

イセエビ科ゼイサス属交雑種フィロゾーマ幼生の完全飼育

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Culture of a Hybrid of Spiny Lobster Genus *Jasus* from Egg Stage to Puerulus

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Hybridization was accomplished between *Jasus novaehollandiae* and *Jasus edwardsii* in the laboratory. Hybrid phyllosoma hatched out from female *Jasus novaehollandiae* were co-cultured at 18°C with phyllosoma of *Jasus lalandii*. From 1,000 phyllosomas, two individuals reached the final stage; one metamorphosed into puerulus 319 days after hatching out, the other repeated the final stage 324 days after hatching. The larval life history of the hybrid resembled that of *Jasus lalandii* (Kittaka, 1988): at least 15 molts occurred during phyllosoma stage with 20-30 day intermolt intervals for advanced stages. The culture of *Jasus* hybrids throughout phyllosoma development indicates the possibility of culture of temperate palinurids. Evidence generated also supports the hypothesis that these *Jasus* species diverged from a single circumpolar species.

Because of difficulties in the culture of warm water palinurids along the northeast coast of Japan, cold temperate species of genus *Jasus* have been used for the larval culture experiments at Sanriku since 1983. The first successful culture from egg stage to puerulus was demonstrated for *Jasus lalandii* obtained from the Cape, South Africa by Kittaka.¹⁾ There are 6 other species in the genus *Jasus*. Among them *Jasus novaehollandiae*, Tasmanian species, and *Jasus edwardsii*, New Zealand species, are very similar in morphology.²⁾ A slight genetic variation was reported by Smith *et al.*³⁾ Identification of these species is particularly difficult during phyllosoma stage.⁴⁾ These facts point out a possibility of hybridization of these populations in the wilds, at sites where phyllosoma can drift; such as across the Tasman Sea. Mating experiments between the species may give one solution for this hypothesis.

The authors have carried out mating experiment between *Jasus novaehollandiae* and *Jasus edwardsii* since 1986. This paper deals with the culture of the hybrid phyllosoma obtained.

Materials and Methods

Materials

Jasus novaehollandiae caught along the west coast of Tasmania were shipped by air from Hobart to Tokyo in November 1985 and January 1986. *Jasus edwardsii* caught along the east coast of the

North Island of New Zealand were shipped from Wellington to Tokyo in December 1985. A combination of female *Jasus novaehollandiae* and male *Jasus edwardsii* (Exp. 1) or female *Jasus edwardsii* and male *Jasus novaehollandiae* (Exp. 2) was introduced into separate FRP tanks (dimensions: 2.5 m × 1.2 m × height 0.7 m) with running seawater and aeration on 23 May 1986.

Methods

Water temperature ranged between 12°C and 18°C in the breeding tanks and *Mytilus edulis* were given as food daily. Molting and mating occurred from the end of May to the end of June. All females were found to be carrying eggs in early July. The females hatched out naupliosoma at the end of August for Exp. 2 and in the middle of September for Exp. 1. Approximately 16,000 first stage hybrid phyllosomas from Exp. 2 and 1,000 from Exp. 1 were introduced into separate 100 l circular culture tank. In these tanks, the phyllosomas of *Jasus lalandii* were co-cultured beginning on 1 August 1986 as reported in the previous paper.¹⁾

For the phyllosoma culture, seawater treated with a 5 μ ceramic filter and ultra-violet sterilizer was supplied at the bottom through a recirculating system. Cultured maine *Chlorella* was added to the tank water. Water temperature was maintained at about 18°C. Feeding was done with a combination of *Artemia* and *Mytilus edulis*. Water temperature, salinity, pH, density of *Chlorella* and

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Table 1. Hybridization between *Jasus novaehollandiae* and *Jasus edwardsii*

No of exp.	No. of female	Date of Introduction	Date of pre-spawning molt (M)	Date of ^{*3} Spawning (S)	Date of Hatching (H)	Days ^{*4} (H—M)	No. of Phyllosoma hatched ^{*5}
1 ^{*1}	1	23 May	16 June	10 July	8–10 Sept.	84	22,000
	2	"	25 June	10 July	11–13 Sept.	80	16,500
2 ^{*2}	1	23 May	27 May	—	24–26 Aug.	89	22,000
	2	"	1 June	—	27–29 Aug.	87	31,500
	3	"	3 June	—	28–29 Aug.	86	75,000
	4	"	7 June	7 Aug.	29–30 Aug.	83	54,800

*1 Two female *Jasus novaehollandiae* and 3 male *Jasus edwardsii*.

