

Some Characteristics of a Coldwater Copepod *Calanus cristatus* from Regions of the Japan Sea Covered by the Tsushima Warm Current

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Abstract

Vertical distribution and body structure of a coldwater copepod *Calanus cristatus* (mostly stage V) were investigated south of 40°N in the Japan Sea, where the shallow layers were covered by the Tsushima warm current. Stage V specimens with different body structure occurred, and they were classified arbitrarily into three types: specimens with conspicuous lipids and well developed musculature (solid type), those without lipid and poorly developed musculature (transparent type), and intermediates between these extremes (intermediate type). The transparent type exhibited a diurnal migration pattern at the northern stations with its abundance peaks at 50-75m depth. No such diurnal migration pattern was evident for the transparent type at southern stations, where 10°C isotherm (upper limit of *C. cristatus* can tolerate) is well below the euphotic zone (ca. 100m depth). Solid and intermediate types were most abundant below 300m depth where the temperature was <1°C.

Measurements of prosome length, head length, body composition (dry matter, water, ash), morphological observations on mandibular teeth, and histological examination of the body suggested that the transparent type was the youngest, just moulted from stage IV. It becomes the solid type via the intermediate type through active feeding on phytoplankton. Abrasion of mandibular teeth occurs in the course of this sequential body structure change within stage V.

Because of warm water (>10°C) in the upper layers, *C. cristatus* could not complete a generation in most of the southern Japan Sea. Lack of north-south gradients in the prosome length and composition of specimens with different body structures observed in this study suggest that southerly movement of <1°C deep-water as a mechanism transports *C. cristatus* populations to the south. Details are little known at present.

Key words *Calanus cristatus*, Japan Sea, vertical distribution, body structure, transportation mechanism

Introduction

As a marginal sea of the Pacific Ocean the Japan Sea is located in the subarctic,

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but its upper waters south of ca. 40°N exhibit subtropical character due to the intrusion of the Tsushima Current (a branch of Kuroshio) (Fig. 1). Because of this two layer system, subtropical and boreal species are often found together in plankton samples collected vertically south of 40°N (MORIOKA 1973, 1976; FURUHASHI 1975). Under the warm water, epipelagic coldwater species omnivores and carnivores may maintain populations but this is not possible for herbivores because food is so scarce.

Calanus cristatus is a large grazing copepod, occurring at various depths in most parts of the Japan Sea. It is an important prey of pelagic fishes, especially salmon (ZENKEVITCH 1963; NAKAI 1969; FUKATAKI 1967, 1969). OMORI (1967) used *C. cristatus* as a biological tracer of the Oyashio water and estimated the velocity of southwesterly movement of submerged Oyashio water off east-central Honshu, Japan. Further study of OMORI (1970) indicated that *C. cristatus* specimens from submerged Oyashio water were shorter and relatively depleted in body composition, reflecting poor food supply during a long journey under the warm Kuroshio. OMORI's results suggests that *C. cristatus* in the southern part of the Japan Sea could be transported from the normal habitat in the north.

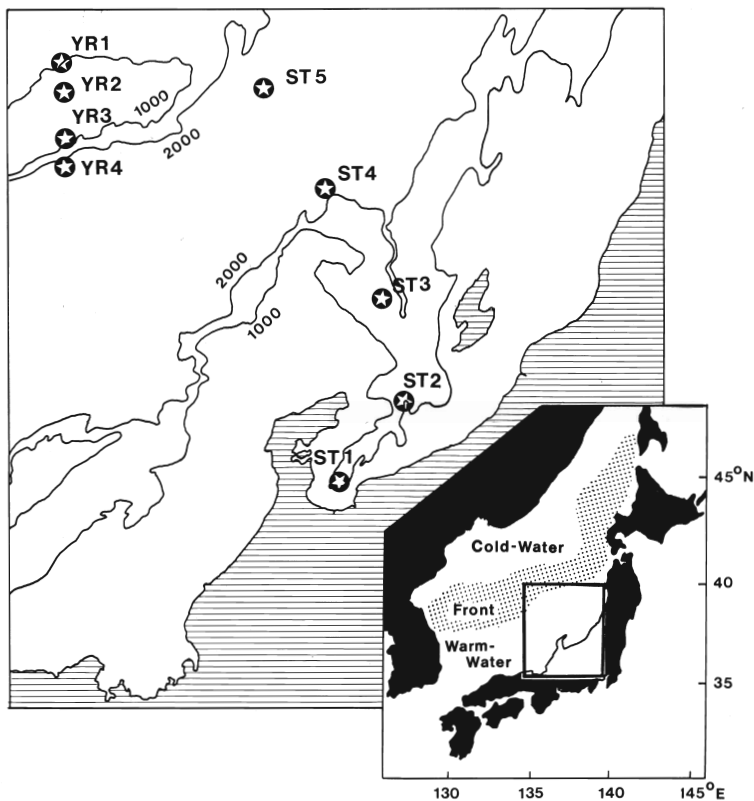


Fig. 1. Sampling stations off Toyama Bay (St 1 to 5), around the Yamato Rise (YR 1 to 4), and depth contours in the southern Japan Sea. The present study site (outlined) is shown in relation to general distributional patterns of warm and cold waters in the upper layer of the Japan Sea in the right-lower figure.

