ON THE POSSIBLE NATURAL INTERBREEDING BETWEEN *CHIONOECETES OPILIO* (O. FABRICIUS) AND *C. JAPONICUS* RATHBUN (CRUSTACEA: DECAPODA), A PRELIMINARY REPORT[1)]

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With 8 Text-figures and Plates VII–VIII

Two crab species of the genus *Chionoecetes* are distributed in the Japan Sea, *C. opilio* (O. FABRICIUS) in the moderate depths from 150 m to 500 m and *C. japonicus* RATHBUN (=*C. angulatus bathyalis* DERJUGIN & KOBJAKOWA) at the deeper levels ranging from 450 m to 2500 m. The former has long been famous to Japanese for its sweet meat by the name "zuwaigani", "matsubagani" or "echizengani" and trawled commercially in abundance as one of the most important items of the deep-sea fisheries in the Japan Sea. The latter, on the other hand, had been overlooked for a long time for its deeper habitat: it was described as new to science as late as in the thirties (RATHBUN 1932; DERJUGIN & KOBJAKOWA 1935) and its fishery was started experimentally in the forties, but it was not until the sixties that its production was increased in any degree (cf. FUKATAKI 1967–1968). *Chionoecetes japonicus* was fished first by deep-bottom gill net, but later a trap fishery was introduced with a better success and at present it is much prevalent among local fishermen, especially in the prefectures of Toyama and Niigata on the west coast of the middle of Honshu Island.

The town of Nô, situated some 130 km southwest of the city of Niigata, is one of the bases of the crab trap-fishery which is carried out on the 600 to 1300 m deep muddy bottom stretching between the Sado Straits and Toyama Bay during the season from September through June. It is stated that every year the fishery has brought some significant earnings.

Some time ago, the authors heard of a peculiar form of *Chionoecetes*, which was occasionally caught together with the typical *C. japonicus* by the above-mentioned

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trap fishery. The fishermen in the vicinity of Nô are familiar with such peculiar forms which they name the "hybrids" between *C. japonicus* and *C. opilio*, though their exact nature of course has remained unrevealed scientifically up to now.

In late October, 1965, the first author was fortunate enough to obtain a single specimen of such forms when he visited the harbor of Nô. Subsequently, the last author succeeded to collect some additional specimens of the same appearance and recorded their occurrences. Upon closer examination of these specimens, the authors have, though with considerable hesitation, finally reached the conclusion that the specimens might really be the hybrids between the two species of *Chionoecetes* mentioned above. Since there are rarely literatures on the natural hybrids among marine invertebrates, especially decapod crustaceans (cf. THAKUR 1961), it may be of some interest to publish here a preliminary report of their observations. Cytological and other detailed examinations on these specimens are left for future studies.

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Material and Methods

Three male specimens of the so-called "hybrids" were examined; their data are give next:

SPECIMEN	DATE	LOCALITY	DEPTH	CARAPACE LENGTH	CARAPACE WIDTH
A	Oct. 22, 1965	16 miles north off Nô	900 m	122 mm	124 mm
B	Mar. 30, 1966	15 miles NNE off Nô	1100 m	112 mm	116 mm
C	May 1, 1966	16 miles north off Nô	900 m	94 mm	96 mm

For comparison, several males of each of *Chionoecetes opilio* and *C. japonicus* were examined; the specimens of the former were obtained at the Niigata fish market (very probably, trawled around Sado Island) and from the trawl fishery products in Wakasa Bay, while those of the latter were caught off Nô by deep-bottom trap together with the "hybrid" specimens. No female "hybrid" specimen was available for study.

The carapace length was measured on the median line from the anterior to the posterior margin, including the rostral horn, and the maximum was measured as to the carapace width. The length of the propodus of cheliped was measured on the posterior or lower margin to the tip of the fixed finger. The distance between the grooves marking respective lateral sides of the interbranchial depression was measured at the narrowest level. All measurements were made by divider and 360–mm rule. The bent of the posterior part of the carapace surface was measured at the junction between the gastric and cardiac regions by angle divider and protractor.

The coloration was examined on fresh specimens as far as possible. Differences in color nuance between each of the parental species and the "hybrid" are discernible on color transparency, though the reproductions in black and white (Pl. VII) look quite similarly to each other.

The morphology of the first pleopod was examined in the same way as that of NISHIMURA (1967).

Comparison between *Chionoecetes opilio, C. japonicus* and the Hybrid

Since the morphological features of the hybrid are very similar to those of normal *Chionoecetes opilio* and *C. japonicus*, merely the differences observed between the hybrid and its parental species are mentioned in the following.

1. Swell of the Branchial Region of the Carapace

In *Chionoecetes opilio* the branchial region is swollen only weakly so that the lateral margins of the carapace are exposed in dorsal view anteriorly to the level of the first pair of ambulatory legs, while in *C. japonicus* it is much more swollen dorsally and laterally so that the lateral margins of the carapace are exposed in dorsal view anteriorly only to the level of the third pair of ambulatory legs. In the hybrid specimens, conditions are as follows:

Specimen A—Grade of swelling of the branchial region is intermediate between *opilio* and *japonicus*, the lateral margins of the carapace being concealed in dorsal view posteriorly to the level of the second pair of ambulatory legs.

Specimen B—Dorsal swelling of the branchial region is rather weak as in *opilio* but lateral swelling is rather strong and conceals in dorsal view the lateral margins of the carapace posteriorly to the level of the second pair of ambulatory legs.

Specimen C—Same as in Specimen A.

