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Feeding and Growth of Captive Adult Japanese Common Squid, *Todarodes pacificus*, Measuring Initial Body Size by Cold Anesthesia*

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Abstract: Maximum feeding rate and relationship between feeding and growth of individual adult Japanese common squid, *Todarodes pacificus*, of about 150 to 600g body weight kept at 15 to 16°C on diets of fish were examined. Squid samples were initially measured, weighed and tagged on the fins for individual identification by a new cold anesthesia method done by directly immersing squid in a small aquarium with cold seawater of 0 to 3°C. Maximum feeding rates for single food-intake and total daily feeding rates for two or three food-intakes per day (percentage of body weight) were 18.9% and 20.5%, respectively, which were consistent with those of natural populations of adult squids. For six live squid during the 39-day feeding experiment, daily growth rates of weight, mantle length and daily feeding rates ranged from 0.42 to 0.81% (mean 0.62%), 0.07 to 0.24% (mean 0.16%) and 2.60 to 3.72% (mean 3.25%), respectively, but daily feeding rates for individual squid varied from 0 to 13.4%. An empirical linear equation for live individuals over a 16 days period was established based on the relationship between daily feeding rate (R) and daily growth rate in weight (GW): GW = 0.39R-0.66 (r^2 = 0.76), and predicted a daily feeding rate for maintenance of 1.67%.

Introduction

The Japanese common squid, *Todarodes pacificus*, is an important fishery resource in Japan; it inhabits the northwestern North Pacific Ocean including the waters around the Japan archipelago and the whole of the Japan Sea. The squid populations in waters near Japan are appropriately differentiated as winter-, summer-, and autumn-spawning subpopulations on the basis of spawning seasons, growth patterns and other features (Okutani, 1983). Despite many studies of the feeding habits of the squid (Okutani, 1962; Okiyama, 1965; Hamabe and Shimizu, 1966), little is known about bioenergetic aspects of their life in nature. In the past, direct studies on feeding, growth rates and conversion efficiency of *T. pacificus* have been difficult because of some problems of maintaining them in captivity; these squid are powerful swimmers and tend to dash against the sides of the tank. Recently, Sakurai (1987) succeeded long term maintenance for 82 days of this species and some experiments in captivity have become feasible (Sakurai *et al.*, 1990; Nakamura and Sakurai, 1990, 1991).

As for long term maintenance of Ommastrephidae, O'Dor *et al.* (1977) first reported to have maintained *Illex illecebrosus*, which is very similar in size and life cycle to *T. pacificus*, in a large tank for 82 days. Furthermore, feeding and growth to the commercial size of this species on diets of fish and crustaceans have been reported (O'Dor *et al.*, 1980; Hirtle *et al.*, 1981).

This paper reports an investigation of maximum feeding rate, the relationship between feeding and growth and conversion efficiency in captive adult Japanese common squid, which were measured in terms of initial body size and then tagged for individual identification by a new cold anesthesia method.

Materials and Methods

Maximum feeding experiment

On 26 July 1990, 77 live adult squid were taken from a set net (depth 50 m) inshore at Kinaoshi, southern Hokkaido. They were transfered to the Usujiri Fisheries Laboratory, Faculty of Fisheries, Hokkaido

* Contribution 262 from the Research Institute of North Pacific Fisheries, Hokkaido University.

