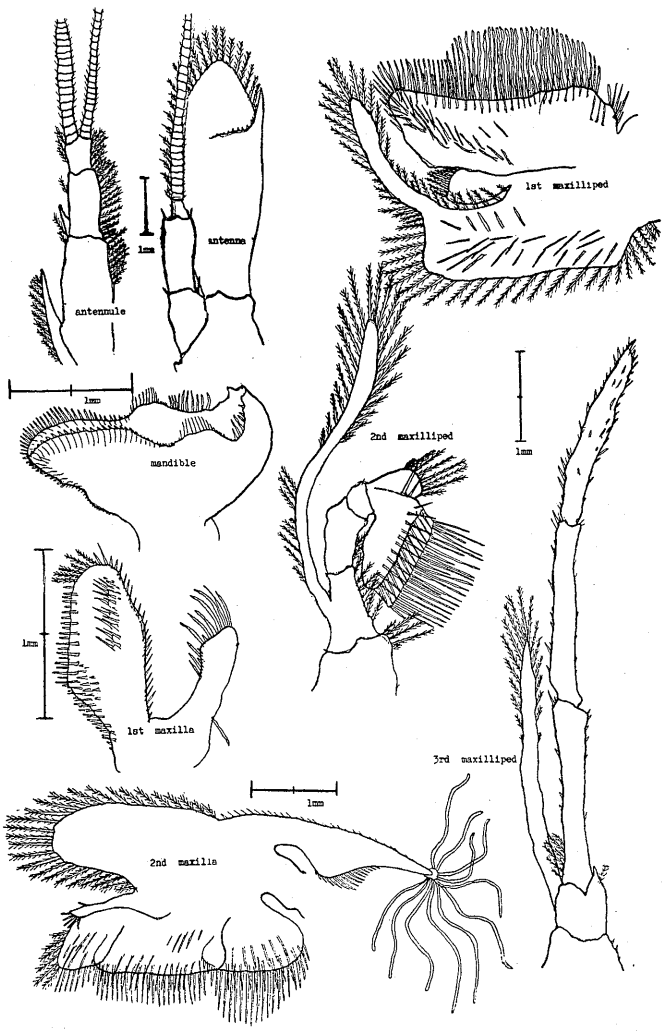

Fig. 2 Antennule, antenna, mandible, maxillas and maxillipeds of adult

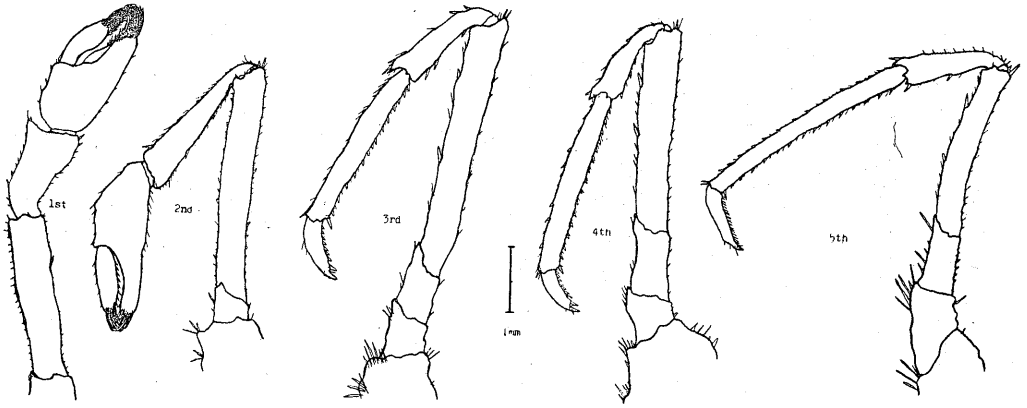

Fig. 3 Pereiopods (1st~5th) of adult

Ⅲ Observation

A Body-color

By *ILLUSTRATED ENCYCLOPAEDIA OF THE FAUNA OF JAPAN* the body color is blackish brown at the freshness and by the PLATE in *ENCYCLOPAEDIA ZOOLOGICA LILUSTRATED IN COLORS* it is grey green. Our shrimp has many variations in body color but the many are semitransparent grey green, the blackish brown shrimp exists conparatively and in this shrimp there is a widely striped brown design on the back side through the carapace and abdomen, and the reddish sometimes.

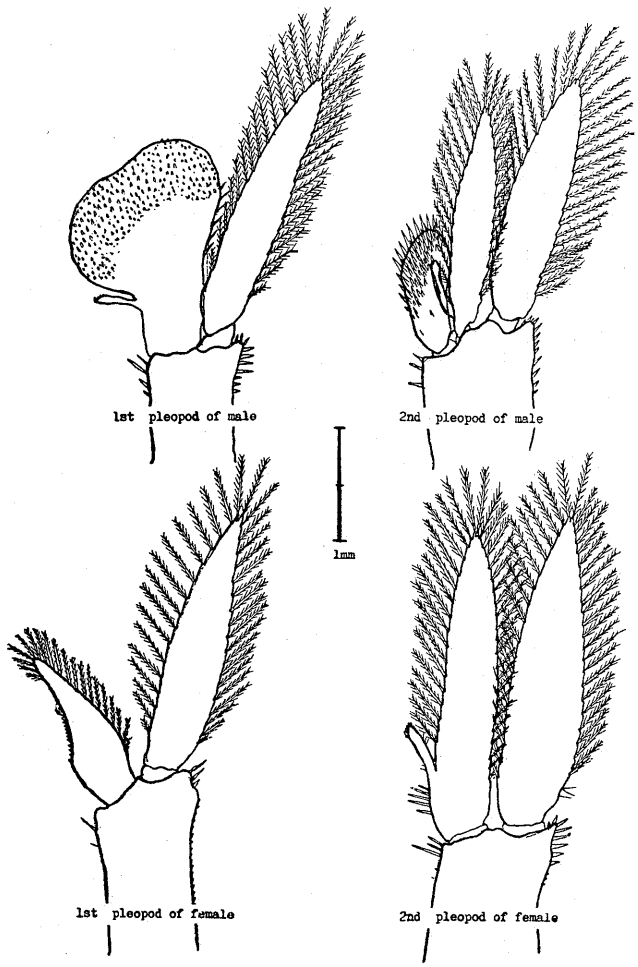

Fig. 4 1st and 2nd pleopod of adult (differences of both sexes)