The present study aims at the evaluation of horizontal and vertical distribution of *C. cristatus* in the waters south of 40°N in the Japan Sea (i.e. area covered by warm water) in relation to the vertical profile of water temperature. Further, the nutritional condition of *C. cristatus* was investigated by morphological and histological examinations, and body composition analyses.

Materials and methods

Field samplings: Sampling were made aboard R/V Mizuho-Maru at 5 stations to the north of Toyama Bay (Fig. 1) during the periods May 28 to June 7, September 1 and 2, and December 5 and 6 in 1987. December samplings were limited to Sts 1 and 2 because of adverse sea conditions. Zooplankton distributed from the surface to 1000m depth horizons were collected with sets of MTD nets (56cm mouth diameter, 0.35mm mesh aperture, MOTODA 1971), each equipped with a Rigosha flow-meter on its mouth ring to register the volume of water passing through the net. The nets were towed for 0.5–1.0 h. Additional samples were obtained by vertical hauls (from 500m depth to the surface) with a Norpac net (45cm mouth diameter, 0.35mm mesh aperture, MOTODA 1957) during Tanshu-Maru cruise to Yamato Rise in April 16–10, 1987. After collection, zooplankton samples were preserved immediately in 10% buffered formalin-seawater. In the shore laboratory,

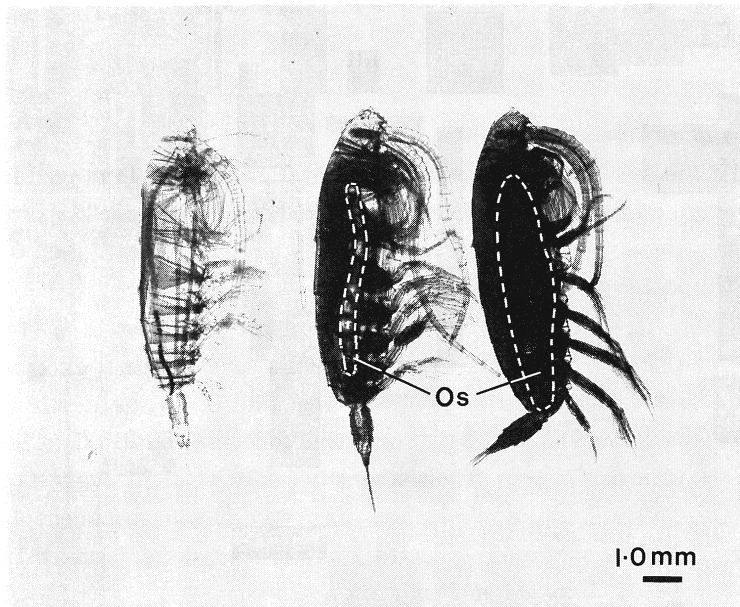


Fig. 2. *Calanus cristatus* CV with three different types of body structure: “solid” type (right) with well developed musculature and a large oilsac (Os) which occupies nearly a half of body volume (outlined by hatched line); “transparent” type (left), with poorly developed musculature and no lipid; and “intermediate” type (middle) with intermediate features between solid and transparent types.

specimens of *C. cristatus* were counted and sorted out for the following measurements and observations.

Measurements/observations: Prosome length was measured under a Wild microscope to the nearest 0.1mm. At the same time, body conditions were examined and classified to the following three categories; “solid” type specimens with a conspicuous amount of lipids and rigid musculature, “transparent” type specimens with poorly developed musculature and no lipids, and “intermediate” type specimens with conditions between solid and transparent types (Fig. 2).

Masticatory edges of the mandibles were removed from formalin preserved specimens, rinsed in distilled water, dehydrated through graded ethanol series, critical-point dried, gold coated and observed with a Hitachi S 415 SEM.

For histological examination, preserved CVs were rinsed in distilled water, dehydrated through graded ethanol series, embedded in paraffin to obtain sequential sections (ca. 8 μ m thickness). Sections thus obtained were stained in Mayer’s hematoxylin-eosin for microscopic observation.

Body composition: Body composition including water, dry matter and ash were determined on solid and transparent type specimens. Preserved specimens of both types were rinsed briefly in distilled water. They were weighed (wet weight) individually and dried at 60°C for 24h. After obtaining dry weight, they were incinerated at 450°C for 12h to obtain ash weight. For detailed procedures of body composition analyses see OMORI and IKEDA (1984).

Results

Horizontal and vertical distribution of CV:

In April the surface temperatures of four stations (YR 1–4) ranged from 6.0 to 8.4°C. Averaging over these stations, CV occurred at a density of 538 specimens 1000 m⁻³. Among them, solid type occupied 18.1%, intermediate type, 63.2% and transparent type, 18.7%.