University, and were held in a raceway tank (5.5 m in length, 2.5 m in width, 1 m in depth, and 12,000 ℓ in capacity) which had a half-closed recirculating and filtering system, i.e. a little seawater was continually flowing out of the tank for maintaining a good seawater quality. Tank walls are painted with stripes of black paint to increase contrast and make the walls more visible to squids. They were first held with food organisms (live anchovy, *Engraulis japonicus* and sardine, *Sardinops melanostictus*) and later their food changed from live fish to fish fillets during the period of 10 days before the start of a feeding experiment. On 6 August, 28 animals in good condition were selected and tagged with thin vinyl color ribbon tags fixed through the fins to allow individual identification by a new cold anesthesia method, which consists of directly immersing squids in a small aquarium with cold seawater of 0 to 3°C. The squid was handheld and gently immersed into cold seawater for a period of five to ten minutes until swimming movements completely stopped and the animal sat on the bottom. Squids occasionally inked in the aquarium, and the ink was immediately dipnetted out with a fine-mesh net as in the case of the loliginid squids undergoing ethanol anesthesia (Hanlon *et al.*, 1983). The period of handling was less than 15 minutes. No squids died from this handling, and the anesthetized animals immediately recovered and resumed swimming before reaching the bottom of the tank. Unmarked squid were removed to other tanks. A regime of 15h light and 9h dark was maintained throughout the study, with the light phase commencing at 0400h. Water temperature was kept at 15 to 16°C by the cooling untis (2.75 KW).

After starving for 24 hours, the maximum feeding experiment was done during 4 days from 8 to 11 August. During the first two days, the squid were fed three times daily, at 1000, 1300 and 1500h, and during the following two days they were fed twice daily, at 1000 and 1500h. Food used was only fresh sardine fillets, because the squid ate only the fleshy portion of the fish, leaving the skeleton including head and tail intact (O'Dor *et al.*, 1980; Sakurai, 1987). Food items were cut into medium sized pieces (about 5 to 15g in weight), weighed in mg and presented individually; the food weight and the identification taggs of the squid taking the food were recorded. Feeding was stopped when several consecutive prey items were ignored (Hirtle *et al.*, 1981). Uneaten food were removed from the tank. The rejected portions of food were removed with a dipnet and weighed to assess the ration individually, but such a case was very rarely encountered.

The feeding rate for single food-intake and the total daily feeding rate are expressed as percentages of estimated weight of an individual at each day of the feeding experiment. The estimated weight was back-calculated from the final body weight in this experiment, which used the values of daily growth increments obtained by the following experiment on feeding and growth. The estimated body weights ranged from 141 to 413g, the final mantle lengths from 201 to 290 mm.

Feeding and growth experiment

On 30 October 1990, 40 live adult squids were taken from a set net inshore at Kinaoshi and were held in the same tank and by the same methods as in the above-mentioned feeding experiment. In addition to tagging for individual identification, 21 individuals in good condition were selected and measured with body weights in mg and mantle lengths in mm by cold anesthesia. The tagging and measuring of the squid required that each animal was out of the water for 60–120 seconds. Weights were taken after the squid were held vertically and a glass tube inserted into the mantle cavity allowed to eliminate the seawater in the cavity (O'Dor *et al.*, 1980). The initial range in mantle length for 21 squids was from 211 to 271 mm, and from 194 to 548g in weight, 67% were male and both sexes were immature or maturing. The feeding regime lasted 37 days followed by two day of fasting. A regime of 11h light and 13h dark was maintained throughout the study, with the light phase commencing at 0630h, according to the natural photoperiod during this season. A small light was provided for preventing skin damage resulting from contact with the tank wall during the dark period. Water temperature was kept at a mean of 15.6°C (range: 14.8 to 16.0°C), and pH values ranged from 7.4 to 7.8, but the input of fresh seawater was increased when pH values became lower 7.6.

When animals died during the experiment, the date of death, sex, mantle length and body weight were recorded. Final length and weight were measured on day 38 or 39 (7 and 8 December). Food chiefly used was round herring fillets, *Etrumeus teres*, but also sardine, anchovy and Pacific saury, *Cololabis saira* once in the morning of each day until feeding was stopped, when several consecutive prey items were ignored. Uneaten food and the rejected portions of food were removed from the tank and weighed to assess the ration individually. Rations of each animal were daily recorded through the whole experiment.