*2 Four female *Jasus edwardsii* and 3 male *Jasus novaehollandiae*.

*3 Date of spawning was determined by egg-bearing status. Sometimes, this was found later than actual spawning.

*4 No. of days from molting to hatching. Date of molting and hatching was observed accurately.

*5 No. of phyllosoma collected.

Table 2. Rearing of phyllosoma of *Jasus* hybrid^{*1}

Phyllosoma	No. 1			No. 2 ^{*2}			No. of surviving individuals
	Stage	Date ^{*3}	Cumulative days	Intermolt days	Date ^{*3}	Cumulative days	
I	15 Sept.	0	(10)	15 Sept.	0	(12)	1,000
II	(25 Sept.) 3 Oct.	(10) 18	(10)	(27 Sept.)	(12)	(13)	
III	(5 Oct.)	(20)	(15)	(10 Oct.)	(25)	(18)	68
IV	(20 Oct.) 5 Nov.	(35) 51	(17)	(28 Oct.)	(43)	(20)	
V	6 Nov.	52	20	(17 Nov.)	(63)	(20)	2
VI	26 Nov. ^{*4}	72	20	7 Dec.	83	19	
VII	16 Dec.	92	20	26 Dec.	102	27	2
VIII	5 Jan. ^{*4}	112	20	22 Jan.	129	19	
"	25 Jan.	132	27	10 Feb.	148	29	2
IX	21 Feb. ^{*4}	159	27	11 Mar.	177	21	
"	20 Mar.	186	25	1 Apr.	198	27	2
X	14 Apr. ^{*4}	211	26	28 Apr.	225	29	
"	10 May	237	26	27 May	254	22	2
"	5 June	263	27	18 June	276	23	
XI	2 July	290	29	11 July	299		2
PRL ^{*5}	31 July	319					

*1 Female *J. novaehollandiae* × male *J. edwardsii*.

*2 The individual lost one eyestalk on 23 Feb., was malformed on 5 Aug. and died on 10 Sept.

*3 Period of the experiment: 1986–1987.

*4 Molt may be missing. Intermolt period was averaged.

*5 Puerulus.

Note: Numerals in parentheses indicate estimated values.

rate of water exchange were measured daily.

Results

Hybridization

Mating between both species was successful as shown in Table 1.

All females were found to be egg-bearing and naupliosoma hatched out in late summer and early autumn. Although the date of mating

(spawning) was not determined accurately, the duration from pre-spawning molt to hatching was rather stable: 80–84 (average 82) and 83–89 (average 86) days at 12.0–19.0 (average 15.5) °C for *Jasus novaehollandiae* and *Jasus edwardsii*, respectively.

The average number of first stage phyllosomas hatched out per female was approximately 19,000 for *Jasus novaehollandiae* and 46,000 for *Jasus edwardsii*.