2. Ridges on the Branchial Region of the Carapace

In *C. japonicus* there are three conspicuous ridges demarcating respectively the outer-lateral, inner-lateral and posterior edges of a roughly triangular swelling of the branchial region on each side (Text-fig. 1), while in *opilio* the two lateral ridges are much less distinct and the posterior one is quite obscure. In the hybrid specimens, these ridges are in the following states:

Specimen A—Just intermediate between *japonicus* and *opilio.*
Specimen B—A little more distinct and closer to the state in *japonicus* than in Specimen A.
Specimen C—Distinct and close to the state in *japonicus*

3. Appearance of the Carapace Surface

In both *C. opilio* and *C. japonicus*, the carapace surface is scattered with small blunt and wart-like prominences, but their size and arrangement differ somewhat between the two species. In *opilio*, the prominences are minute and mostly gathered in clusters or tubercles, each including up to 15–30 prominences and leaving the interspace smooth and free from any prominences. In *japonicus*, on the other hand, the prominences are gathered in tubercles only partly and each tubercle includes fewer

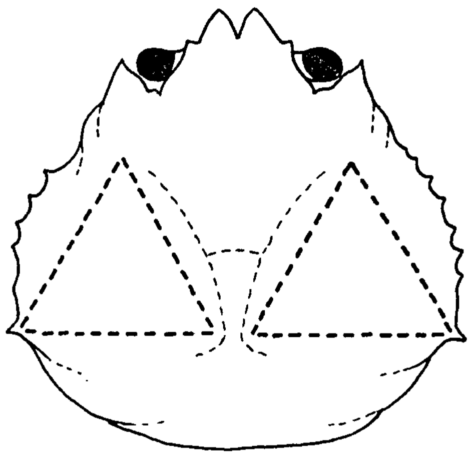


Fig. 1. Diagrammatic representation of the three ridges marking the borders of the triangular swell in each branchial region in *Chionoecetes japonicus*.

numbers of them, less than 9–10, thus the interspace is furnished with many conspicuous solitary prominences, particularly in the posterior half of the carapace. Respective tubercles and prominences are more remarkable in *japonicus* than in *opilio.*

In all the hybrids examined, the features of prominences are similar to one another: respective tubercles include large numbers of prominences up to 15–20 as in *opilio*, but the interspace is furnished with many independent prominences as in *japonicus*. The tubercles and respective prominences are similarly, or more, conspicuous as in *japonicus*; especially in Specimen C, the tubercles are much more remarkable than in the typical *japonicus.*

4. Feature of the Postero-lateral Angle of the Branchial Region

In *C. japonicus*, the outer-lateral and posterior ridges on each branchial region are both very distinct and converge in an acute angle to form a strong spine, with a small inconspicuous accessory tubercle situated just posterior to it; while in *C. opilio*, the ridges are not so conspicuous and the point where they converge is furnished merely with an indistinct tubercle or cluster of minute prominences, though it is immediately followed by an accessory tubercle of similar structure. In the hybrids, the converging point of the two ridges is:

Specimen A—Forming a large spine, with an accessory spine similarly conspicuous[2].

Specimen B—Forming a conspicuous spine[2], immediately followed by a tubercle of prominences.

Specimen C—Forming a large compound spine and with an accessory spine of similar structure; the compound spines consist each of several well-developed and sharply-pointed prominences bundled together.

The spines or prominences at the postero-lateral angle of the branchial region in the hybrids are as remarkable as or more remarkable than in *japonicus* and the tubercles are almost as large as in *opilio*. Such features in the hybrids may be expressed as a superposition of the two appearances respectively seen in *japonicus* and *opilio*.

5. *Configuration of the Interbranchial Region*

In *C. japonicus*, the interbranchial depression is well defined on both lateral sides by conspicuous grooves and is narrow and convex acutely, while in *C. opilio*, the grooves are defined weakly and the depression is broad and convex only gently. The space between the lateral grooves is 3.2–4.3% of the carapace width (C.W.) in *japonicus* and 6.3–9.0% in *opilio*, according to the measurements made by KISHIDA (1962) and the supplemental data obtained by the present authors. The conditions in the hybrid specimens, on the other hand, are as follows:

Specimen A—Rather close to the configuration in *opilio*. Intergroove space (IG.S.) is 5.6% of C.W.

Specimen B—Same as in Specimen A. IG.S. is 5.2% of C.W.

Specimen C—Rather close to the configuration in *japonicus*. IG.S. is 4.7% of C.W.

6. *Bent of the Carapace Surface*

In *C. japonicus* (Text-fig. 2a), the anterior two thirds of the dorsal surface of the carapace are almost horizontal or parallel to the side margin in lateral view, but the posterior third is sharply bent down. In *C. opilio* (Text-fig. 2b), on the other hand, the contour of the anterior two thirds is slightly inclined posteriorly and the posterior bent is not so sharp as in *japonicus* (cf. FUKATAKI 1965).

2) On closer examination, it has been revealed that these spines are each nothing but a single much enlarged one out of the prominences forming the tubercle or cluster at the angle.

In the hybrids, the conditions are:

Specimen A—The anterior two thirds are almost horizontal and the posterior third is inclined as steeply as in *japonicus*.

Specimen B—The anterior two thirds are inclined posteriorly but less steeply than in *opilio*; the inclination of the posterior third is similar to that in *japonicus*.

Specimen C—Same as in Specimen B.