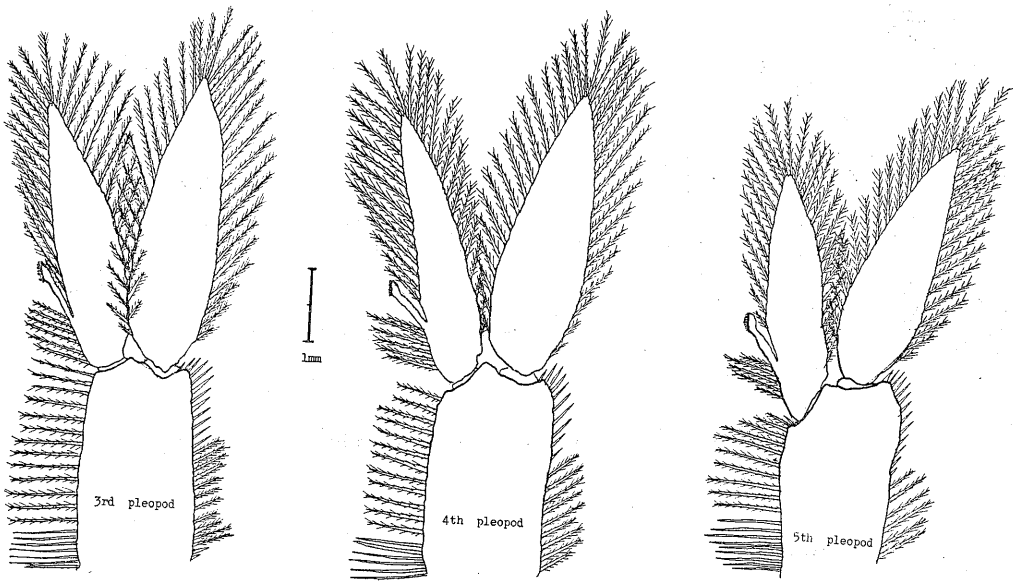

Fig. 5 3rd～5th pleopods of adult

B Differences in both sexes

KAMITA has shown that in the mound of the size distribution of the adult *Neocaridina denticulata* the female is more larger than the male, and this is the same result to ours. In the adult which collected at the first decade of May, the range of the female body length is 16.0—25.5mm and its mean is 21.2 mm, the male is 16.0 — 20.0 mm, 18.2 mm. But it is almost imposible to distinguish the both sexes by its body length only. The differences of the both sexes in this species are clearly in the Ist and 2nd pleopods as Fig. 4 showes, namely at the 2nd pleopod the endopodite and exopodite are almost same size in female, but in male the exopodite is larger, and the other is very smaller, and the endopodite is attached to the enlarged and thickened appendix masculina which has many setae. In the next place at the Ist pleopod the exopodite is normal slender form, the endopodite is very large and pear-shaped in male as KUBO described, but in the Ist pleopod of female the endopodite is smaller and more slender than the exopodite and is not seen the special form such as male.

C Number of rostral teeth

The number of rostral teeth showed in Table 1 by sex as it is a important standard of the classification. About the dorsal teeth there is the differenc by sex. and our number of rostral teeth comes within the range of *ENCYCLOPAEDIA ZOOLOGICA ILLUSTRATED IN COLOURS* and *ILLUSTRATED ENCYCLOPAEDIA OF THE FAUNA OF JAPAN* and is similar to the KEMP's range and its mode, but is more few than the KUBO's number which was collected in various districts of this country.

D Number of spine at telson

There are many spines at telson, namely spine exist at the both sides in the dorsal face of telson and at the terminal margin of telson. Table 2 showes the number of the side spines of our shrimp, its mode and peak incline towards the large number than KUBO's examination. And the number of the spines at the terminal margin of telson is shown in Table 3, it has the wide distribution than the others.

Table 1 The number of rostral teeth

male								female								
No. of dorsal tooth / No. of ventral tooth	1	2	3	4	5	6	Total	No. of dorsal tooth / No. of ventral tooth	2	3	4	5	6	7	8	Total
9	—	1	1	—	—	—	2	10	2	1	—	—	—	—	—	3
10	—	1	—	—	—	—	1	11	—	—	—	1	—	—	—	1
11	—	—	2	1	1	—	4	12	2	3	—	—	—	1	—	6
12	1	—	4	2	1	—	8	13	2	4	1	2	—	—	—	9
13	—	1	1	1	1	—	4	14	1	2	7	3	1	—	—	14
14	—	—	1	1	—	—	2	15	1	2	6	—	6	—	1	16
15	—	—	—	—	—	—	—	16	—	—	1	3	2	—	—	6
16	—	—	—	1	—	—	1	17	—	—	1	3	—	—	—	4
17	—	—	—	2	—	1	3	18	—	—	1	—	—	—	—	1
Total	1	3	9	8	3	1	25	Total	8	12	17	12	9	1	1	60

Table 2 The number of spinule the outer uropod

male								female							
Left / Right	2	3	4	5	6	7	Total	Left / Right	2	3	4	5	6	7	Total
2	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	3	—	1	1	—	—	—	2
4	—	—	3	1	—	—	4	4	—	—	4	3	—	—	7
5	—	—	—	12	1	—	13	5	1	—	4	23	3	—	31
6	—	—	—	2	3	—	5	6	—	—	1	5	5	—	11
7	—	—	—	—	—	—	—	7	—	—	—	—	—	1	1
Total	—	—	3	15	4	—	22	Total	1	1	10	31	8	1	52

Table 3 The number of spine at the terminal margin of the outer uropod

Sex / No. of spine	6	7	8	9	10	11	12	13	Total
male	—	—	—	1	—	1	20	5	27
female	1	—	2	1	4	8	34	7	57

E Hatching

The adult shrimp was removed to the columnar glass water tank in the sunny laboratory from the outdoor concrete breeding pool at autumn of 1959, and each tanks include 15 males and 15 females. They performed the molting in the period between the last decade of November and the first decade of December in these tanks with both sexes. The many *Eichhornia crassipes* are held in these tanks at the laboratory and outdoor breeding pool, and the shrimp takes hold of the long fibers of the root of *Eichhornia crassipes* and molts. After this molting they hibernate in the soft mud at the bottom of the tanks. We took notice of it in the first decade of April of 1960 that the females in the tanks maintain the many egges in the between of each pleopods. So it is presumed that the period of the copulation and spawning is between the middle decade of December and the last decade of March. We has not observed about the development of their gonad, the copulation, the spawning and its food organism etc. After hibernation the male specimens molted at the middle decade of April in the glass water tank. The egg of this shrimp is larger than the other fresh water shrimps egg and it grows up to about 1.6mm×1.05 in front of hatching, and the number of egg in this species is about 100—140 and is very few in comparison with the others, and there is a positive correlation between the body length and the number of egges. At the glass tanks in the laboratory, the hatching is performed in the period from the middle decade of May to the last decade of June. In the outdoor pool it is the same term. After the hatching these young shrimps molt in several times and when they grow up about 16 mm in body length after two monthes from the hatching they maintain many eggs. In the outdoor pool these young shrimps are holden only and their parents which tided over the winter is not put in this pool, so it is seemed the male reaches to the sexual maturity too as the female maintain the many eggs. Describing afterwards these shrimp can be distinguished in both sexes by the appendix masculina when they grow up about 11 mm in body length after a month from the hatching, so it is guessed that the gonad matures in both sexes. This is the second spawning season in this year. The hatching of this second spawning is between the first decade of August and the middle decade of September. The large group of the shrimp which tided over the winter and spawned in the first spawning season is not spawn in this period. And in the second spawning the number of egges is about 40—50 and is more few than in the first spawning, it is seemed that this is for the reason of the little body length. There are two mode in the size distribution of this shrimp during from the latter part of spring to summer, namely the one is the large group of parent shrimp which tided over the winter the other is the small group of the formers successors, then there are three modes in the size distribution at autumn, namely the smallest group in three modes is the shrimp which hatched out from the small shrimp in the period from summer to autumn. The egges of this shrimp adhere in the pleopods by the elastic fibroid egg handle and is not fallen off easily from the pleopods and it is similar to the case of *Cambarus affinis*. The color of egg which has been maintained by the parent shrimp is thick dark green in the beginning, but it turns into semitransparent light brown and is noticed the larval eyes in egg as the hatching draws near. (PLATE I, Fig 1.) In hatching the parent shrimp acts taking hold of the long fibers of the root of *Eichhornia crassipes* in no exception in this case. And the hatching is not performed in the daytime in general and it is seemed that the greater part of shrimp is hatched out from evening to daybreak and its necessary time is about ten hours. PLATE I, Fig. 2 shows the circumstances that the young shrimp has been hatched out from the egg,