During May–June surface temperatures were the lowest at St 5 (14.7°C) and highest at St 3 (18.3°C). Day and night samplings revealed that, excepting night data at Sts 4 and 5, the occurrence of CV was limited to the depth where the temperature was below 5°C (Fig. 3). Specimens collected above 5°C at Sts 4 and 5 were all of the transparent type. Their occurrence only at night suggests a diurnal migration. Over 5 stations the abundance peak was 48–208 specimens 1000m⁻³ at 250–450m depth. Of the specimens collected, transparent type represented 13.9–33.7%, intermediate type, 11.4–66.7%, and solid type, 12.6–54.9%.

In September surface temperatures were 19.0–25.6°C. The abundance peak of CV ranged from 56 to 315 specimens 1000m⁻³, and it was located at 300–600m depth. At St 5, a second abundance peak composed largely of transparent type specimens appeared at 75m depth. Over 5 stations the proportion of transparent type was 4.3–39.0%, intermediate type, 6.5–24.7%, and solid type, 36.6–89.1%.

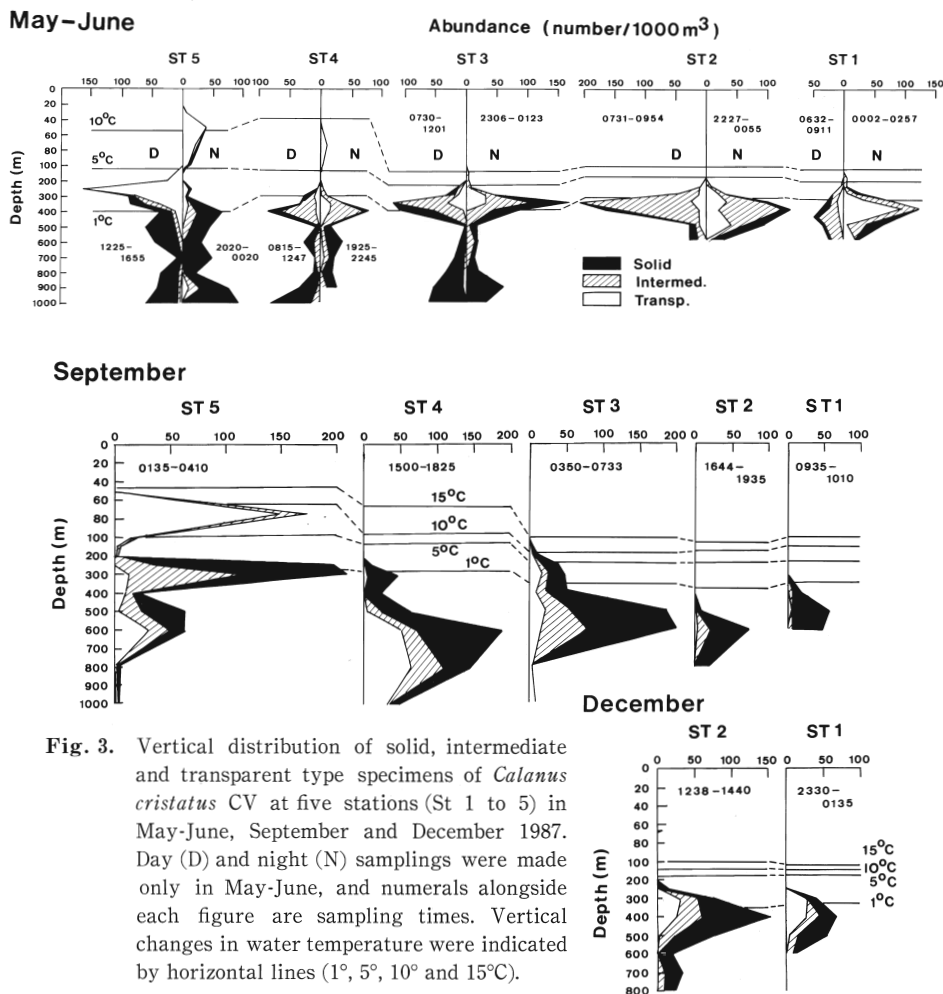


Fig. 3. Vertical distribution of solid, intermediate and transparent type specimens of *Calanus cristatus* CV at five stations (St 1 to 5) in May-June, September and December 1987. Day (D) and night (N) samplings were made only in May-June, and numerals alongside each figure are sampling times. Vertical changes in water temperature were indicated by horizontal lines (1°, 5°, 10° and 15°C).

While only two stations were surveyed in December, surface temperatures were near 16.8°C. No specimens were collected from water above 5°C. The abundance peak of 68–154 specimens 1000m⁻³ was found at 400m depth.

Horizontal and vertical distributions of CIV and CVI:

CIV occurred at YR 2 in April, at Sts 5, 4 and 2 in June, at Sts 5, 4, 3 and 2 in September, and at both Sts 1 and 2 in December (Fig. 4). They were most abundant at the northern station (St 5) (the number recorded at YR 2 was 22 specimens 1000m⁻³, which is not shown in Fig. 4). Day and night data at Sts 4 and 5 in June indicate a pattern of diurnal vertical migration in this stage. The vertical range of distribution of CIV extended from 50m (St 5, June) to 1000m depth (Sts 3, 4 and 5, September).