A series of daily feeding rates (DFRn) for each live individual during the 38 or 39-day feeding experiment was calculated as follows:

$$DFRn = Rn/Wn, \text{ and } Wn = Wi + (Wf - Wi)/t \times Tn$$

where Rn (g) and Wn (g) are the ration and the estimated body weight of each date (Tn) from the initial day of this experiment, respectively, Wi (g) is the initial body weight, Wf (g) is the final body weight, and t is the time interval in days.

Daily feeding rate (DFR), daily growth rate in body weight (DGRW) and daily growth rate in mantle length (DGRL) for live individuals over a 16 days period were calculated as indicated by O'Dor *et al.* (1980) and Yoshida and Sakurai (1984):

$$DFR = R/[(Wf + Wi)/2] \times (100/t)$$
$$DGRW = (Wf - Wi)/[(Wf + Wi)/2] \times (100/t)$$
$$DGRL = (Lf - Li)/[(Lf + Li)/2] \times (100/t)$$

where R (g) is the ration ingested by each individual, Li (mm) is the initial mantle length, and Lf (mm) is the final mantle length.

Results

Maximum feeding experiment

Estimates of maximum feeding rate for single food-intake and total daily feeding rate were obtained by the 4-day experiment with two feeding groups; the group fed three times daily during the first two days and the group fed twice daily during the last two days (Table 1). In the group fed three times

Table 1. Summary of experiments on the maximum feeding rate of *T. pacificus* on a diet of fish fillets twice or three times daily, 8–12, August 1990*

Feeding pattern	First feeding rate		Second feeding rate		Third feeding rate		Total daily feeding rate	
	N	mean ± S.D. (range, %)	N	mean ± S.D. (range, %)	N	mean ± S.D. (range, %)	N	mean ± S.D. (range, %)
Squid fed three times/day								
Only first	6	7.02 ± 3.42 (4.29–18.92)					6	7.02 ± 3.42 (4.29–18.92)
Only second			1	6.79			1	6.79
Only third					8	6.54 ± 3.30 (3.09–13.73)	8	6.54 ± 3.30 (3.09–13.73)
First-third	12	7.33 ± 2.58 (3.31–12.02)			12	6.35 ± 2.43 (4.01–11.69)	12	13.32 ± 4.00 (7.34–20.52)
First-second	4	5.49 ± 2.95 (3.51–9.84)	4	6.07 ± 1.52 (4.41–7.52)			4	11.56 ± 3.76 (8.97–17.02)
Squid fed twice/day								
Only first	17	6.37 ± 1.44 (4.02–9.02)					17	6.07 ± 1.44 (4.07–9.02)
Only second			8	6.44 ± 1.18 (4.56–8.36)			8	6.44;-1.18 (4.56–8.36)
First-second	21	5.71 ± 1.61 (2.17–8.99)	21	5.64 ± 1.73 (2.68–9.89)			21	11.35 ± 2.75 (7.45–17.90)

* Body weights ranged from 141 to 413g. Feeding time: squid fed three times /day (10:00, 13:00, 15:00), fed twice /day (10:00, 15:00)

daily, 31 cases were observed that ingested once or twice, animals which ate only once were 48% in total, and squid ingesting at all feeding opportunities did not occur. Their mean feeding rates ranged from 6.5 to 7.0%. The maximum feeding rate observed in this experiment was 36.9g of food ingested by a 195g animal, which was 18.9% of the body weight. In animals that ate twice out of three times daily, the first-second feeding was done by 4 animals (12.9% in total), the first-third feeding was done by 12 animals (38.7%) whereas the second-third feeding did not occur. When the feeding interval is longer than the first-third feeding interval, squids feeding twice tend to increase in number. In the group fed twice daily at an interval of 5h, 46 cases were observed that ingested once or twice daily, the squid which ate only once represented 54.3% in total and their mean feeding rates were 6.37 and 6.44%, respectively. Whereas, mean feeding rates for the first and second ingestion of squids ate twice daily were 5.71 and 5.64% less than that of squids fed once daily, respectively. The maximum feeding rate observed in this experiment was 26.1g of food ingested by a 263.8g animal, or 9.89% of the body weight.