namely when the egg shell had split and the young shrimp had come out from the egg the shell contracts and adheres at the back side of carapace of young shrimp and at this time the young shrimp adheres in the pleopods of the parent's shrimp with the egg shell yet. After about 20 minutes from the hatching the young shrimp performes the Ist molting. During this 20 minutes the young shrimp does not move the body except the maxilliped. The Ist molting requires about one minute, and after this molting the young shurimp separates from the parent for the first time and begins to swim activly. The parent shrimp melts in company with the egg shells which has attached in their pleopods when the young shrimps had acted the 2nd molting.

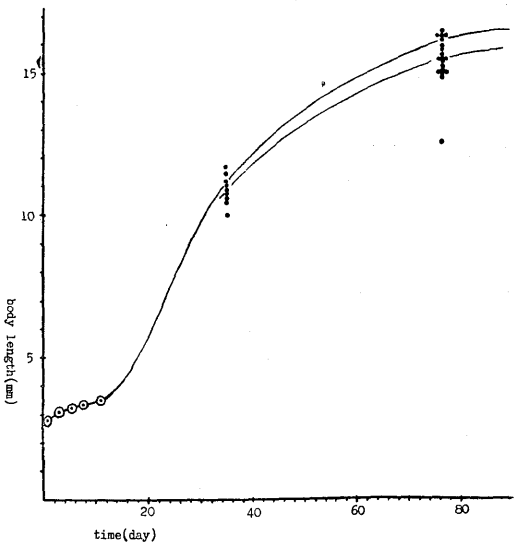

Fig. 6 Growth curve, ⊙···mean length in each larval stages

F Development and growth

PLATE I, Fig. 3 shows the shrimp after the Ist molting. In Japan, the studing about the development of the young shrimp is very few, especially in the fresh water. YOKOYA has reported in detail about the metamorphosis of *Paratya compressa improvisa* and *Leander paucidens*, in their Ist larval stage and the later several stages the body form is different from the parent remarkably. But in *N. denticnlata* there is a few difference between the young shrimp after Ist molting and its parent. The difference of both are following points, namely the shape of telson and uropod in the former differs from its parent as PLATE VIII, and the rate that the carapace has occupied to body length in the former is larger than the parent slightly, and in parent the size of the 2nd abdorminal segment is larger than the other but in the former the each abdorminal segments are same size. The 2nd molting is performed after 2 and 3 days from the Ist molting. The young shrimp after the 2nd molting is the nearly same shape to the parent and the form of telson and uropods are very transformed. The 3rd molting is performed after 2 and 3 days from the 2nd molting. The 4th molting is after 1—3 days from the 3rd. The 5th molting is after 3 and 4 days from the 4th. PLATE VIII shows the variations about the shape of telson and uropod in the each larval stages. By this PLATE the shape of the telson and uropod after the 5th molting is not different from that of the parent. The forms of the shrimp at the each stages are shown in PLATE I—III. And the antennule and antenna, the mandible and maxillas, maxillipeds, pereiopods, pleopods, telson and uropod in the each stages are shown in PLATE IV—VIII.

And the yolk is noticed in a small quantity in the carapace of the young shrimp after 5th molting. The color of the excrement in the young shrimp stage is colorless and transparent jellify untill the shrimp after the 4th molting but the color of it in the shrimp after the 5th molting changes to amber color, and since the next stage the color of it is deep blackish brown and is same color to that of parent. From the absence of the yolk and the change of the color of the excrement at the larval stage, it is seemed that the shrimp after the 5th molting begins to take the food. And the growth of the shrimp from this stage is very rapidly. The difference in both sexes is not clearly

untill the shrimp after the 5th molting yet, but in the young shrimp which grows up about 11 mm in body length after a month from the hatching, the characteristic of the sex already appears clearly and the both sexes can be distinguished by the Ist and 2nd pleopods. Fig. 6 is shows the growthing curve during about two monthes since the hatching.

⑥ The others

This shrimps are attacked frequently by the fish and the larva of dragon-fly etc. during they has been the young stage untill about 10 mm in body length. And this shrimps are very delicate to the chemicals such as insecticides, so it is not uncommon that they were annihilated in the vast region on account of use of it. But this shrimp is not so delicate for the change of natural emvironments such as the water temperature, and the food at the breeding is the rice-bran and so on which is very easy to receive, and their growth is rapidly and the period which reaches to sexual maturity from the hatching is very short. So the propagation of this shrimp is simple and not difficult.

Ⅳ Summary

1) *Neocaridina denticulata* De Haan is not most popular fresh water shrimp in the south-west of Japan, but owing to the diffusion of the insecticides in the paddy-field after the war, it is going to be annihilated. On the one hand the demand to this shrimp has increased as it is the most desirable live-bait in the coastal sea. We has studied about the behavior of this shrimp since the autumn of 1958 to know the way of its propagation and in this paper we report about the development and growth of this shrimp.

2) We collected this shrimp from the pools among the mountains in the neighbouring of Sasebo city.

3) Our shrimp has many variations in body color but the many are semitransparent grey green, the blackish brown comparatively and the reddish sometimes.

4) The differences of both sexes in the adult of this shrimp are following, (1) the size distribution of females is larger than males, (2) at the Ist pleopod of this shrimp the exopodite is normal slender form and the endopodite is very large and pear-shaped in male, but in female the endopodite is smaller and more slender than the exopodite and is not seen the special form such as male, (3) at the 2nd pleopod the endopodite and exopodite are almost same size in female but in male the exopodite is larger and the other is very smaller, and the endopodite is attached to the enlarged and thickened appendix masculina which has many setae.