CVI males were found in June and September from more than 250m depth.

Prosome length of CV:

Prosome length data of three types of CVs at each station in April, May-June,

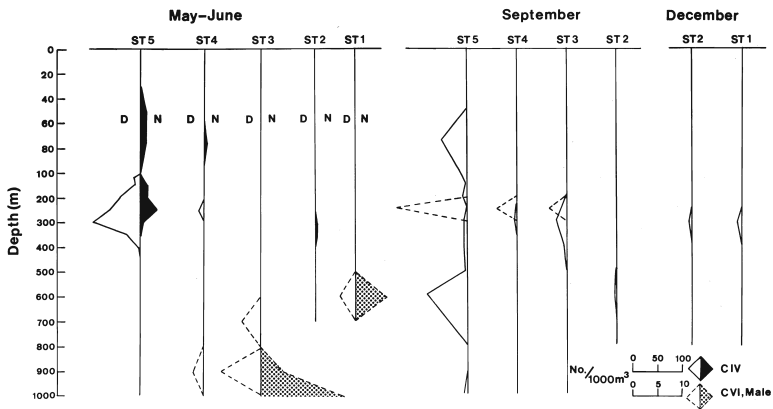


Fig. 4. Vertical distributions of CIV and CVI males of *Calanus cristatus* at five stations (St 1 to 5) in May-June, September and December 1987. Day (D) and night (N) samplings were made only in May-June. For sampling times and vertical distribution of water temperature at each station of respective months, see Fig. 3.

September and December were summarized in Fig. 5. Complete data sets of May-June and September, which covered all 5 stations, showed a difference of prosome length between stations. This was investigated by regression analyses (Table 1), which indicated that prosome length tended to increase with station number in all three types of CV (excluding transparent CV of May-June). In other words, prosome length became smaller southward. However, the contribution of station number to this trend is very small (0.4–0.9%) or nil as judged by correlation coefficients (r^2). It is, therefore, concluded that the small north to south decline of prosome length of CV is not statistically significant.

Seasonal differences in the prosome length of CV at the same stations are not noticeable, since the $\pm 95\%$ confidence intervals (CI) of the means overlap each other considerably (Fig. 4). When all seasonal data were pooled over all stations, mean prosome lengths of CV were 8.0mm (± 0.3 , 1 SD, N=1168) for the solid type, 7.8mm (± 0.5 , N=909) for the intermediate type, and 7.7mm (± 0.3 , N=657) for the transparent type (for further discussion, see below).

Morphology of mandibular masticatory edges:

BEKLEMISHEV (1959) provided a terminology for the dentition of the Calanidae. Along the mandibular gnathobase there are two ventral teeth (V_I and V_{II}), four central teeth (C_I to C_{IV}), and three dorsal teeth (D_I to D_{III}). Tooth V_{II} is not conspicuous in *C. cristatus*. The present observations were (1) of the degree of abrasion on C_{III} and C_{IV} , and D_I to D_{III} and (2) of the comb-like elastic setae (Es) along the bases of C_{III} to D_{III} (Fig. 6, B–D). Compared to those of the transparent type CV, the crowns of C_{III} and C_{IV} and main mass of D_I , D_{II} and D_{III} were greatly worn down in solid type CVs. Likewise, the elastic setae on the base of C_{III} to D_{III} were broken off in solid type CVs. Teeth and elastic setae of intermediate type CVs exhibited transitional features between those of the transparent and solid types.

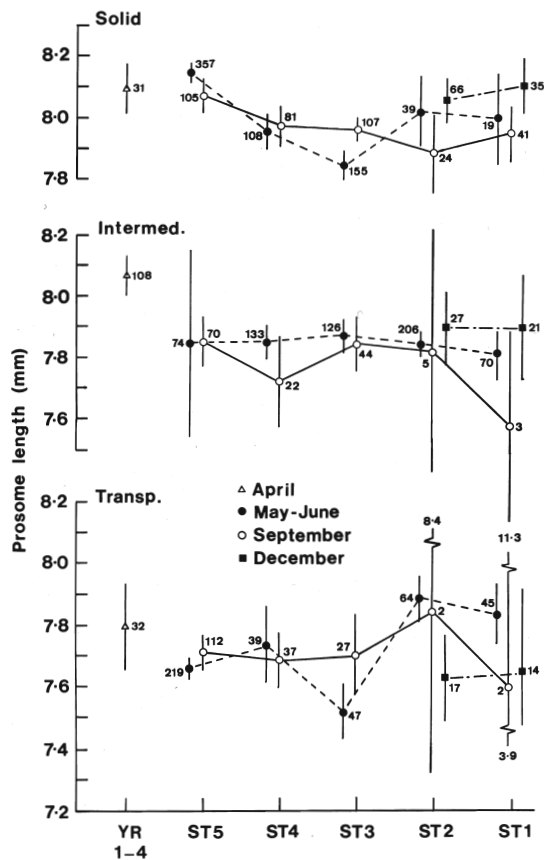


Fig. 5. Prosome length of solid, intermediate (intermed.) and transparent (transp.) type specimens of *Calanus cristatus* CV at each station in April, May-June, September and December 1987. Means \pm 95% CI. Numerals alongside of each mean are the number of specimens measured.