YAMAMOTO (1950) has ever measured the bent angle between the gastric and cardiac regions in some male specimens of *C. japonicus* and *C. opilio* taken from the southern part of the Japan Sea; his results are 122°–130° in *japonicus* and 143°–151° in *opilio*. The angles measured by the present authors fall completely within the ranges cited above. In the hybrids examined, on the other hand, the angles are somewhat intermediate between *japonicus* and *opilio* as shown below:

Specimen A—134°
Specimen B—132°
Specimen C—137°

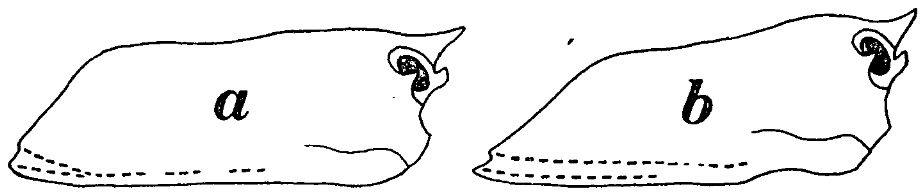


Fig. 2. Diagrammatic representation of the bent of the carapace and the distribution of the two spinal series along the posterior and postero-lateral margins of the carapace in *Chionoecetes japonicus* (a) and *C. opilio* (b). (After FUKATAKI 1965; slightly modified).

7. Spinal Series below the Postorbital Spine

In both *C. opilio* and *C. japonicus*, there is a horizontal series of a few small spines on the antero-lateral side of the carapace in the suborbital region (Text-fig. 3, B). The exact position of these spines is, however, somewhat different between the species: in *opilio*, the spines are arranged nearly at the middle level of the span between the tip of the postorbital spine (Text-fig. 3, A) and the horizontal spinose ridge (Text-fig. 3, C) which is running from the upper corner of the buccal frame posteriorly along the antero-lateral margin of the carapace (Fig. 1 in Pl. VIII); in *japonicus*, on the other hand, the spines are arranged approximately at the level of the upper third of the span between the tip of the postorbital spine and the horizontal spinose ridge along the antero-lateral margin of the carapace (Fig. 2 in Pl. VIII).

In the hybrid specimens, the level of the spinal arrangement in question is roughly intermediate between those in *opilio* and *japonicus*; it is above the middle but below the upper third of the span between the tip of the postorbital spine and the horizontal spinose ridge (Figs. 3 and 4 in Pl. VIII). However, it must be added that the three specimens are situated in this character somewhat nearer *opilio* rather than *japonicus*.

8. Spinules on the Inner Ventral Edge of the Postorbital Spine

As noted by FUKATAKI (1965), *C. opilio* and *C. japonicus* differ from each other in the number and arrangement of the spinules on the inner ventral edge of the postorbital spine (Text-fig. 3, D). According to FUKATAKI and the further data by the present authors, a series of 8–14 (mostly 11–13) very minute spinules furnish the entire length of the edge which then looks rather as serrated in *opilio* (Fig. 1 in Pl. VIII), while 1–4 spinules are found only in the proximal part of the edge in *japonicus* (Fig. 2 in Pl. VIII).

The hybrids resemble in this character more or less *japonicus*, as 3 or 4 spinules are found only in the proximal part of the edge on either sides (Figs. 3 and 4 in Pl. VIII).

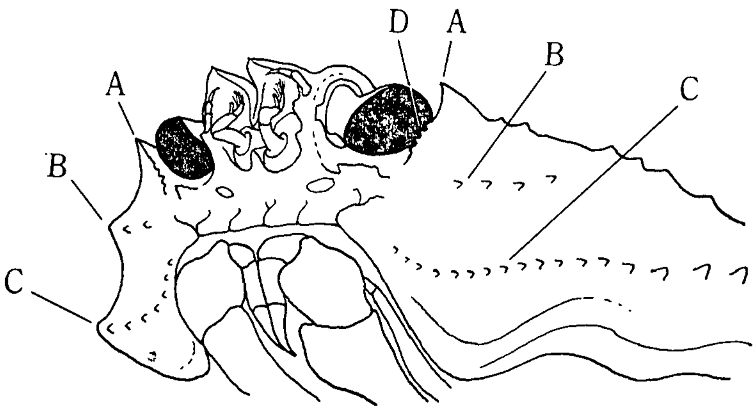


Fig. 3. Diagrammatic representation of the three spinal series in the suborbital and subhepatic regions of *Chionoecetes*.
A—Postorbital spine; B—Spinal series below the postorbital spine; C—Spinal series issuing from the upper corner of the buccal frame; D—Spinules on the inner ventral edge of the postorbital spine.

9. Spinal Series on the Posterior and Postero-lateral Margins of the Carapace

In both *C. opilio* and *C. japonicus*, the posterior margin of the carapace is furnished with a horizontal series of numerous spines arranged on a sharp edge and the postero-lateral margin with another horizontal series of spines similarly arranged on a conspicuous edge. In the metabranchial region where the two spinal series are overlapped, the postero-lateral series is situated above the posterior series. However, as noted by FUKATAKI (1965), these two spinal series run anteriorly in *opilio* (Text-fig. 2b) parallel to each other, the lower posterior series to just the base of the second ambulatory legs and the upper postero-lateral series almost to the base of the first ambulatory legs, without any conspicuous interruptions. Meanwhile, in *japonicus* (Text-fig. 2a), these spinal series are united together above the base of the third ambulatory legs into a single series which attains anteriorly, though with some interruptions, to the base of the second or further of the first ambulatory legs.

The conditions in the hybrids are all very similar to that in *opilio*: the two spinal series run anteriorly parallel to each other without being united, the lower series to just the base of the second ambulatory legs and the upper series to the base of the second or further of the first ambulatory legs, with no interruption at least posterior to the base of the second legs.