5) Our shrimp has the special number in the dorsal and ventral teeth at rostrum, in the spines of the both sides at the dorsal face of telson and in the spines at the terminal margin of telson as the tables show.

6) After hibernation the male molts at the middle of April and the female spawns the eggs and holds this eggs in his pleopods, and the hatching is performed in the period from the middle decade of May to the last decade of June, this is the first hatching season in this year.

7) The egg of this shrimp is larger than the other, and the number of eggs in this species is very few in comparison with the other and there is a positive correlation between the body length and the number of eggs. After the spawning the eggs adhere in the pleopods by the elastic fibroid egg handle.

8) The shape of the young shrimp after the hatching is almost the same to the parent except the telson and uropods as the PLATE Ⅷ shows. This shrimp does not metamorphose.

9) The figures of the body, antennas, mandible, maxillas, maxillipeds, pereiopods, pleopods, telson and uropods are shown at PLATES in the each larval stages.

10) In the shrimp after the 5th molting (after about 10 days from the hatching), there is no yolk in the carapace and the color of the excrement changes so it is seemed that the shrimp after the 5th molting begins to take the food. Its growth from this stage is rapidly.

11) In the young shrimp which grows up about 11mm in body length after a month from the hatching, the characteristic of the sex already appears and the both sexes can be distinguished by Ist and 2nd pleopods, it is guessed that the gonad matures in both sexes since this time.

12) The shrimp which grows up about 16 mm in body length after two monthes from the hatching molts the eggs which has held between the pleopods, namely this is the second hatching season in this year and it is the period from the first decade of August to the middle decade of September. The molting and development of this larval shrimp which had hatched out in this hatching season is same to that in the first hatching season. And the parent shrimp in the first hatching season does not perform the spawning and hatching.

13) The growth curve of this shrimp is indicated in Fig. 6.

14) This shrimp has been alive more than two years at least.

15) This shrimp is very delicate to the chemicals such as insecticides, but is not so delicate for the change of natural environments such as the water temperature and its growth is rapidly and the period which reaches to the sexual maturity is short and its food at the breeding is the rice-bram and so on which is very easy to receive, So the propagation of this shrimp is not difficult.

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VI Plate

PLATE I

Fig. 1 Egg

Fig. 2 The young shrimp in the Ist larval stage which is performing the Ist molting after the hatching

Fig. 3 Ist larval stage after Ist molting

PLATE II

Fig. 1 2nd larval stage after 2nd molting

Fig. 2 3rd larval stage after 3rd molting

PLATE III

Fig. 1 4th larval stage after 4th molting

Fig. 2 5th larval stage after 5th molting

PLATE IV

Antennule, antenna, mandible and maxillas in the each larval stages

Fig. 1 Antennule (1st larval stage——5th)

Fig. 2 Antenna (1—5)

Fig. 3 Mandible (1—5)

Fig. 4 Ist maxilla (1—5)

Fig. 5 2nd maxilla (1—5)

PLATE V

Maxillipeds in the each larval stages

Fig. 1 Ist maxilliped (1—5)

Fig. 2 2nd maxilliped (1—5)

Fi.g 3 3rd maxilliped (1—5)

PLATE VI

Pereiopods in the each larval stages

Fig. 1 Ist pereiopod (1—5)

Fig. 2 2nd pereiopod (1—5)

Fig. 3 3rd pereiopod (1—5)

Fig. 4 4th pereiopod (1—5)

Fig. 5 5th pereiopod (1—5)

PLATE VII

Pleopods in the each larval stages

Fig. 1 Ist pleopod (1—5)

Fig. 2 2nd pleopod (1—5)

Fig. 3 3rd pleopod (1—5)

PLATE VIII

Telson and uropods in the each larval stages (1—5)

PLATE I

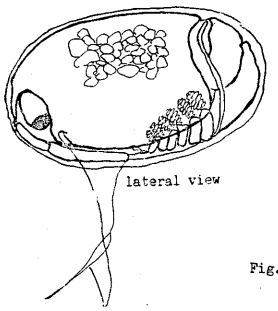
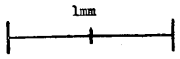


Fig.1



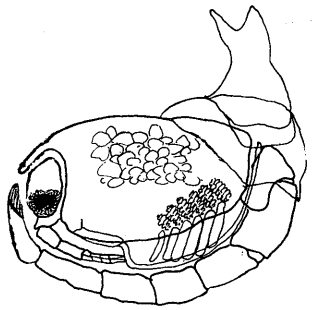
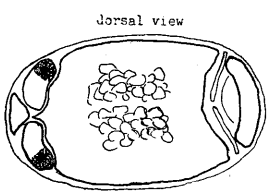
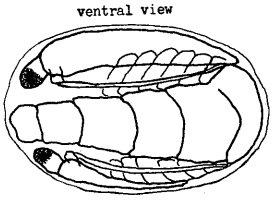
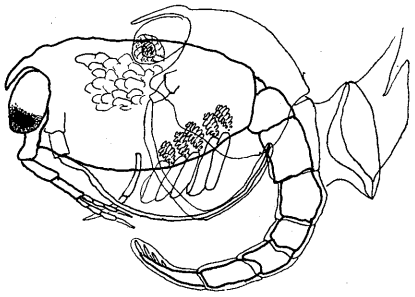