Table 1. Regression analyses of prosome length (Y, mm) of *Calanus cristatus* CV on sampling station number (X, 1 to 5, see Fig. 1). NS: Not significant.

Month	Type	Regression model		N	r	P
		Y=bX+a				
		b	a			
May-June	Solid	0.089	7.67	678	0.301	<0.01
	Intermediate	0.008	7.82	609	0.018	NS
	Transparent	-0.047	7.88	414	0.224	<0.01
September	Solid	0.046	7.82	358	0.196	<0.01
	Intermediate	0.019	7.74	144	0.063	NS
	Transparent	0.008	7.67	180	0.023	NS

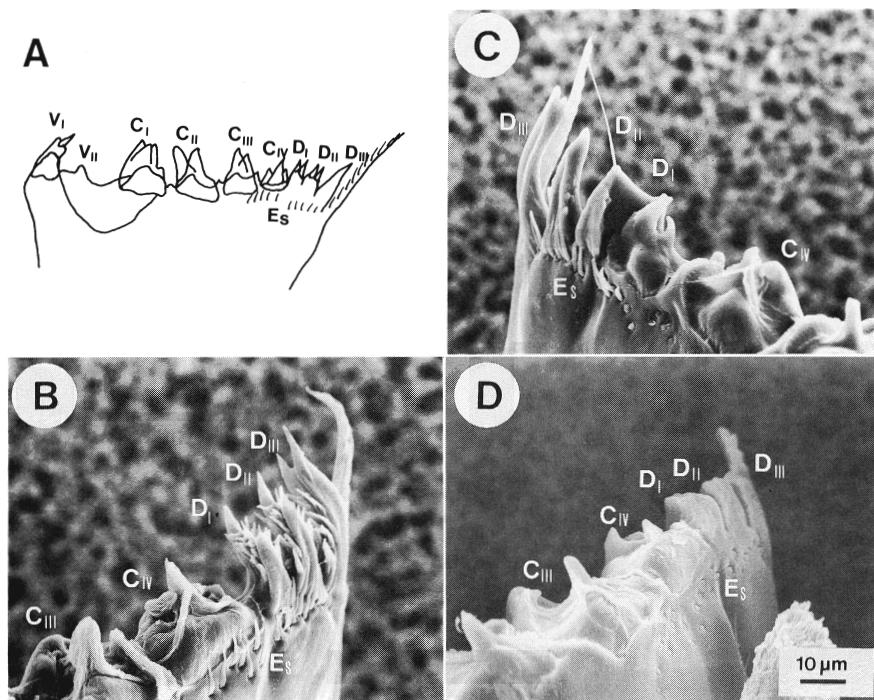


Fig. 6. A schematic diagram of masticatory edge of mandibles of *Calanus* (A). SEM micrograph of masticatory edges of transparent type (B), intermediate type (C) and solid type (D) of *Calanus cristatus* CV. D: Dorsal teeth, C: Central teeth, V: Ventral teeth, Es: Elastic setae.

Histological observation:

Medial transverse section of solid type CV shows well developed dorsal longitudinal muscles and extensor muscles of swimming feet (Fig. 7). A large cavity seen in the center is the oilsac, from which the contents (lipid) were lost during the process of dehydration through graded ethanol. The gut and part of the gonad are seen above the oilsac.

Transparent type specimens were depressed dorso-ventrally in the course of preparation for histological sectioning because of the lack of materials in the body (Fig. 7). Compared to the solid type, most of muscles are poorly developed and no oilsac is seen, as mentioned earlier. The gut is visible in the middle of the flattened body with some unidentified materials in it.

Body composition:

Results on CIV and two extreme body composition types of CV (transparent and solid types) were summarized in Table 2. Mean prosome length (PL), wet weight (WW) and dry weight (DW) of CIV were 5.1mm, 5.8mg and 0.28mg, respectively, all of which were much less than those of CV.

