Note on *Calanus tonsus* Brady in Japanese Waters

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Synopsis: *Calanus plumchrus* Marukawa has been believed to be a distinct species in Japan. On closer examination of the adult specimens of the species, taken from the deep waters of the Japan Sea, it revealed that *Calanus plumchrus* is the immature specimen of *Calanus tonsus* Brady.

Introduction

Calanus tonsus was first described by Brady in 1883 from the Atlantic and Pacific Oceans. It has been described by Farran (1929), Campbell (1930), Wilson (1934) and Davis (1949) since. I have collected the adult female specimens of *Calanus tonsus* Brady and *Calanus cristatus* Kröyer from the deep waters of Sagami bay. *Calanus cristatus* is one of the most common species in the northern waters of Japan. There is the another species of Calanus which is very abundant in the same region. The species was first described and figured by Ch. Sato (1913) from the surface water of Hokkaido under the name *Calanus sp.* Marukawa (1921) described the same species, and named it *Calanus plumchrus*. According to Sato and Marukawa, the species is very abundant in the northern cold waters of Japan, and is called "Isada" in Japanese by fishermen. It is one of the most important food for herring and mackerel in the sea surrounding Hokkaido. The species is widely distributed in the northern water of Japan, but it has not been found along the Pacific coast of Japan as far south as the cape Inuboye, Chiba Prefecture. It is also distributed in the Sea of Japan, and has been collected off the coast of San-in District (Furuhashi, 1952, 1953). The specimens hitherto been collected from the surface layer are all immature. Anraku (1952) figured the 5th pair of legs of the adult male taken from the deep water off the west coast of Hokkaido. But none in Japan has noticed that *C. plumchrus* is synonymous to *C. tonsus*.

Neither the adult male nor the immature specimens of *C. plumchrus* have been met with in the Izu region, the Pacific coast of middle Japan, where I had, for a long time, been engaged in the study of the pelagic copepods. I

could have fortunately, during my sojourn in the San-in District in 1953, the adult specimens of *Calanus plumchrus* both female and male by the courtesy of Mr. K. Furuhashi, the member of the Maizuru Marine Observatory. The specimens were collected from the deep water of the Japan Sea by the research ship belonging to the observatory in 1951. On closer examination of the specimens, it revealed that *Calanus plumchrus* and *Calanus tonsus* are the same species, differing only in the developmental stage.

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Description

Female. Length 4.16–4.40 mm. Cephalothorax elongate ovate. The frontal margin of the head narrowly rounded when viewed from the lateral; there is no crest or process on the frontal margin of the head, but a small lump of oil globule, oval in shape, is observed just beneath the cuticle; fig. 1. a. this lump is more remarkable in the immature specimen. The body is full of oil globules.

Fig. 1.

Abdomen is contained 3.7-times in the length of the cephalothorax. The abdominal segments and the furca in the proportional lengths

Segment 1+2	3	4	5	Furca	
42	18	13	9	18=100	

Genital flap, in lateral aspect, is produced triangularly in the middle of the genital opening (fig. 1, b, c). The process was not observed in my previous female specimen of *C. tonsus* taken from Sagami bay.

1st antenna broken off in the distal portion. The setae on the anterior

margin of the joints are feeble. 2nd antenna of usual *Calanus*-type. Mandible pulp has a broad 2nd basal joint which is furnished with 4 setae on the inner margin; the exopodite is longer than the endopodite; the 1st joint of the endopodite carries a sack-shaped protuberance, and 2 long and 2 short setae on the inner distal margin; the 2nd joint of the endopodite has 9 long and 2 short setae on the distal margin; the cutting edge smooth, with only several reduced teeth. 1st maxilla has a naked 1st inner lobe; the 2nd inner lobe naked or with 2 small setae; my previous specimen has a single seta on the 2nd inner lobe. 5th pair of legs have no serration on the inner margin of the 1st basal joint.

Male. Length 4.40–4.82 mm. Head is separated from the thoracic segment, and so is the 4th from the 5th. Head dilated in the oral region when viewed from the dorsal; the greatest width about $\frac{1}{3}$ the length of the cephalothorax. In lateral view the frontal margin of the head is evenly rounded. There is a remarkable ridge on the mid-dorsal line, about the anterior $\frac{1}{4}$ of the head. The posterior margin of the head distinctly produced in the mid-dorsal line when viewed from the lateral (fig. 2, a, b). The lateral corner of the last thoracic segment rounded; it extends posteriorly about to the middle of the genital segment. Rostrum consists of 2 slender filaments. Frontal organ slightly perceptible.