Fig.2







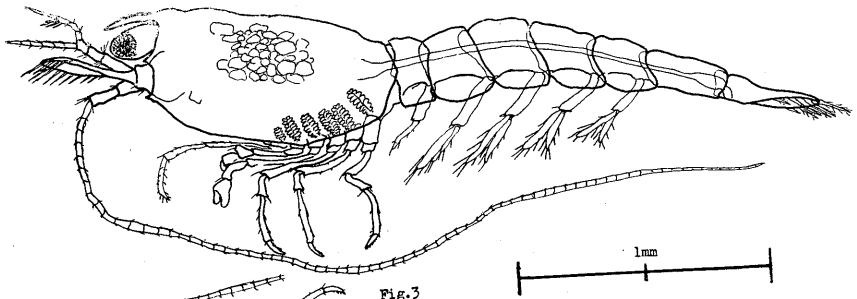


Fig.3

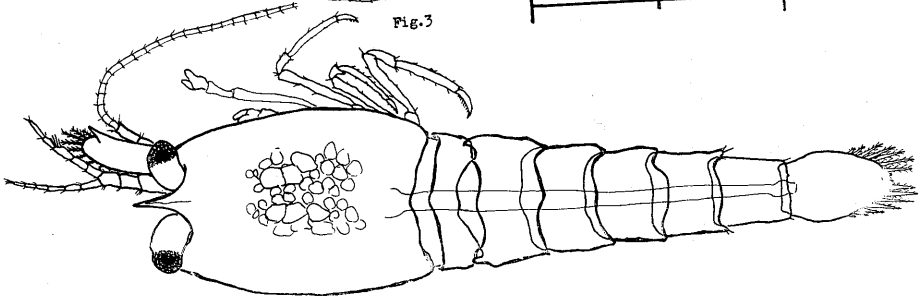


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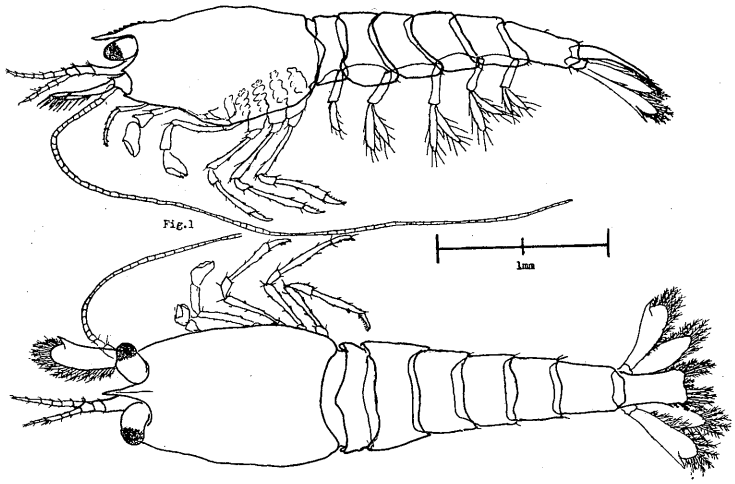
PLATE II



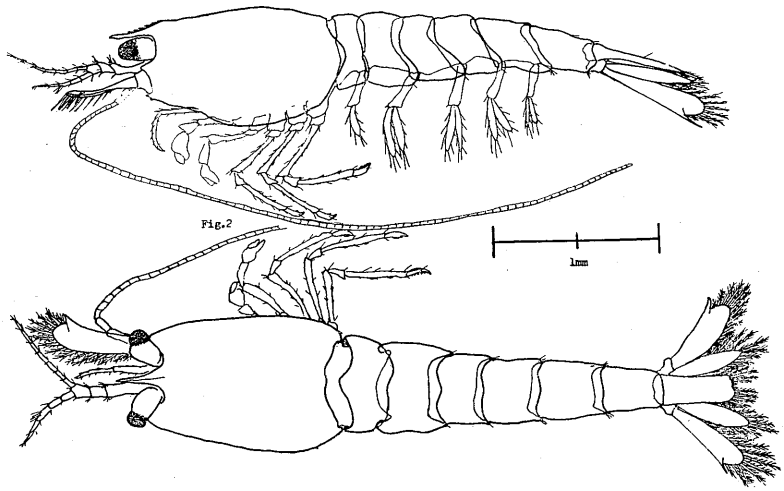


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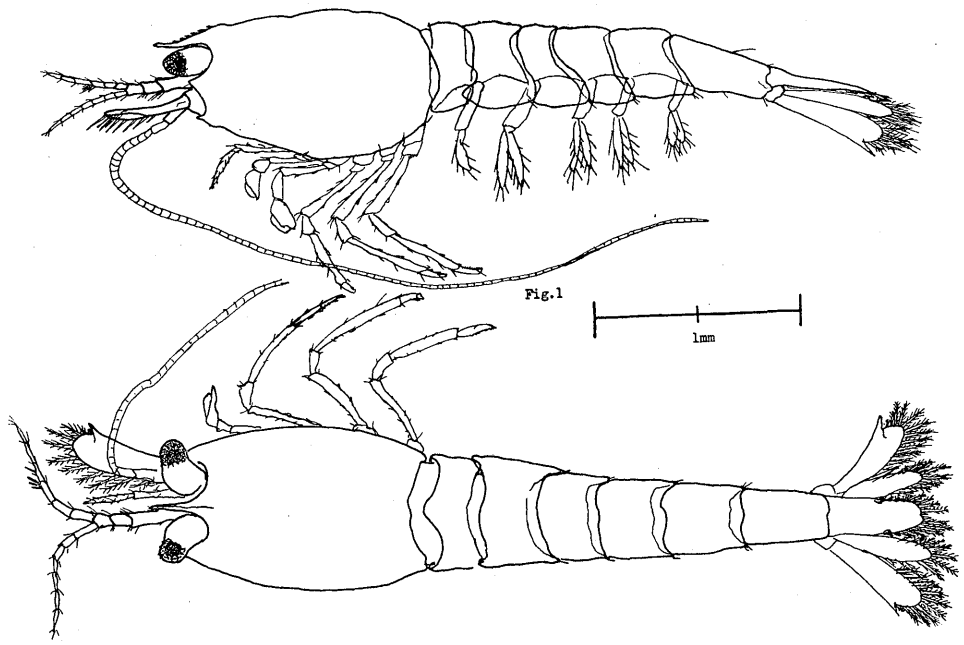
PLATE III