Compared to the solid type CV, transparent type CV exhibited lesser PL, WW, DW and ash content (Ash). Water content (H₂O) was greater for the transparent type. The ratio of head to prosome (HL/PL) was dissimilar between these two types

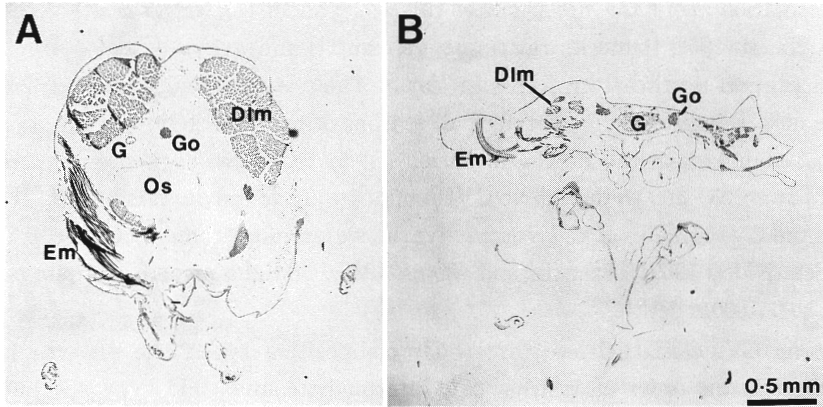


Fig. 7. Medial transverse section of solid type (A) and transparent type (B) of *Calanus cristatus* CV. Muscles are almost absent in B. Dlm: Dorsal longitudinal muscles, Em: extensory muscles, G: gut, Go: gonad, Os: oilsac.

Table 2. Prosome length (PL, mm), head length to prosome length ratio (HL/PL), wet weight (WW, mg), dry weight (DW, mg), water content (H₂O, %WW) and ash content (Ash, %DW) of CIV and CV (solid and transparent types) of *Calanus cristatus*. Differences between means of solid and transparent type CVs were examined by *t*-test. ND=not determined

	CIV		CV				<i>t</i> -value	P
	N	X±1SD	Solid type		Transparent type			
	N	X±1SD	N	X±1SD	N	X±1SD		
PL	4	5.1 ±0.1	20	7.9 ±0.3	20	7.7 ±0.3	2.83	<0.01
HL/PL		ND	20	0.44±0.01	20	0.46±0.02	5.16	<0.001
WW	4	5.8 ±0.3	20	23.8 ±2.7	20	19.1 ±3.8	4.57	<0.001
DW	4	0.28±0.02	20	4.71±0.78	20	0.93±0.36	19.65	<0.001
H ₂ O	4	95.1 ±0.3	20	80.1 ±3.3	20	95.2 ±1.4	18.90	<0.001
Ash	4	9.0 ±8.5	20	4.4 ±3.4	20	21.4 ±20.0	3.74	<0.001

of CV. Most differences were small (3% for PL), but statistically significant. Large differences were found for DW (506%) and relative ash content (486%).

Discussion

In the subarctic Pacific, spawning of *C. cristatus* continues at depth throughout the year with a peak in November (MILLER *et al.* 1984). Hatched nauplii migrate up and develop to early copepodite stages when they reach upper waters where phytoplankton are abundant. After accumulating a large amount of lipids in the body, CVs migrate down to deep-water, moult to CVI (adult), and reproduction takes place. Teeth do not form on the mandibles at CVI, so there is no feeding at this final stage. The entire life cycle is one year, with the CVs in deep-water serving as an over-wintering stock.

Information about the life cycle of this copepod in the Japan Sea is presently limited. NAKAI (1969) found its floating eggs, nauplii and gravid females from 1000–2000m depth, off northeastern Korea in June. The present results showed that CV was the most numerous stage through all seasons of the year, followed by CIV. CIV was most abundant at the northern station (St 5). CVI males were found in low numbers from 250–1000m depth. No CVI females were found in this study. This is because the CVI females of *C. cristatus* live in water more than 1000m deep in the Japan Sea (NAKAI 1969; TERAZAKI and WADA 1988), and the present samplings were limited to 0–1000m depth.

Among CVs classified into three body composition types, the prosome length was shorter in the order of transparent, intermediate and solid type specimens. However, the greater head to prosome ratio (HL/PL, see Table 2) found in the transparent type specimens results from full folding of the telescopic body structure in the absence of lipids (C. B. MILLER, personal communication). From the HL/PL ratio of 0.44, head length for solid type is estimated as 3.5mm from its mean prosome length (7.9mm). When lipids were completely removed, headless prosome length for solid type becomes as 4.1mm. Prosome length thus reconstructed (3.5+4.1=7.6mm) for lipid extracted solid type is close to 7.7mm observed for transparent type. It is therefore evident that observed differences in prosome length between three types of CVs are derived from differences in packing. Influence of limited food availability on the size and body composition of planktonic copepods is well documented in laboratory experiments (PAFFENHÖFER 1970; MULLIN and BROOKS 1970). From this view the present results on *C. cristatus* V suggest no dissimilar feeding histories between transparent and solid CVs prior to moult from CIV to CV. Considering the radical increase in body size from CIV (5.1mm PL, 0.28mg DW) to CV (7.7mm PL, 0.93mg DW, transparent type in Table 2), specimens just moulted to CV cannot be lipid rich. Transparent CVs fill their muscles and deposit lipid in the body through their active feeding on phytoplankton. This explanation is consistent with the large capacity of the digestive tract seen in the transparent CVs (Fig. 6), and with sequential abrasion of teeth from transparent type CVs to solid type CVs via intermediate type CVs. (Fig. 6)