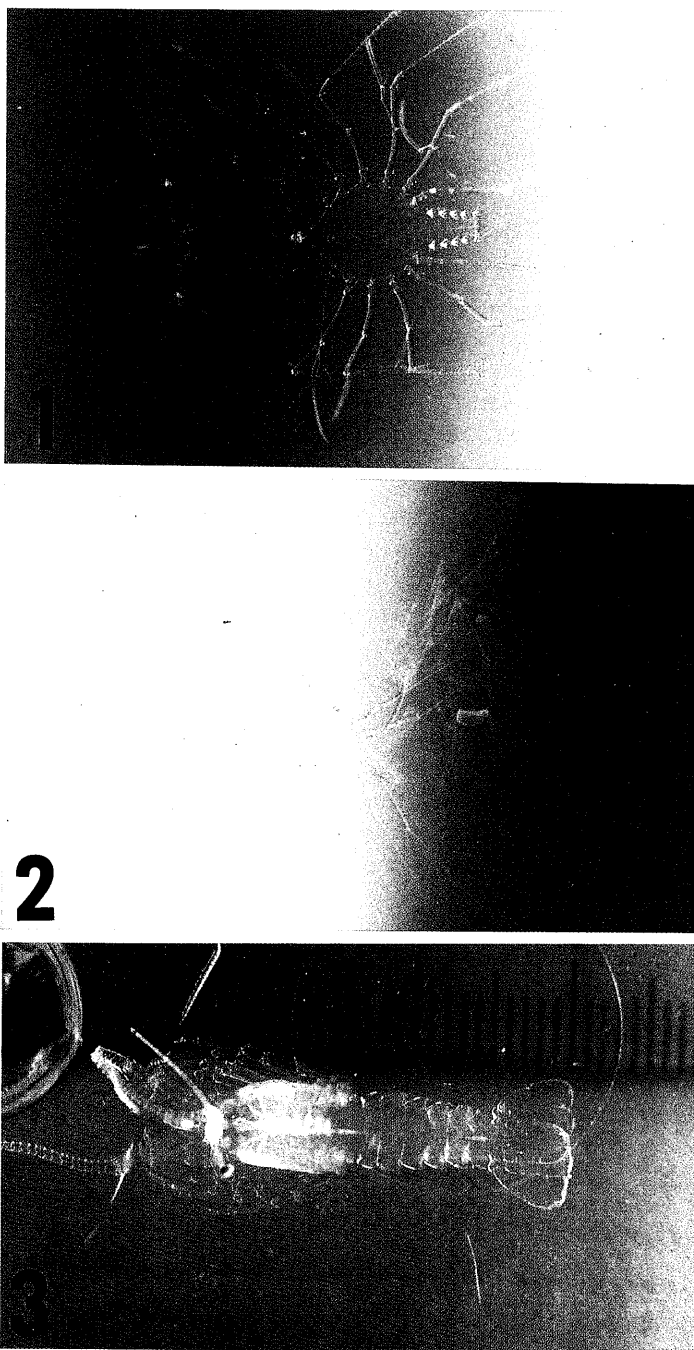


Fig. 1–3. Larval stage of *Jasus* hybrid between female *Jasus novaehollandiae* and male *Jasus edwardsii*, cultured in the laboratory.

Fig. 1. The 11th stage of phyllosoma, 303 days after hatching out. The individual metamorphosed into the puerulus stage after 16 days. The figure shows swimming posture in the culture tank (front view).

Fig. 2. Side view of the same individual, showing feeding posture upon a piece of *Mytilus edulis*.

Fig. 3. Puerulus, 319 days after hatching out. Antennule and antennae were malformed during metamorphosing. The scales represent 1 mm.

Table 3. Rearing condition for the hybrid*¹ phyllosoma

Period	September 1986–May 1987	June–July 1987
Water temperature, °C	18.8 (17.0–20.6)	18.6 (17.9–20.0)
Salinity, ‰	35.3 (34.4–36.4)	35.1 (34.2–35.7)
pH	8.28 (8.00–8.56)	8.43 (8.30–8.50)
<i>Chlorella</i> , 10 ⁶ /ml	989 (288–2,130)	413 (223–672)
Water exchange, daily %	1.56 (0–11.4)	0 (0–0)
<i>Mytilus edulis</i> , No. of pieces given/day	9.2 (0–17)	15.1 (8–16)

*¹ Hybrid between female *Jasus novaehollandiae* and male *Jasus edwardsii*.

Note. Culture period for phyllosoma of *Jasus lalandii*: 1 August 1986–3 June 1987; for the hybrid phyllosoma: 15 September 1986–31 July 1987.

Numerals in parentheses indicate range of the values.

Survival and Molting

As shown in Table 2, heavy mortality was observed for the hybrids (female *Jasus novaehollandiae* × male *Jasus edwardsii*) for a 51 day period after hatching. However, the 2 surviving individuals were cultured until final stage without mortality. One individual (No. 1) was estimated to molt 15 times in 319 days and metamorphosed into puerulus stage. The other individual (No. 2) was estimated to molt 15 times in 324 days but remained in the final stage. The latter individual lost one eye with the eyestalk at the 9th stage due to handling failure. The appendages of this individual became malformed at the final molt.

The staging was done based on the descriptions by Lesser^{5,6)} and Inoue.⁷⁾ Although the molting shell to the 7th stage was not found for the individual No. 1, it is believed that the individual molted twice at the 8th and the 9th stage respectively, and 3 times at the 10th stage judging from the intermolt period of 20–23 days shown by *J. lalandii*.¹⁾ The individual No. 2 molted and advanced as No. 1 did. The intermolt period was 10–20 days for early stage phyllosoma and 20–30 days for advanced stage phyllosoma (Table 2).