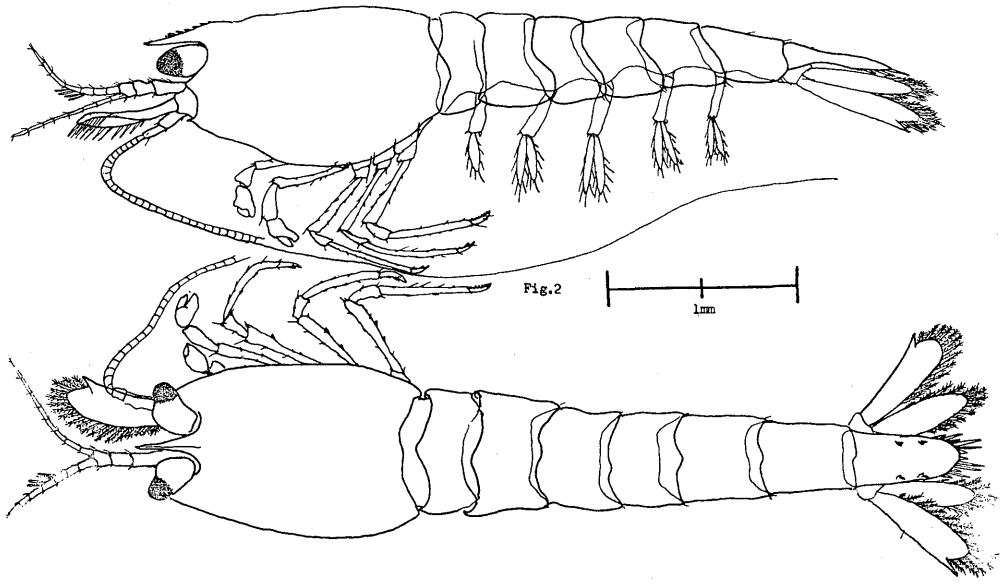


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PLATE IV

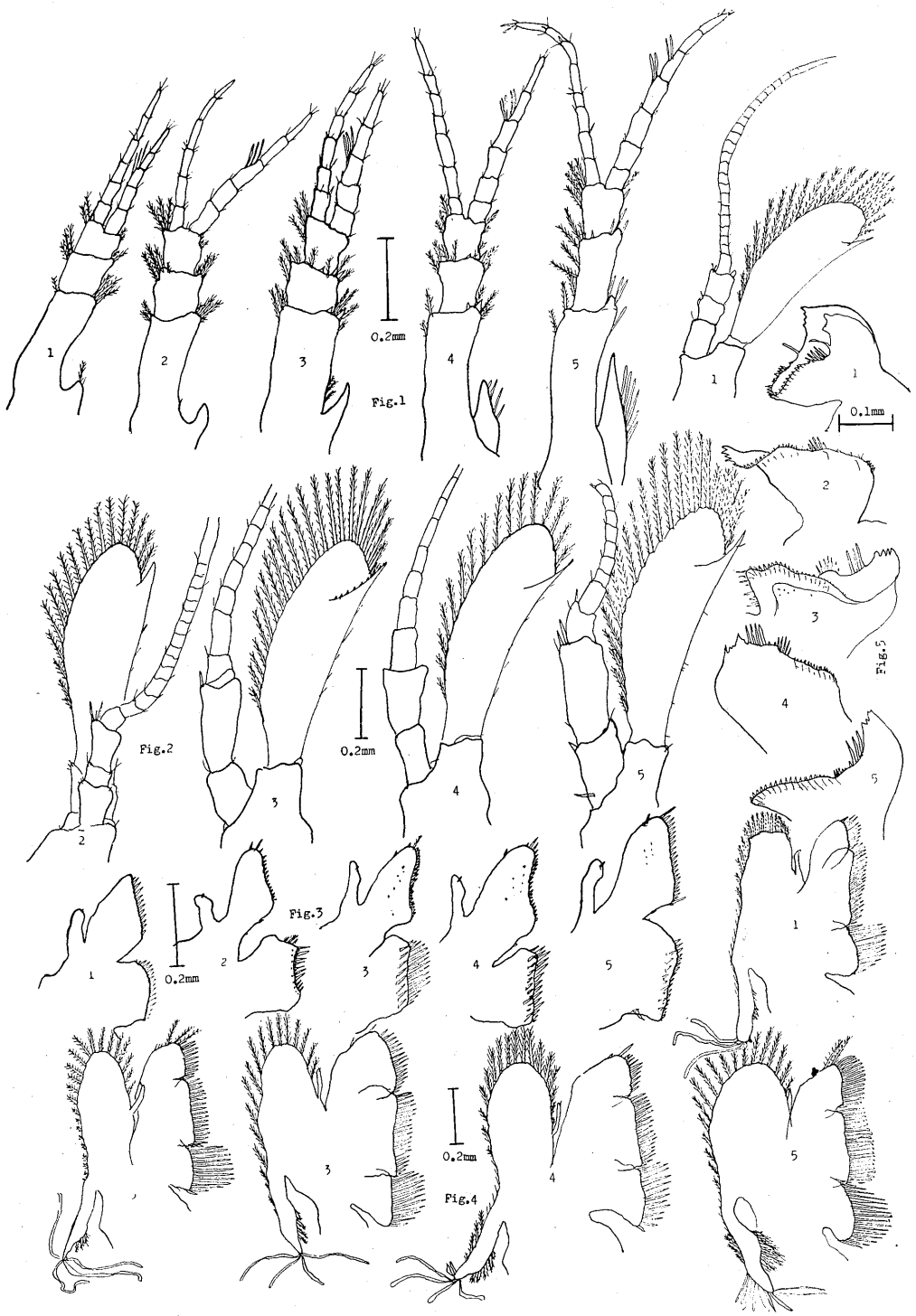

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PLATE V

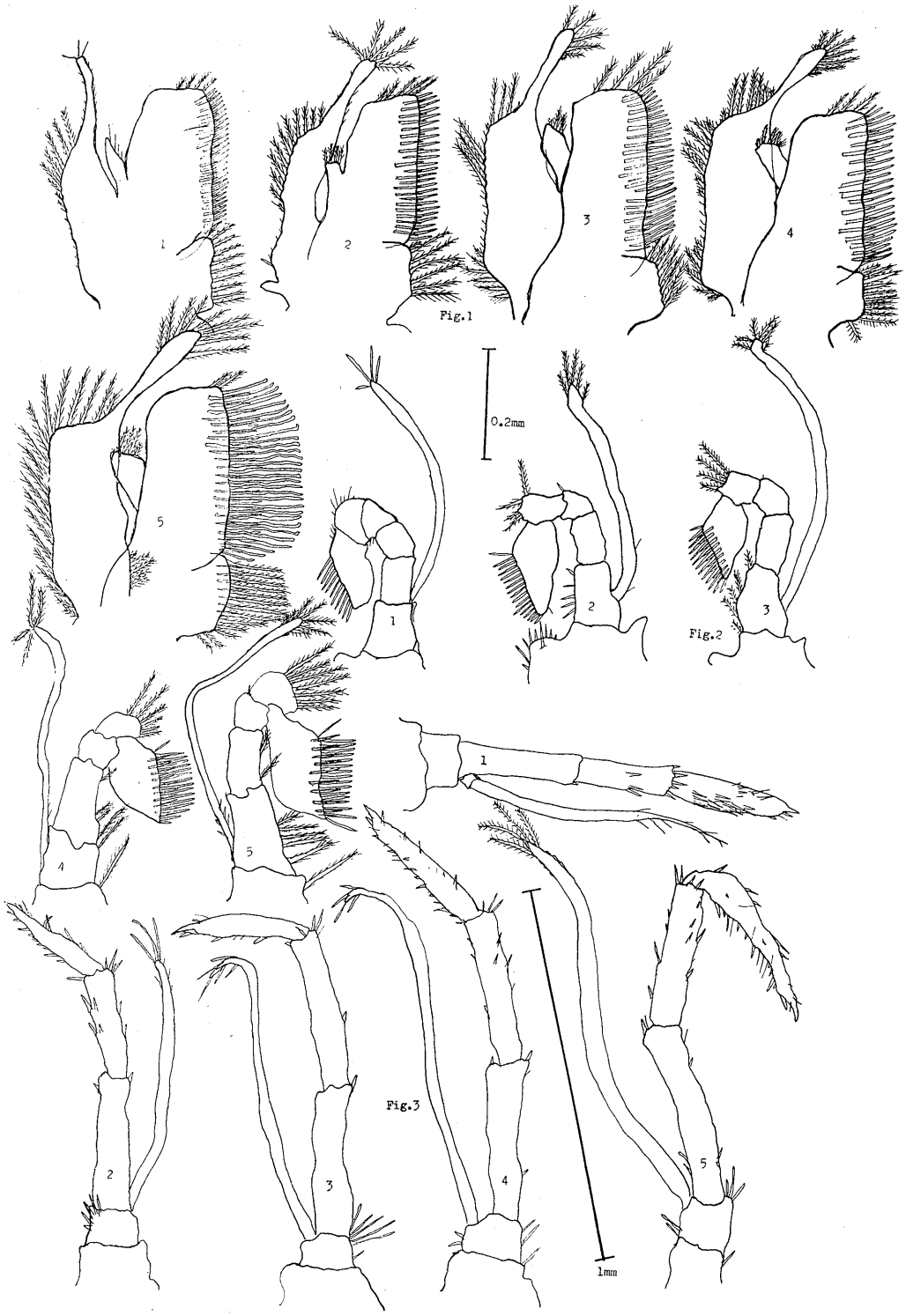