10. Length of the Propodus of Chelipeds

FUKATAKI (1965) states that the relative length of the propodus of female chelipeds is larger in *C. opilio* than in *C. japonicus* on the specimens ca. 60 to 85 mm in carapace

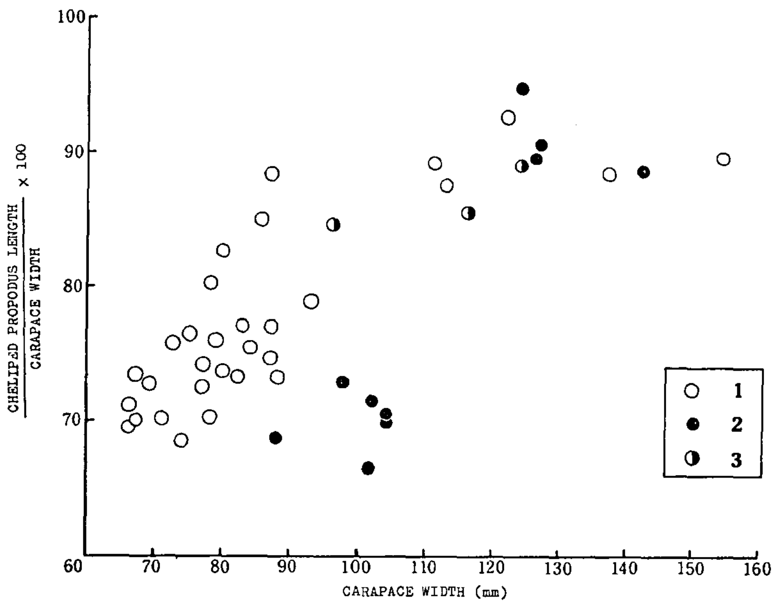


Fig. 4. Diagram showing the relative length of the cheliped propodus in male specimens of *Chionoecetes opilio* (1), *C. japonicus* (2) and the hybrids (3).

width. Text-figure 4 is prepared to see whether such a relationship is ascertained in male individuals, too. The values for *opilio* are obtained on the specimens caught in Wakasa Bay in November 1968, and those for *japonicus* are cited from KISHIDA (1962) who examined the specimens taken from off San'in District, western Honshu. It is seen that no apparent difference is noticed between the two species in the individuals larger than ca. 110 mm in carapace width but that in the individuals smaller than ca. 105 mm in carapace width the relative length of cheliped propodus is somewhat larger in *opilio* (1 in the figure) than in *japonicus* (2) as in the female.

Of the values in the three hybrids examined (3 in the figure), those of the larger

Specimens A and B are seemingly included within the common range of larger *opilio* and *japonicus*, while the value of the smaller Specimen C is distinctly included in the range of smaller *opilio* but not of smaller *japonicus*.

It seems that the proportional length of cheliped propodus in medium and small individuals of the hybrid resembles that of *opilio* rather than that of *japonicus* of the similar size, though this generalization requires further study on ample material in the future.

11. Structure of the First Pleopod

The morphology of the male first pleopod in *C. opilio* and *C. japonicus* was studied previously (NISHIMURA 1967) and some important differences were noticed between the two species, especially in regard to the curvature of the tip and the number and distribution of spinous filaments on the distal part.

The shape, especially that of the distal part, of the first pleopod in the three hybrids is shown in Text-figs. 5–8 and the number and distribution of spinous filaments are given in Table 1. The data on two more hybrids collected by the second author at Nô are added in the table. The spinous filaments are there classified and counted according to the method adopted in the previous paper (NISHIMURA op. cit.).

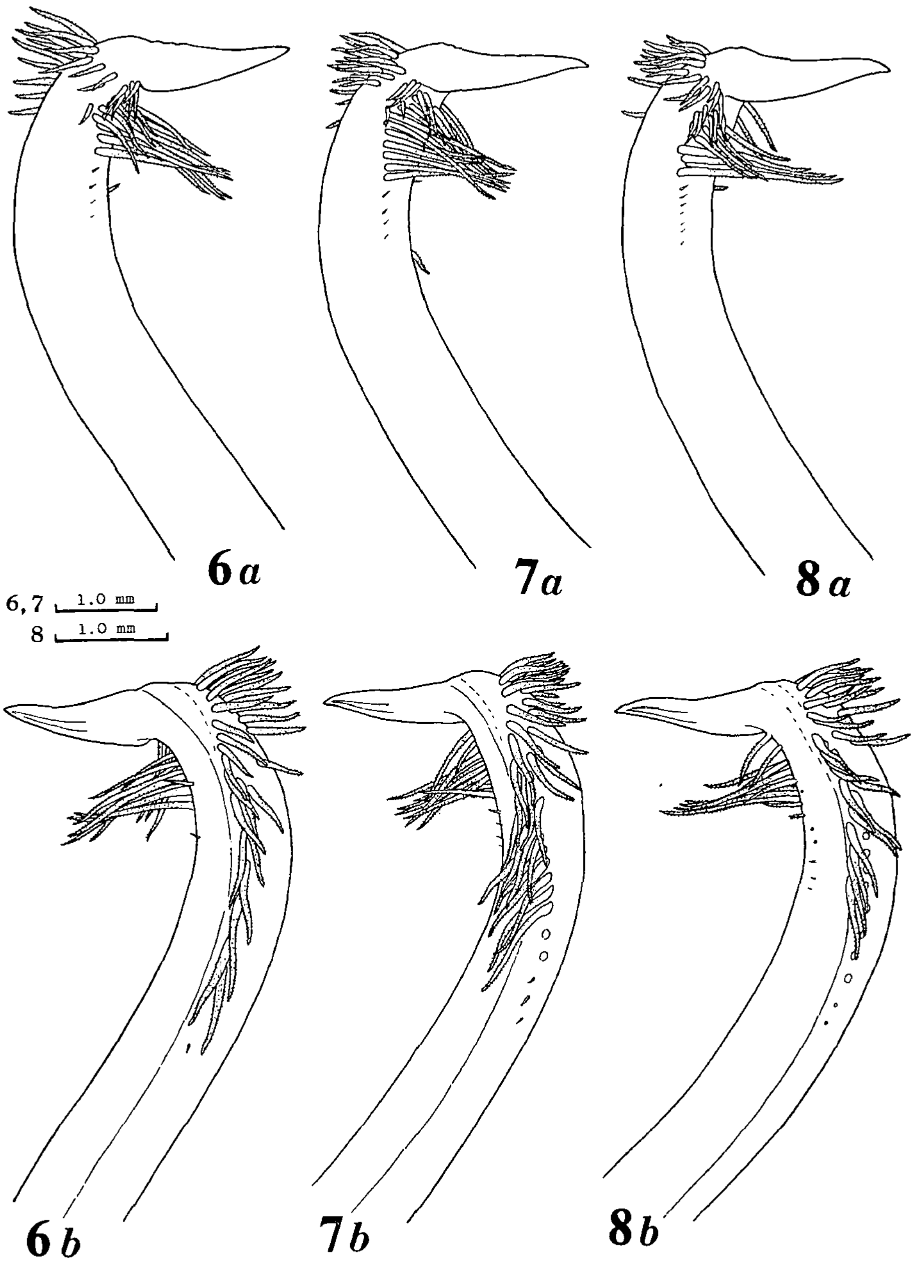
Comparing the morphology of the hybrid first pleopod with the normal morphology in *opilio* and *japonicus* as shown in Text-figs. 1–10 in NISHIMURA (op. cit.), it is clearly seen that the shape of the tip of the pleopod in the hybrids resembles much more