MILLER *et al.* (1984) think that the most critical period of this species to complete its life cycle is a three-month active feeding at CV to deposit a large amount of lipid in the body for reproduction after moult to CVI. Our calculations based on the body composition data combined with realistic ingestion rates of CV from a conventional incubation method (DAGG *et al.* 1982) show that the transition time from transparent type to solid type is 55 days (Table 3). From gut pigment analysis DAGG and WYMAN (1983) reported ingestion rate of CV as high as 18.3 $\mu\text{gC individual}^{-1}\text{h}^{-1}$. When this very high ingestion rate is used the time required from transparent type to solid type becomes much shorter (8.5 days). However, because of migration of CV to the depths of lower food concentrations, maintenance of such a high ingestion rate over 24h in the field is considered to be unrealistic (DAGG and WYMAN 1983).

Table 3. Carbon budgets for transparent type to grow to solid type within CV stage of *Calanus cristatus*

(1) Carbon in solid and transparent types:				
Type	DW (mg)*	× Organic matter (%DW)*	× C content**=C (mg)	
Solid	4.71	0.956	0.653	2.94
Transp.	0.93	0.786	0.529	0.39
*from Table 2				
**77.6%DW for lipid, and 52.9%DW for protein, after Gnaiger (1983).				
A mixture of lipid and protein (1:1) was assumed for solid type, and only protein for transparent type.				
(2) Ingestion: 3.3 μ gC/individual/h, after Dagg et al.(1982).				
(3) Assimilation efficiency: 0.7, after Omori & Ikeda (1984).				
(4) Metabolic loss: 1.2 μ l O ₂ /individual/h, after Ikeda (1971), which is equivalent to 1.2 × 0.85*** × 12/22.4 = 0.55 μ g C/individual/h.				
***Mean RQ for mixed metabolic substrates of lipid (0.72) and protein (0.97), after Gnaiger (1983).				
(5) Time required for the growth of transparent type to solid type:				
[(1)solid – (1)transp] × 1000 / (3) [(2) – (4)] =				
(2.94 – 0.39) × 1000 / [0.7(3.3 – 0.55)] = 1325 hrs = 55 days.				

To the south of 40°N in the Japan Sea, phytoplankton are most abundant during April-May and limited to 0–100m depth. Concentrations as high as 1–1.5 μ g chlorophyll-a l^{-1} have been reported at 20–75m depth (OHWADA 1971; IMAI *et al.* 1988). Seasonal chlorophyll-a data collected near the present transect (Sts 2 through 5) in 1987 showed no appreciable deviations from this general seasonal pattern of phytoplankton abundance in the southern waters of the Japan Sea (MAIZURU MARINE OBSERVATORY 1987a, b, c, d). The present observation of co-occurrence of CVs with different body composition at the same stations implies dissimilar timing of moulting from CIV to CV in relation to phytoplankton abundance. Vertical distribution of CVs showed that only transparent type CVs migrated up into shallow layers (50–75m) at night to feed. This night migration of transparent CVs was recorded at 0–100m depth at Sts 4 and 5 in June and St 5 in September. Absence of CVs in 0–100m depths at other stations may be explained by the tolerance of CVs for temperatures up to 10°C, but induction of their migration needs the existence of food phytoplankton within this temperature limit. At southern stations (Sts 1, 2 and 3), 10°C isotherms are deeper than 100m throughout a year, so that *C. cristatus* could not repeat their normal life cycle there.

In order to quantify the nutritional conditions of CV populations at each station, Population Nutritional Scores (PNS) were computed, assigning a score of 10 for solid type, of 5 for intermediate type, and of 1 for transparent type (Fig. 8). PNS is defined as $(10N_s + 5N_i + 1N_t) / (N_s + N_i + N_t)$, where N_s , N_i and N_t are the number of solid, intermediate and transparent type specimens, respectively, of a given sample. For data sets collected in May-June, day and night PNS were computed separately

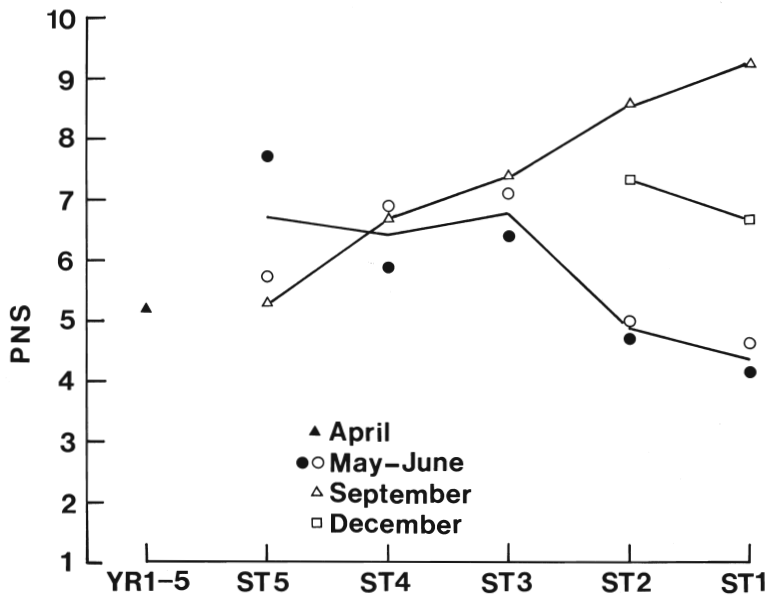


Fig. 8. Population Nutritional Scores (PNS) of *Calanus cristatus* CV at each station in April, May-June, September and December 1987. Open and solid circles of May-June data represent day and night data respectively. For details, see text.