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PLATE VI

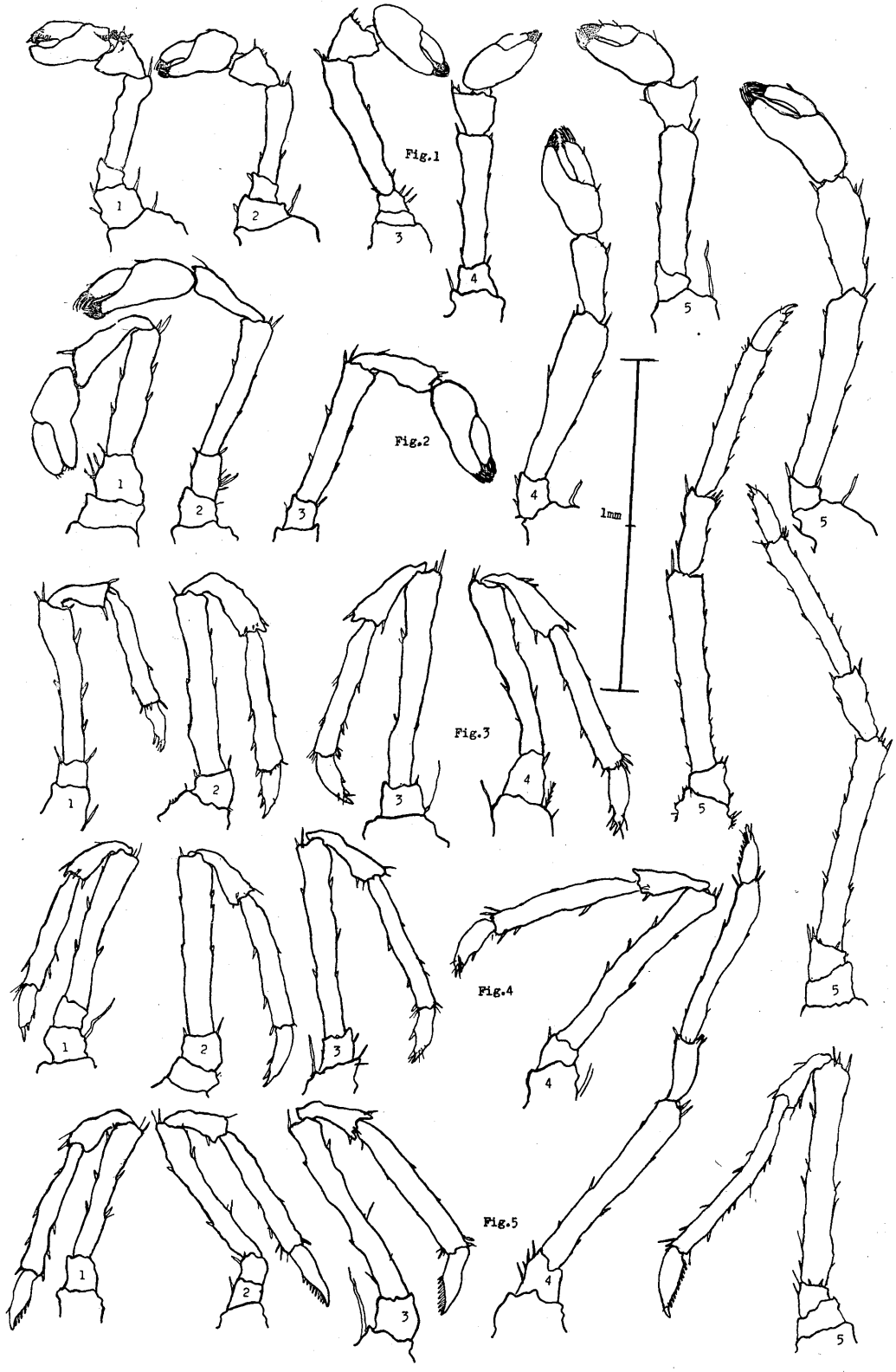

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PLATE VII

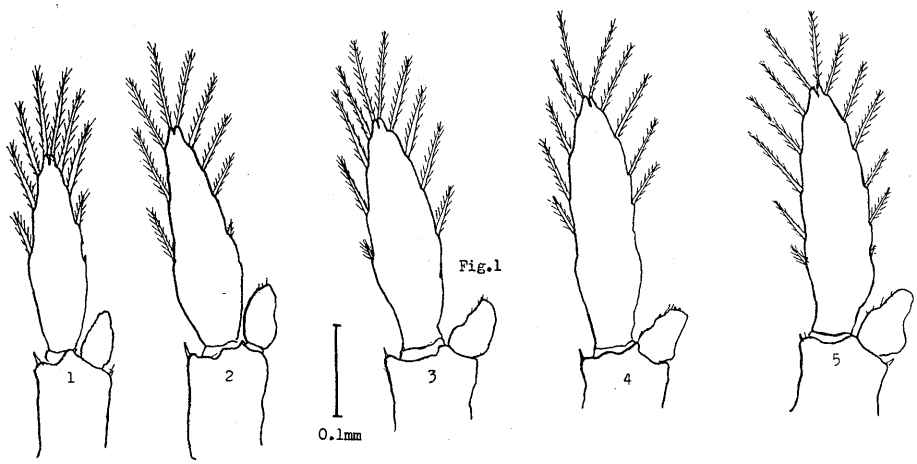

Fig.1