Fig. 5. Sternal aspect of the male first pleopod of the hybrid (Specimen A). ×2.3

Table 1. Distribution of spinous filaments in respective filament groups in the distal part of the right first pleopod of the hybrid specimens. Arabic numerals indicate the numbers of large filaments, while Roman numerals concern the rudimentary filaments.

SPECIMEN	CARAPACE LENGTH (mm)	FILAMENT GROUPS				
		I_s	I_m	II	III_a	III_s
A	122	9+i	29	11	14+vii	1+ii
B	112	9+iii	30	8	16+xi	5+viii
C	94	10	28	11	15+ix	6+viii
Extra-A†	99	8+iii	27	9	15+vii	5+v
Extra-B†	95	6+ii	31	14	12+vi	4+iv

† Both collected from the 900 m deep bottom 16 miles north off Nô on May 1, 1966.



Figs. 6–8. Distal part of the right first pleopod of the hybrid specimens. 6–Specimen A (carapace length 122 mm); 7–Specimen B (112 mm); 8–Specimen C (94 mm). a—Abdominal aspect; b—Sternal aspect.

closely that of *opilio* than that of *japonicus*. In the hybrids, however, the distal reflection is not so strong and the tip is proportionately not so short as in *opilio*; moreover, a slight indication of recurvature is noticeable at the distal point at least in three of the five specimens examined. In these respects, the hybrids approach to *japonicus*. As to the distribution of the spinous filaments, on the other hand, the states of the filament groups I_s and I_m resemble somewhat those in *japonicus*, the states of the filament groups III_a and III_s are rather similar to those in *opilio*, but the state of the filament group II cannot be assigned to either species. It is also noted that the filaments in the group III_s are as in *opilio* not all rudimentary, though even the largest ones are distinctly smaller in size than those in the other groups. In this feature, the hybrids differ from *japonicus* in which the filaments in the group III_s are all rudimentary or lacking altogether as shown in Table 2 in NISHIMURA (1967).

In examining the spinous filaments in the hybrids, attention was drawn to a peculiar fact that some to many of the filaments, especially those in the proximal part of the group I_s, were broken off in nearly all pleopods examined. Such a feature was quite exceptional in the male first pleopods of *opilio* and *japonicus*, a large number of which were examined previously by the first author. It is at present quite unknown why such an incomplete state occurs so often in the hybrids and what biological

Table 2. The coloration of fresh specimens.

CHIONOECETES JAPONICUS	*CHIONOECETES OPILIO*	HYBRID
	CARAPACE	
Carmine anteriorly and centrally, pale scarlet laterally and posteriorly. Tip of prominences dark carmine. No iridescence.	Grayish red-brown anteriorly and centrally, reddish brown laterally and posteriorly. Often iridescent.	Yellowish orange anteriorly and centrally, orange-yellow laterally and posteriorly. Tip of prominences carmine. No iridescence.
	STERNUM	
Dark carmine.	Yellowish white, pinkish peripherally.	Pale orange-yellow, much paler peripherally.
	CHELIPEDS	
Carmine dorsally and dark carmine ventrally; distal half of dactyls and fixed fingers pinkish, with white tip.	Brown and often iridescent dorsally, light brown ventrally; tip of dactyls and fixed fingers white.	Yellowish orange dorsally and orange-yellow ventrally; distal half of dactyls and fixed fingers pinkish, with white tip.
	AMBULATORY LEGS, DORSAL SIDE	
Yellowish carmine proximally and carmine distally. Tip of dactyls yellow.	Brown proximally and light brown distally; often iridescent. Tip of dactyls yellow.	Yellowish orange proximally and yellowish carmine distally. Tip of dactyls yellow.
	AMBULATORY LEGS, VENTRAL SIDE	
Dark carmine.	Yellowish or pinkish white proximally and light brown distally.	Orange-yellow proximally and yellowish orange distally.

meaning it implies. This might suggest some physical difficulty in the copulation between the hybrid male and the normal female of *opilio* or *japonicus* (but see below, p. 206).

12. Coloration

Differences in the body coloration between *C. japonicus*, *C. opilio* and the hybrids are fully given in Table 2.