to examine the range of errors of this method. While the difference in day and night PNS was large at St 5, both scores at other stations were fairly close each other. In May-June, PNSs declined toward the southern station (St 1), but the reverse was the case in September. PNS in December fell between those of May-June and September. Greater PNS seen in September and December at southern stations are mainly due to the increase of solid type specimens (cf. Fig. 3). PNS obtained at Yamato Rise (YR 1-5) in April was close to those at St 5 in May-June.

As mentioned above, there is no chance for CVs to encounter abundant phytoplankton from May-June onward at southern stations (Sts 1 and 2); the lipid rich CVs (solid type) which occurred at Sts 1 and 2 in September were considered to be transported in an intermittent manner from northern waters. Assuming that CV populations were transported from the north with $<1^{\circ}\text{C}$ water and this happened just after our survey in May-June (since no such the populations were detected in this period), movement of $<1^{\circ}\text{C}$ water from St 5 to St 1 (320km) was estimated as $320\text{km}/3\text{mo}=4.11\text{cm}/\text{sec}$. When $<1^{\circ}\text{C}$ water meanders in the course of its southern movement, its velocity would be much faster than this. Recent long term records of moored current meters have revealed a complex southward movement of water at depth in the Japan Sea (KITANI and NAGATA 1989). Possibly, *C. cristatus* CV with different feeding histories after the moult into this stage are captured by $<1^{\circ}\text{C}$ water in their normal, northern habitat and moved to the south. In addition to complex movement, this very low temperature water (as compared with $2-3^{\circ}\text{C}$ of sub-

merged Oyashio water) may be another mechanism which allows the long residence of *C. cristatus* populations at the depth in southern Japan Sea where the euphotic zone is well occupied by warm water. Low temperature may facilitate saving of energy expenditure by non-feeding CVs during their transport.

Compared with OMORI's results on *C. cristatus* CVs from the submerged Oyashio water, the present results from the southern Japan Sea are different in that no appreciable reduction was seen in body size, and specimens of dissimilar body composition types (solid, intermediate and transparent) occurred together at all stations. *C. cristatus* in submerged Oyashio water are destined die off without producing a new generation. Among those found in the southern waters of the Japan Sea, solid type CVs can be expected to moult to adults, but the fates of intermediate and, particularly of transparent type CVs, which occurred all seasons, are unknown. Provided that the transparent type CV can survive under the condition of low temperature, those in deep-water are considered to have little chance of encountering abundant phytoplankton again. TERAZAKI and WADA (1988) reported a mass occurrence of carcasses of *C. cristatus* CV in the Japan Sea, which may be the fate of transparent type *C. cristatus* in this region.

Acknowledgments

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日本海の対馬暖流域に出現した冷水性かいあし類
Calanus cristatus の諸特性について

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対馬暖流の影響下にある日本海北緯40度以南海域で、かいあし類 *Calanus cristatus* コペポダイト V期の鉛直分布、頭胸長、体筋肉の発達度合、油球の有無、口部咀嚼器（大顎裁断歯）の形態、体成分について調べた。採集が実施された1987年4月、5—6月、9月、12月を通じて、体筋肉が発達して大きな油球を持つ個体（solid タイプ）、体筋肉が未発達で油球を持たない個体（transparent タイプ）、両タイプの中間的性状を示す個体（intermediate タイプ）が肉眼的に識別された。また、組織切片を作成して、これらのタイプに属する個体の体内構造を観察した。各タイプに属する個体の見かけの頭胸長は有意に異なるが、油球の有無による頭胸部伸縮の影響を補正すると差がみられなくなる。solid, intermediate タイプの大部分は水深300m以深の水温1℃以下の日本海固有水中に分布すること、transparent タイプは北方の採集点で夜間に50—75m水深まで浮上すること、生息水温の上限が10℃付近であることが判った。大顎裁断歯のSEM観察により、transparent, intermediate, solid タイプの順に裁断歯の摩耗が進行することが判り、これはV期に脱皮した直後の transparent タイプが活発な摂餌を行って intermediate タイプ、solid タイプへと順次移行することが示された。

C. cristatus は植食性かいあし類で、一世代の長さが一年と考えられるが、日本海南部海域では同種の生息水温上限（10℃）の等温線が有光層（100m以浅）よりも深くなり、正常な世代継続ができない。日本海南部海域に出現する本種の輸送機構として、北部海域で生成・南下する日本海固有水の可能性を検討した。