Abdomen 5-jointed, and is contained 3-times in the length of the cephalothorax. The segments are in the proportional lengths $\frac{\text{Segm. 1 2 3 4 5 Furca}}{32 11 32 19 14 10 14} = 100$. The genital opening on the left side of the 1st segment. Furcal rami pararell, 1.34-times as long as wide.

1st antenna 24-jointed. While the female 1st antenna is feeble, and in most specimens it is broken off in the distal portion, the male 1st antenna is strong and well kept. The antenna extends posteriorly beyond the end of the furca by distal 4 joints. The joints are in the following proportional lengths:

$\frac{1 \sim 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ 9 \ 10 \ 11 \ 12 \ 13 \ 14 \ 15 \ 16 \ 17 \ 18 \ 19 \ 20 \ 21 \ 22 \ 23 \ 24 \ 25}{103 \ 41 \ 38 \ 41 \ 38 \ 38 \ 24 \ 24 \ 35 \ 35 \ 41 \ 45 \ 48 \ 46 \ 46 \ 46 \ 46 \ 52 \ 45 \ 45 \ 38 \ 31 \ 24 \ 21} = 1000$;

the joints 1–2, 3, 7, 14, 18, 21 and 24 are each furnished with a long seta; the joints 1 to 18, and the joint 25 have each well-developed aesthetask. 2nd antenna has the endopodite about as long as the exopodite; the 1st joint of the endopodite swollen on the inner distal corner, and carries 1 long and 1 short setae. Mandible as in the adult female: the broad 2nd basal joint has 2 short setae, a small process furnished with a small seta, and a short seta on the inner margin; the exopodite 1.7-times as long as the endopodite; the 1st joint of the endopodite

Fig. 2.

has a sack-shaped protuberance, and 2 setae on the inner distal margin; the cutting edge soft-skinned, and has only 4 reduced teeth (fig. 2, c, d). 1st maxilla as that of the adult female: the 1st inner lobe is devoid of seta; the 2nd inner lobe has 2 short setae; the 3rd inner lobe which is furnished with fine hairs on the inner margin has 4 rather long setae; the 1st joint of the endopodite has 4 setae on the inner margin; the 2nd joint of the endopodite has 3 setae; the 3rd joint has 6 setae on the distal margin; the exopodite has 11 setae; the 1st outer lobe has 7 long and 3 short setae on the anterior margin; the 2nd outer lobe naked. 2nd maxilla well developed: the outer margin of the 1st basal joint arched; the spinulation on the inner lobes as of usual *Calanus*-type (fig. 2, e). The 1st and 2nd basal joints of maxilliped are about of equal lengths; the joints are very voluminous when compared with those of the adult female; the external setae on the 4th and 5th joints of the endopodite are very strong and curved (fig. 3, a).

Swimming legs have each 3-jointed exopodite and endopodite. 1st leg has an

Fig. 3.

inner marginal setae on the 1st basal joint; the 2nd basal joint has a curved inner distal seta; the 1st joint of the exopodite has, beside an usual inner marginal seta, a small conical process which can be easily observed without dissection in lateral view; this peculiar process is observed also in the female 1st leg; the outer edge spine on the 1st joint of the exopodite are strong, reaching to the distal margin of the joint; the 2nd joint of the exopodite has a strong outer-edge spine and an inner marginal seta; the 3rd joint of the exopodite has 2 small outer marginal spines, a slender terminal spine, and 4 inner marginal setae; the terminal spine is longer than the 3rd joint of the exopodite (fig. 3, b). In the 2nd leg the 1st basal joint has an inner marginal seta; the 2nd basal joint has a strong outer edge spine; the inner margin of the 1st joint of the exopodite is slightly swollen near the proximal end; the terminal spine of the 3rd joint of the exopodite is much shorter than the joint itself (19:24), and has weakly serrated lamella (fig. 3, c). 3rd and 4th legs as in the 2nd leg. The outer marginal spine of the 3rd joint of the 2nd to 4th legs divide the outer margin in the following proportional lengths:

	proximal	distal
2nd leg	22	23
3rd leg	28	29
4th leg	32	26

In the 5th legs the 1st basal joint has no inner marginal seta; the hairs on the inner margin absent; the 2nd basal joint has each an outer distal spine. The right 5th leg is not greatly modified: it is about as long as the left 5th leg; the 1st and 2nd joints of the exopodite have each an outer edge spine; the 2nd joint has a small spine on the inner margin about distal 1/3 of the joint; the 3rd joint has 2 outer marginal spines; the terminal spine is about half the length of the 3rd joint of the exopodite; the inner margin of the 3rd joint is smooth. The endopodite of the right leg extends about to the proximal 1/3 of the 3rd joint of the exopodite; the 1st and 2nd joints of the endopodite have each an inner marginal seta and an outer edge spine; the 3rd joint has 2 outer marginal, 2 apical and 2 inner marginal setae; the outer edge spine at the base of the apical seta is very small. The left 5th leg is modified: the 1st joint of the exopodite is about 2-times as long as the 3rd joint of the exopodite; the inner margin of the joint is furnished with hairs; the 2nd joint of the exopodite is broad, with an outer edge spine; the inner margin of the joint is covered with hairs; the 3rd joint of the exopodite is small, carrying a single small outer marginal spine and 2 apical spines, of which the outer one

is short; the inner one is about half the length of the 3rd joint of the exopodite; the inner margin of the 3rd joint is slightly sinuate, and is furnished with short clumsy hairs; the 3rd joint of the endopodite of the left leg reaches the distal margin of the 2nd joint of the exopodite, and is similar in structure to that of the right leg. fig. 3, d.

Immature specimen. Length 4.26-4.45 mm. The specimen is in the 5th copepodid stage. The discrimination of two sexes was not determined in this stage of the development. General appearance as in the adult female. The lense-shaped protuberance on the frontal margin of the head is more remarkable than in the adult female (fig. 4, a).

Fig. 4.

Abdomen 4-jointed, and is contained about 4.0-timed in the length of the cephalothorax. The abdominal segments and the furca in the proportional lengths $\frac{1 \ 2 \ 3 \ 4 \ \text{Furca}}{14 \ 29 \ 17 \ 14 \ 26} = 100$. Furcal rami pararell, 2-times as long as wide.

1st antenna exceeds the end of the furca by distal 3 joints; the setae on

the joints are very feeble; the 1st and 2nd joints are separated on the posterior margin; the line of demarcation is undetectable on the anterior margin. 2nd antenna as in the adult female. Mandible has no sack-shaped tubercle on the 1st joint of the endopodite. The cutting edge has well-developed teeth (fig. 4, 2). 1st maxilla has a well-developed 1st inner lobe; it is furnished with 9 strong marginal spines and 4 setae; the 2nd inner lobe has 4 long setae; the 3rd inner lobe has 3 setae; the 2nd basal joint has 5 setae; the 1st joint of the endopodite has 4; the 2nd joint has 3; the 3rd joint has 5 setae; the exopodite has 10 setae; the 1st outer lobe has 7+2 setae; the 2nd outer lobe has 1 seta. 2nd maxilla well developed: the setae on the inner lobe are stronger than those in the adult female; the outer marginal seta on the 1st basal joint is slender. The 1st basal joint of the maxilliped is broad, about half as wide as long; the setae on the inner lobes are very strong; these setae are much reduced in the adult female.

1st to 4th swimming legs have each 3-jointed exopodite and endopodite. The peculiar tubercle on the 1st joint of the exopodite of the 1st leg is faintly visible. 5th leg has 2-jointed endopodite. The exopodite broken off in the distal portion, but it may probably be consisted of 2 joints. The 1st basal joint has no seta or hairs on the inner margin.

Remarks

Campbell (1930) described the adult male of *Calanus tonsus* Brady from the Vancouver Island region. The Russian colleague Brodsky (1938) pointed out that *C. plumchrus* Marukawa is synonym of *C. tonsus* Brady. As the Russian papers are inaccessible in Japan, I have been ignorant of the synonymy of these two species. I have doubted, since I had detected *Calanus cristatus* Kröyer, in Sagami bay, the absence of *C. plumchrus* which is one of the most common species in the northern waters of Japan, from the deep layers of the bay. The northern cold water carries with it the cold water species, such as *Calanus cristatus*, *Metridia longa*, *Metridia lucens* and others, in deep layers to the lower latitude along the Pacific coast of Japan. All these species have been detected from the deep and intermediate waters of Sagami bay except *C. plumchrus*. I have never thought of that *C. plumchrus* is synonymous to *C. tonsus* before I had been able to examine the specimen both immature and adult of so-called *C. plumchrus* Marukawa. Marukawa's specimens is clearly identical with *C. tonsus* in the 5th copepodid stage, measuring 4.2-5.2 mm. Sato's specimen measured 4.5 mm. Campbell's 4.5-5.0 mm. These immature specimens have 2-jointed exopodite in the 5th pair of legs. The colour of the

Japanese specimen is whitish pellucid; the plumose setae of the 1st antennae and furcal rami are red.