The coloration of the hybrids is intermediate between those of *japonicus* and *opilio* in many respects; generally speaking, the hybrids are less carmine and more yellowish than *japonicus*, thus tending to the coloration of *opilio*.

Some Ecological Information

The information given below has been gathered by the second author mostly from the fishermen of the district of Nô. They are presented here raw without any scientific confirmation, but in a hope to be very suggestive for the future studies.

1. Meat Content and Quality

It is generally recognized that the meat content is smaller and its quality is very watery in the deep-water species *Chionoecetes japonicus* as compared with those in the shallow-water species *C. opilio*. According to the fishermen of Nô, the meat of the hybrid crabs is more abundant and less watery than in *japonicus* and thus it looks somewhat like the meat of *opilio* of higher commercial value. Actually, the hybrid crabs are traded at higher prices than *japonicus* in market. Such a nature of the hybrid meat not only suggests a physiologically intermediate state between those of the parental species but also seems to reflect the water depths at which the hybrid crabs live, as will be mentioned just below.

2. Vertical Distribution

The deep-water species *C. japonicus* is distributed on the sea floor from 450 m down to 2500 m, but mainly 700 m to 1300 m, while *C. opilio* is found on the bottom from 150 m to 500 m deep, most densely around 200–300 m. The vertical distributional pattern of the hybrids is not known clearly as yet; but according to the fishermen of Nô, they are caught most frequently from the upper reach of the fishing ground of *japonicus*. This seems to show that the habitat of the hybrids is somewhat shallower than that of *japonicus*. The three hybrid specimens examined were caught respectively at 900 m, 900 m and 1100 m, as mentioned already.

In this respect, the following observation seems very suggestive: of the three hybrids examined, Specimen C harbors seven evacuated cocoons of a marine leech, possibly *Carcinobdella cyclostoma* (JOHANSSON) (=*C. kanibir* OKA; cf. VASILIEV 1939 and EPSTEIN 1967), on the posterior surface of the carapace. Cocoons of *Carcinobdella* are found quite frequently on the shallow-water species *opilio*, almost every adult *opilio* bears a few to many cocoons on its carapace (Pl. VII). On the other hand, no leech cocoon has ever been observed on the deep-water species *japonicus* by the present authors. It seems that *Carcinobdella* lives rather at shallower levels in the sea so that the deep-water *japonicus* is avoided from being infected with this leech but at least a part of the hybrid population occur at shallower levels permitting of the infection with the parasitic annelid.

3. Viability in Shallower Environments

According to the fishermen engaged in the trap fishery of *C. japonicus* off Nô, most individuals of *japonicus* are moribund when they are hauled up on board and without any sign of activity, while the hybrids caught together with *japonicus* are still considerably active, crawling about for a while on the deck. This seems to suggest that the hybrids are adapted to the conditions of the shallower water with higher water temperature and lower hydrostatic pressure better than *japonicus*, thus possibly approaching to the physiological nature of the shallow-water *opilio*.

4. Frequency of Occurrence

A preliminary research made by the second author on the crab catch from the fishing ground 900–1100 m deep off Nô shows that the hybrids occur at the rate of 1 : 2000–3000 *japonicus*. Of course, this rate may be subject to changes depending on localities, depths and probably even on seasons. Future more careful examination on the catches from the moderate depths will very likely bring about much more hybrids; then, the incidence of natural hybridization between *japonicus* and *opilio* in the Japan Sea may be estimated more highly.

Discussion

As mentioned already, the so-called hybrid specimens show the intermediate conditions in many characters between the supposed parental species, *Chionoecetes opilio* and *C. japonicus*. Of the twelve morphological characters of the hybrids examined, eight are intermediate between those of *opilio* and *japonicus*, two are similar to those of *opilio*, one is similar to that of *japonicus*, and only the remaining one is seemingly unique, although the respective characters of the hybrids are slightly variable from specimen to specimen. Thus, so far as the external morphology is concerned, it is highly likely that these specimens represent really the natural hybrids between the afore-mentioned two species.

Even if they are accepted as the natural hybrids, nothing definite can be said at present as to the biological features such as hatch rate of the cross-fertilized eggs, survival rate and fertility of these individuals. Either, it is impossible to learn as to the hybrids examined here which of *opilio* or *japonicus* was their father or mother[3]. Only it is certain that at least some of the hybrids survive in certain environments. And, although some slight modifications or defects are found on the male first pleopod of the hybrids, they do not seem to be physically fatal for the hybrids to carry out the copulation. If, on the other hand, either the hybrids are completely infertile or their offspring are completely inviable, then they will act as a source of selection against those parental genotypes which enter into hybridization, leading to the gradual reduction of hybridization until the isolating mechanisms between the parental species become completely effective rather in a short time (cf. FISHER 1930; DOBZHANSKY 1940; SIBLEY 1961; etc.)

In this connection, the following may be of special interest to note. As stated already, DERJUGIN & KOBJAKOWA (1935) treated *C. japonicus* as a subspecies (*bathyalis*) of *C. angulatus* RATHBUN; and according to these Russian authors, the subspecies could be discriminated from the typical form of *angulatus* found in the Bering Sea by (1) the smoother carapace surface with smaller numbers of prominences and tubercles, (2) the less conspicuously swollen branchial region of the carapace, (3) the smaller magnitude in bent of the posterior part of the carapace, and (4) the slightly more flattened and longer ambulatory legs with smaller numbers of prominences on their border in the former than in the latter. It seems now to be quite noteworthy that of these four discriminating characters, at least the first three show each clearly an approximation to the state of *C. opilio* in the respective characters. If the statement by the Russian authors is correct, then, is it impossible to regard this as an indication that an introgressive hybridization has been taking place at a slow but steady rate between *japonicus* and *opilio* within the Japan Sea? As to the subspecific differentiation of *opilio*, if it might ever take place, on the other hand, RATHBUN (1924) once separated the population of the Japan Sea as a subspecies (*elongatus*) distinct from the typical population found in the Bering Sea and the North Atlantic chiefly in that the former had longer ambulatory legs than the latter. But, since her opinion has not necessarily been advocated by all of the subsequent researchers (e.g., MATSUURA 1934; KAMITA