In the group fed three times daily, the mean of total daily feeding rates were 11.6% of the first-

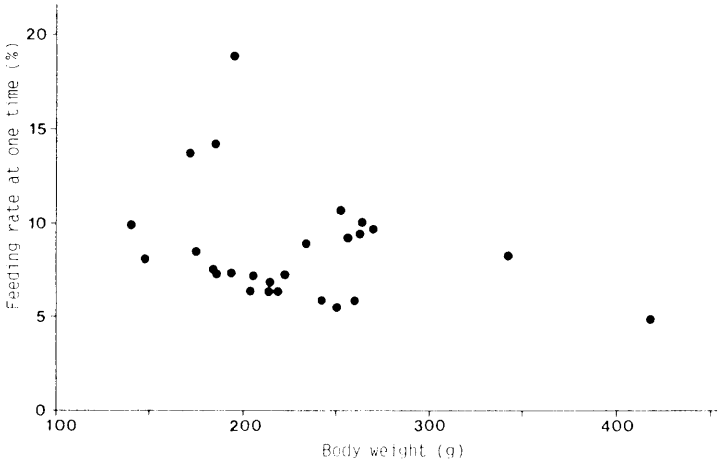

Fig. 1. Relationship of maximum feeding rate for single food-intake to estimated weight in each squid for weights ranging from 141 to 413g during the 4-day experiment from 8 to 12 August, 1990.

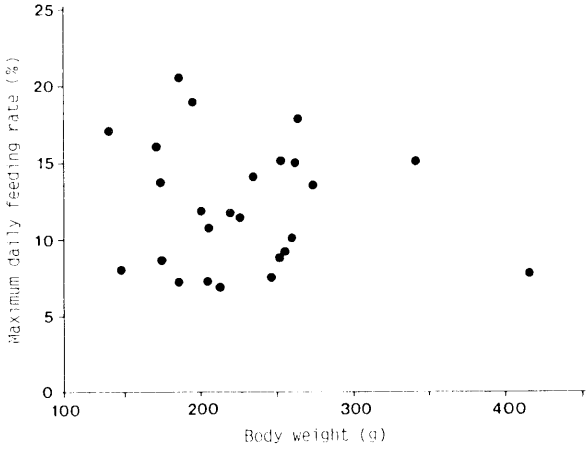

Fig. 2. Relationship of maximum daily feeding rate to estimated body weight in each squid for weights ranging from 141 to 413g during the 4-day experiment from 8 to 12 August, 1990.

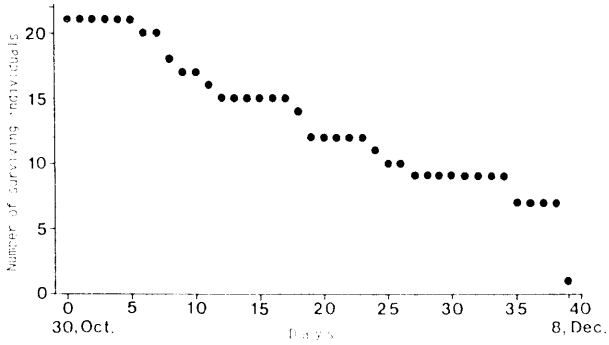

Fig. 3. Number of surviving individuals during the 39-day experiment on the feeding and growth of adult squid from 30 October to 8 December, 1990.

second feeding and 13.3% of the first-third feeding. Further, in the groups fed twice daily, the mean of total daily feeding rate was 11.4%. Total daily feeding rate of the group that ate twice daily was less than twice that of the group that fed only once. The maximum daily feeding rate observed in the whole experiment was 38.2g of food ingested by a 186g animal, or 20.5% of the body weight; the first feeding rate was 8.8% and the third feeding rate was 11.7%.