According to Campbell who studied the life history of *C. tonsus* abundant in the Strait of Georgia, the immature specimen in the 5th copepodid stage is found from the middle of May until January. At that time it is considered as the most important planktonic animal in the general economy of the Strait. The mature female and male come to the surface in January. They exist as an adult for a short period of the year, approximately January and February. The attainment of maturity is characterised by the marked reduction of the mouth appendages, especially that of the cutting edge of the mandible, and the reduced number of setae in the 1st maxilla. The species in the Canadian water appears to pass the greater part of the year in the 5th copepodid stage. During the summer months when the species exists in the 5th copepodid stage the individuals feed intensively on the abundant supply of diatoms available at that time, and store up reserved food. These specimens are filled with oils. This accumulated food is used in the egg producing period. Breeding occurs during April and May in the Strait of Georgia.

The life history of *C. tonsus* in Japanese waters is not well known, but it is probable that the species passes the greater part of the year in deep layers, and comes to the surface during the month April to June when it is in the 5th Copepodid stage. The maturity of the Japanese specimen may, of course, be attained in the 6th copepodid stage. The adult female and male may come to the surface to spawn as it is the case in the Strait of Georgia. But at present the sexual behavior of the animal is entirely unknown in Japanese waters.

Distribution

The species has a wide distribution in the Atlantic and Pacific: Woods Hole region, Maderia and Canary Islands, Gulf of Guinea, off the coast of Uruguay; north eastern and western regions of the North-Pacific, off the coast of Chile and New Zea-land. The species has been recorded in Japan from the cold and less salty waters which have a close communication with the Oyashio current: the Okotsk Sea, east and west coasts of Hokkaido, Mutsu bay and the Sea of Japan. The immature specimen is in the surrounding waters of Hokkaido most abundant from April to June in the surface layer when the temperature of the water is about 13-14°C. The adult male of *Calanus plumchrus* was first described in Japan by Yamada (1938) who obtained the

specimen from the stomach content of a larval cod fish taken in the adjacent water of Korea. Nakai (1942) says the adult individuals are widely distributed in the Sea of Japan in the layer between 600-300 m. all the year round. But Kokubo (1950) failed to detect the adult individual in the vertical haul made from the depth 620 m to the surface off the coast of Aomori Prefecture in March 1950. Motoda et al (1950) have obtained the adult male and immature individuals from the depth more than 300 m. off the coast of Hokkaido in the summer 1948. Anraku (1952) collected the adult female individuals from the layer 500-25 m., and the adult male between 1000 and 500 m. in the pacific coast of northern Japan in Nov. 1948. Furuhashi (1953) obtained the adult individuals both female and male from the deep water (500-0 m) of the south-western area of the Sea of Japan in the summer 1952. I have detected several immature individuals from the surface collections made by the Toyama Fisheries Experimental Station in the Sea of Japan in April, 1953. These Japanese records of collection indicate that the adult individuals have not yet been obtained from the surface layer, and that true feature of relative abundance of the species which is so important in the economy of Japanese waters has been unknown up to the present time.

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Explanation of the text-figures

Fig. 1. Adult female.

- a. Head, lateral view, $\times 25$
- b. Abdomen, lateral view, $\times 25$
- c. Genital segment, ventral view, $\times 50$

Fig. 2. Adult male.

- a. Whole animal, dorsal view, $\times 15$
- b. Head, lateral view, $\times 30$
- c. Mandible pulp, $\times 100$
- d. Cutting edge of mandible, $\times 100$
- e. 2nd maxilla, $\times 100$

Fig. 3. Adult male.

- a. Maxillipeda, $\times 100$
- b. 1st leg, $\times 60$
- c. 2nd leg, $\times 60$
- d. 5th pair of legs, $\times 60$

Fig. 4. Immature specimen

- a. Head, lateral view, $\times 25$
- b. Abdomen, lateral view, $\times 25$
- c. Mandible, $\times 100$