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3) Circumstantial evidences suggest that for most hybrid individuals the father may be *C. opilio* and the mother may be *C. japonicus*. This is because in both *opilio* and *japonicus* the adult males live at considerably deeper levels than the adult females at least around the copulating season so that the probability of encountering of the two species is estimated to be much higher between the male *opilio* and the female *japonicus* than between the female *opilio* and the male *japonicus*. The vertical distribution of *opilio* is studied in detail by Japan Sea Regional Fisheries Research Laboratory & Hyogo Prefectural Fisheries Experimental Station (1965), KON (1969), etc., where it is stated that the adult males live in the range 275 m to 300–400 m from March to November and around 250 m from December to February, while the adult females live around 250 m throughout the year. The data on the vertical distribution of *japonicus* are rather inadequate, but MIZUSAWA (1965) mentions that the adult females become abundant in the zones shallower than 800 m, while the adult males are abundant from 900 m to 1100 m. The spawning, which is supposed to follow immediately after the copulation, is estimated to take place in the period from February to April in *opilio* (MINAMIZAWA 1955; ITO 1963; etc.) and from April to May in *japonicus* (MIZUSAWA 1965).

1941; etc.), it cannot be at present said with confidence whether the population of the Japan Sea is really different from the typical form of the species or not. In view of the importance involved in this point, it is much expected for someone in the future to scrutinize RATHBUN's data in the new light and to study once again on the subspecies problem of this crab on an ampler material and by a more exact statistical method in a close comparison with the morphological features of *C. angulatus*.

Lastly, the trend in vertical distribution suggested above for the hybrids seems to indicate that they are fitted to the environment at intermediate depths with moderate water temperature and moderate hydrostatic pressure. Only those young hybrid crabs which have settled down after a long pelagic phase[4)] to the sea floor of intermediate depth will be viable, while those which have settled down to the bottom of shallower or deeper levels might be eliminated sooner or later.

Summary

1. Brachyuran specimens that are seemingly the natural hybrids between *Chionoecetes opilio* (O. FABRICIUS) and *C. japonicus* RATHBUN are caught occasionally from the sea floor about 900–1100 m deep off Nô near Niigata in the eastern Japan Sea.

2. In many morphological characters, these specimens show the intermediate condition between the supposed parental species, though in a few characters they tend to either of the parental species. Further, they are seemingly intermediate in physiological and ecological characters, too.

3. A discussion is presented on the genetic aspects of the hybrid population and some attendant problems pertaining to the taxonomic status of the parental species living in the Japan Sea.

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4) In a recent paper, FUKATAKI (1969) estimates that the pelagic larval phase of *C. opilio* and *C. japonicus* will extend over five to eight months.

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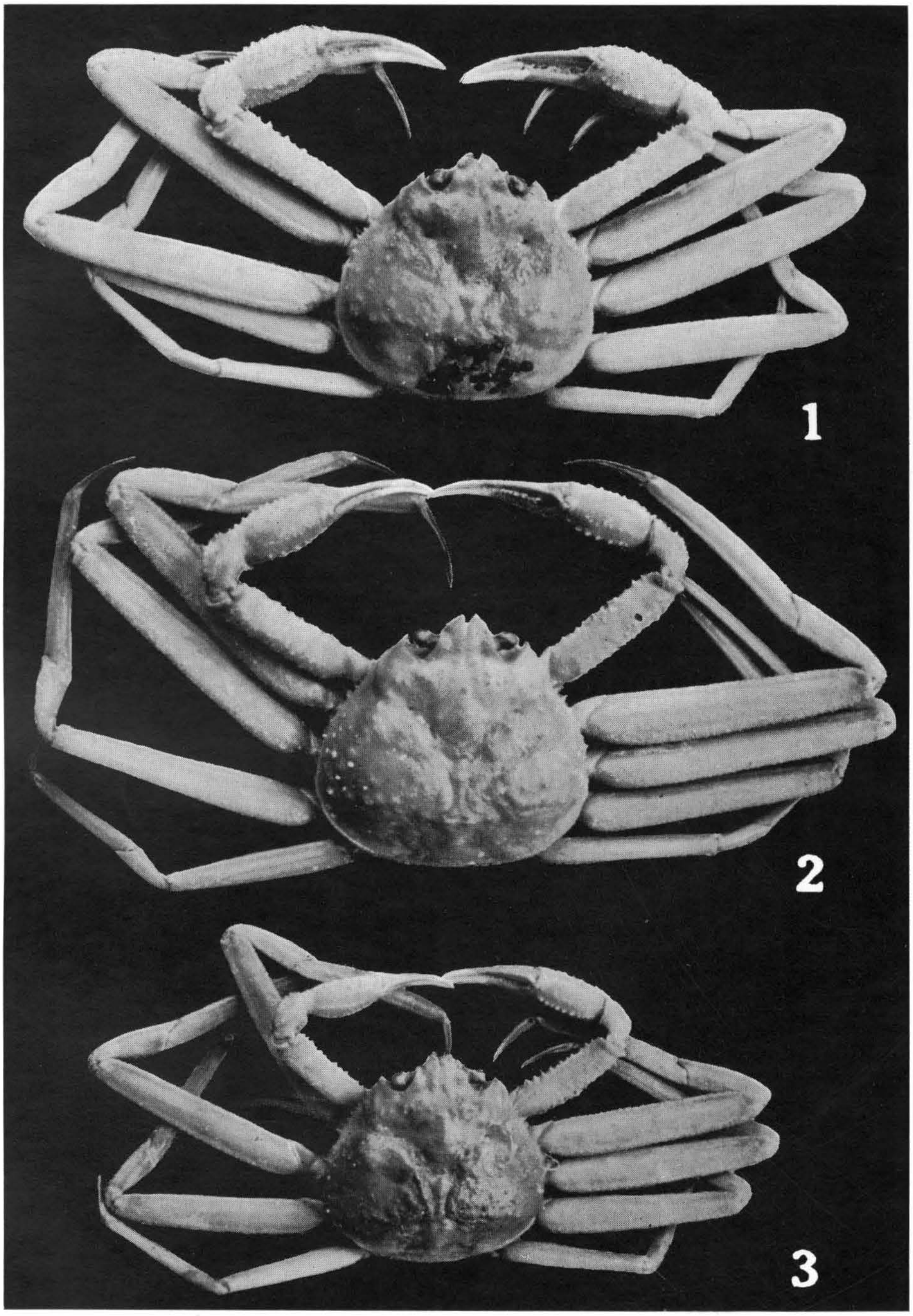
EXPLANATION OF PLATES