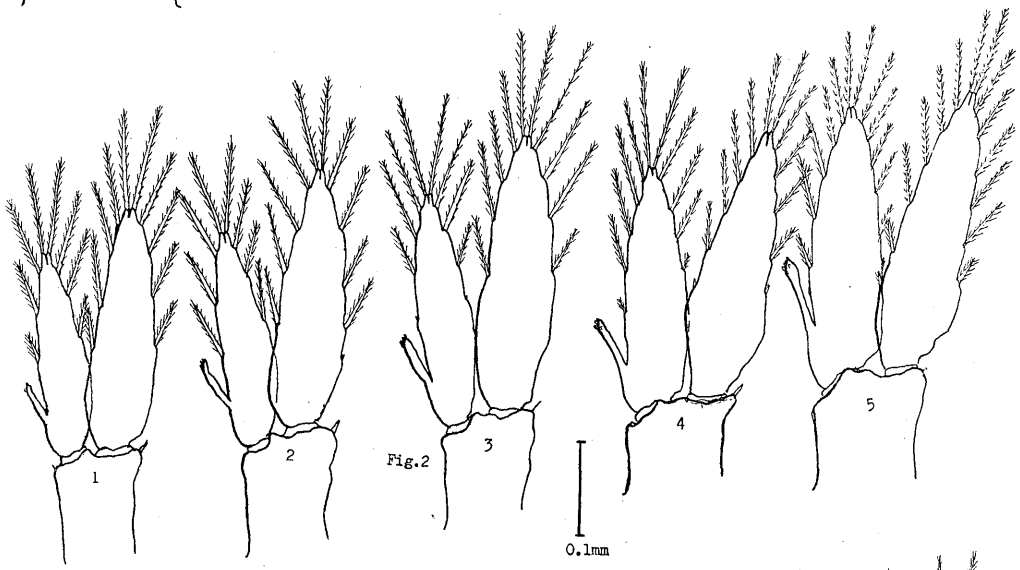

Fig.2

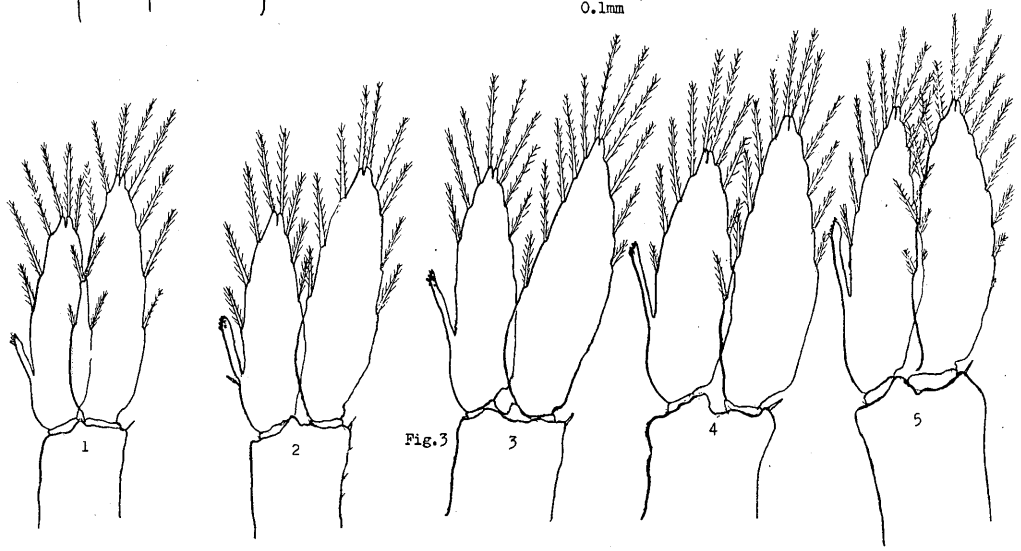

Fig.3

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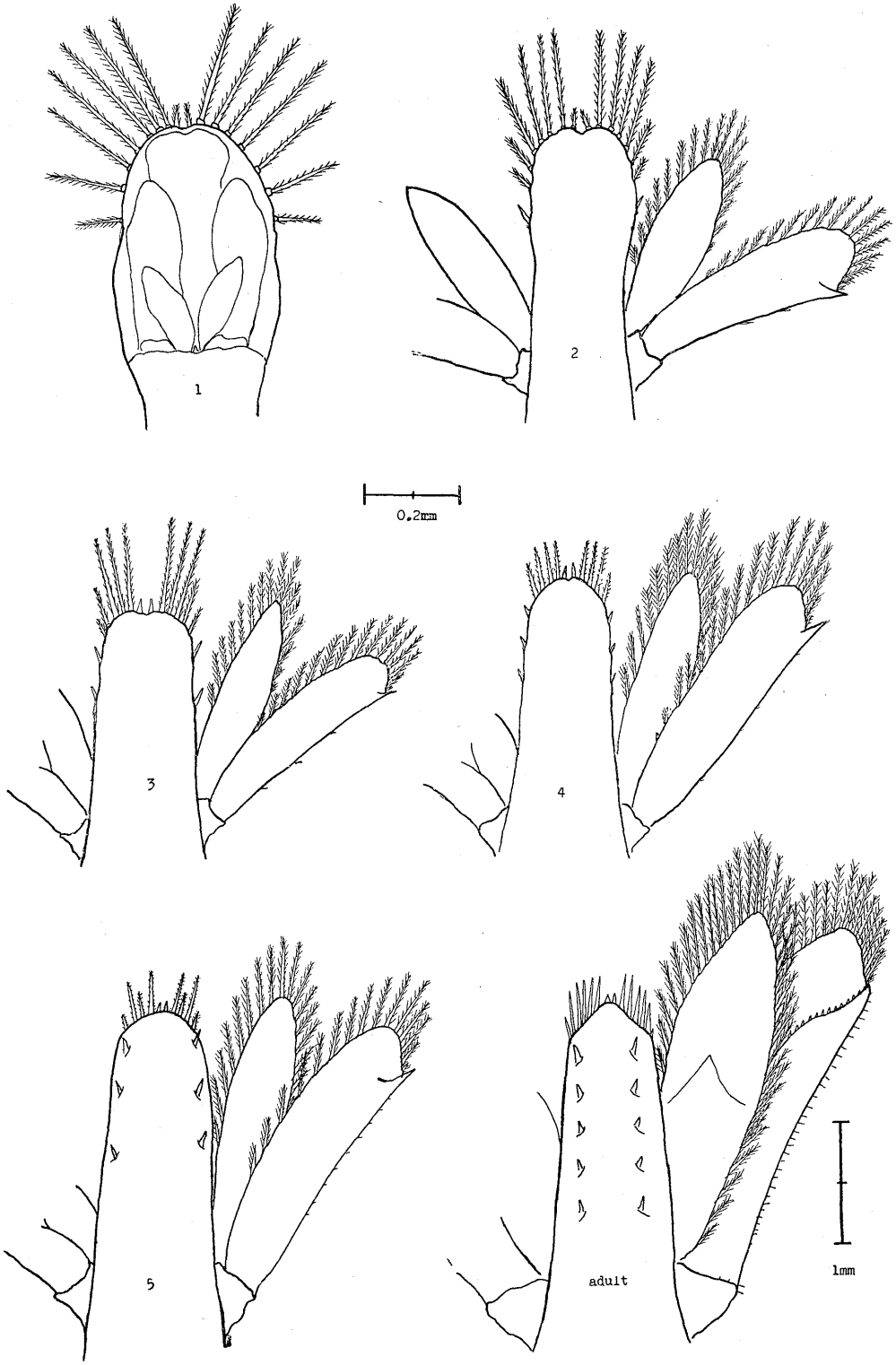
PLATE VIII



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