The phyllosoma of another hybrid (female *Jasus edwardsii* × male *Jasus novaehollandiae*) did not survive due to failure of water quality control.

Metamorphosis into Puerulus Stage

The final stage phyllosoma No. 1 (Fig. 1, 2) stopped feeding 3 days before molting. The abdomen increased in thickness and 2 hours before molting the eyestalks became flaccid. This is similar to the progression of *Jasus lalandii*.¹⁾ Phyllosoma No. 1 started to molt at 19:30 on 31 July 1987. Soon after, phyllosoma No. 2 grasped No. 1 with appendages and this rather aggressive behaviour continued for more than 30 minutes. The latter was forced to release the former when we injected tank water using a pipette. Phyllosoma

No. 1 finished molting at 20:30. Because of the trouble during molting, the antennules and antennae of the newly metamorphosed puerulus were malformed; particularly on right side. The right eyestalk was stretched at molting. It seemed to recover after molting and the puerulus swam actively. However, the puerulus lost the eye on 3 August and was found dead 4 days after metamorphosing (Fig. 3).

Phyllosoma No. 2 molted at regular intervals as shown in Table 2. The phyllosoma was malformed during the final stage and metamorphosing was delayed.

Rearing Condition

Water quality and feeding for the period from the first phyllosoma to puerulus are identical to those reported for *Jasus lalandii* in the previous paper.¹⁾ Rearing conditions after 4 June 1987 are summarized in Table 3.

Water quality such as temperature, salinity, etc. and kind of food given were similar during the entire culture period. However, tank water was not exchanged with filtered sterilized sea water in June and July, 1987. This may have resulted in poor water quality prior to the final molting for the hybrid phyllosoma.

Discussion

The experimental results demonstrate the second complete larval development for the genus *Jasus*, family Palinuridae, following the success shown for *Jasus lalandii*.¹⁾ Both were cultured in the same tank, however, age differences allowed the hybrid to be distinguished from *Jasus lalandii*. Identification was done easily by noting differences in body size.

Although detailed descriptions of the larval development of *Jasus novaehollandiae* have not yet been published, development is considered to

closely resemble *Jasus edwardsii*.⁴⁾ Our observations showed that the development of pereiopods for the hybrids followed that of *Jasus edwardsii* as described by Lesser.⁶⁾ The hybrid demonstrated the same early life history as seen in *Jasus lalandii*, i.e., a total of 15 molts (estimated) for phyllosoma stage, multiple molting at the 8–10th stages, relatively regular intermolt intervals, very low survival rate at early stages followed by very high survival after midstage.

Metamorphosis into puerulus for the hybrid indicates that the requirements for both environment and nutrition are the same as those for *Jasus lalandii*. Presumably, these conditions could also be applied to both *Jasus novaehollandiae* and *Jasus edwardsii*. Incomplete molting found at metamorphosing and at final stage was probably due to failure of the seawater exchange system for a 2 month period at late phyllosoma stage. Although better survival was shown for the hybrid compared to *Jasus lalandii*, further experiments are necessary to demonstrate any hybrid vigor.

In reference to possible role of the eyestalk in regulating molt intervals, it is interesting to review the intervals and frequency in the phyllosoma (No. 2) that lost one eyestalk. Previous work on the effects of eyestalk ablation in palinurid lobsters has not been conclusive.⁸⁾ After losing the eyestalk, the individual (No. 2) molted 7 times beginning at the 9th stage until final stage with an average of 24.5 days intermolt intervals, while the counterpart without the eyestalk ablation (No. 1) molted 7 times beginning at the 9th stage until puerulus stage with an average of 26.7 days intermolt intervals. This fact supports the work done for adultformed palinurids, which showed that there were no molt inhibiting substances in the eyestalk.^{9,10)}

The genus *Jasus* is divided into two groups; *lalandii* and *verreauxi*. The former consists of six species,¹¹⁾ and includes *lalandii*, *novaehollandiae* and *edwardsii* used in the present culture experiments. Mating experiments between *Jasus lalandii* and *Jasus novaehollandiae* also carried out

in our laboratory.¹²⁾ The hybridizations within the *lalandii* group support the hypothesis that these species diverged from a single circumpolar ancestor. The results of culture of the hybrid phyllosoma between *Jasus lalandii* from South Africa and *Jasus novaehollandiae* from South Australia will be reported in a following paper.

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