PLATE VII. Dorsal aspects of the adult male specimens of *Chionoecetes opilio* (1), *C. japonicus* (3) and the hybrid, Specimen A (2). ×0.3
About 25 evacuated cocoons of *Carcinobdella* are attached to the posterior part of the carapace of *C. opilio*.

PLATE VIII. Suborbital and subhepatic regions of the carapace in *Chionoecetes opilio* (1), *C. japonicus* (2) and the two hybrids, Specimen A (3) and Specimen B (4).



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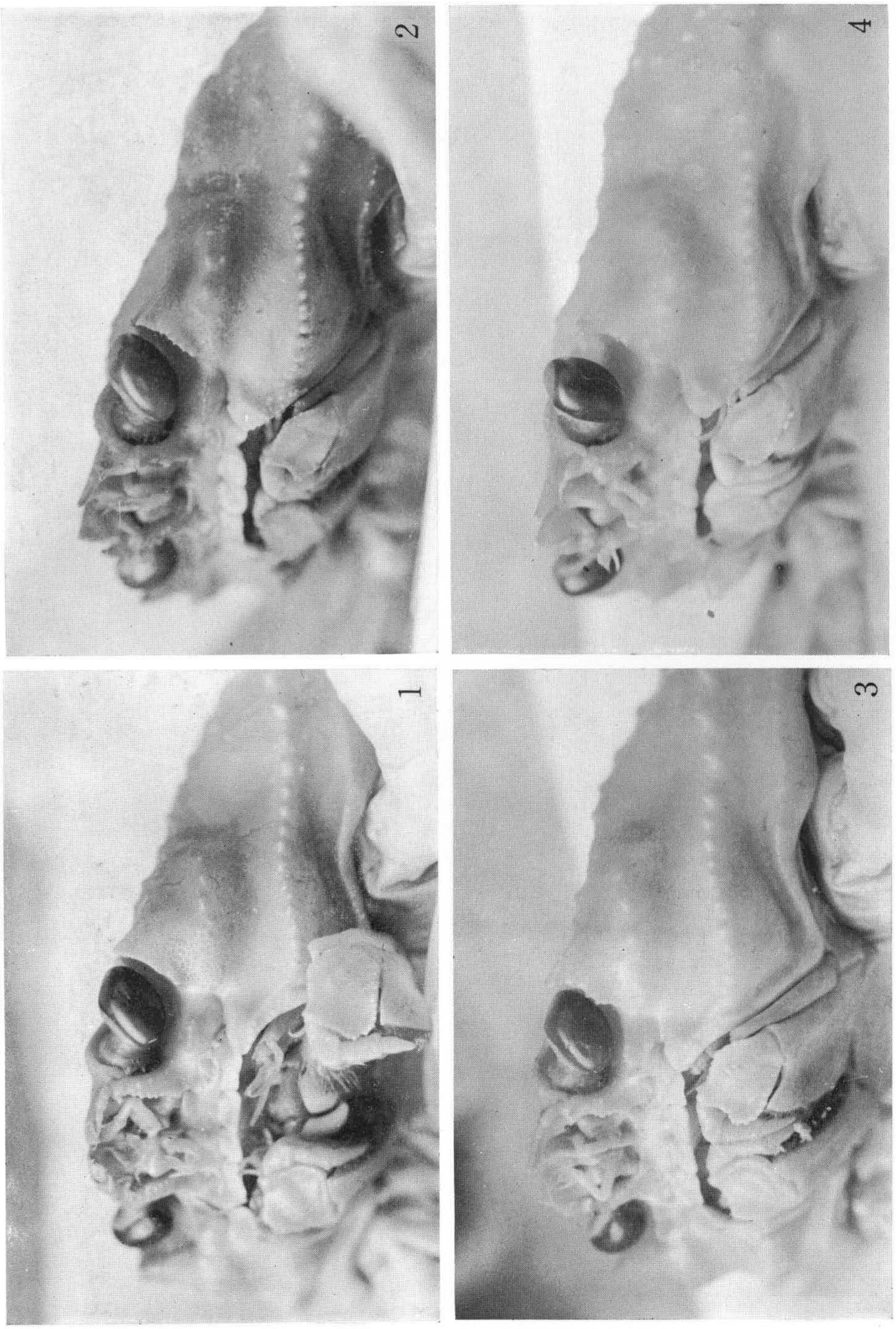

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