The relationship of maximum feeding rate per ingestion to estimated body weight of each animal for weighing 141 to 413g during the 4-day experiment was shown in Fig. 1. Maximum feeding rates show a tendency to decrease with increasing body weight, but the linear relationship is not clear ($N = 27$, $r = -0.27$, $0.1 < \alpha < 0.2$). The relationship of maximum total daily feeding rate to estimated body weight for each squid is shown in Fig. 2. These rates ranged within 20.5% and the relationship between total daily feeding rate and body length is not clear.

Feeding and growth

The number of survivals of the 39-day experiment from 30 October to 8 December is shown in Fig. 3; 7 animals survived to 38 or 39 days at the end of this experiment. The cause of death of animals during the experiment can be derived from skin damage, which is mainly represented by injury of the top part of the fin due to the dashing against the sides of the tank, and of the body surface damaged by mating actions of ripe males.

Although 7 animals survived during the 38 or 39-day feeding experiment, one animal could not be measured for the lack of the top of the fin. Therefore, a series of daily feeding rates for individual squid, daily growth rate of body weight and mantle length, daily feeding rate, and conversion rate were calculated for each of six live squid until the end of the experiment (Fig. 4 and Table 2). A series of daily feeding rates (DFRn) for six live squid is shown in Fig. 4. DFRn varied from 0 to 13.4% as a percentage of body weight, and the maximum feeding rate observed was 57.2g of food ingested by a 426g animal, or 13.4% of the body weight. Two days indicated by the dotted line in Fig. 4 represent the date of animals starved for another experiment on the digestive process, which is not included in this result.

The values of each individual in daily growth rate of body weight and mantle length, the daily feeding rate and conversion rate calculated by growth of weight (g)/food (g) for six live squid are summurised in Table 2. In these squid, the maximum growth of weight and length were 141g of a 552g squid (final weight), and 23 mm of a 269 mm animal (final length), respectively. In addition, the maximum mean daily ration was 17.9g ingested by a 552g animal (final weight). The daily growth increments of body weight, mantle length and daily rations ranged from 1.68 to 3.62g (mean 2.33g), 0.18 to 0.61 mm (mean 0.40 mm) and 10.1 to 17.9g (mean 12.5g), respectively. Furthermore, the daily growth rates of weight, length, daily feeding rates, and food conversion rates ranged from 0.42 to 0.81% (mean 0.62%), 0.07 to 0.24% (mean 0.16%), 2.60 to 3.72% (mean 3.25%) and 14.53 to 24.2% (mean 18.80%), respectively. Although the daily feeding rates were lower compared with the maximum feeding experiment done during a 4-days period, increments of both body weight and body length were significant.

An empirical linear equation for 14 live individuals, in which 8 animals kept over a 16 days period

were added to 6 live squid kept over 38 days, was established based on the relationship between daily feeding rate (DFR) and daily growth rate of weight (DGRW) at a mean temperature of 15.6°C (Fig. 5). This feeding and growth relationship is described by the equation:

$$DGRW = 0.39\ DFR - 0.66\ (N = 14,\ r^2 = 0.763)$$

The relation fits in 232 to 271 mm and 246 to 411g animals at initial length and weight, and in 237 to 290 mm and 262 to 602g squid at final length and weight. As indicated in Fig. 5, daily growth rate of weight is a linear function of daily feeding rate. This growth and feeding relationship makes it possible to calculate the maintenance ration (DGRW = 0) and conversion efficiency for about 250–600g adult squid. The maintenance ration at 15.6°C is 1.67% of body weight per day and conversion efficiancy is 39%. However, the weight loss (DFR = 0) obtained from starved squid could not be calculated because all 14 individuals had ingested food although two squid indicated no weight gain for the lower ration.

The daily growth rate of length (DGRL) plotted against DFR for 14 individual squid is shown in Fig. 6. No relationship between DGRL and DFR was described by a linear equation, but the increments of length were recognized for squid that ingested more than 2.3% of body weight.

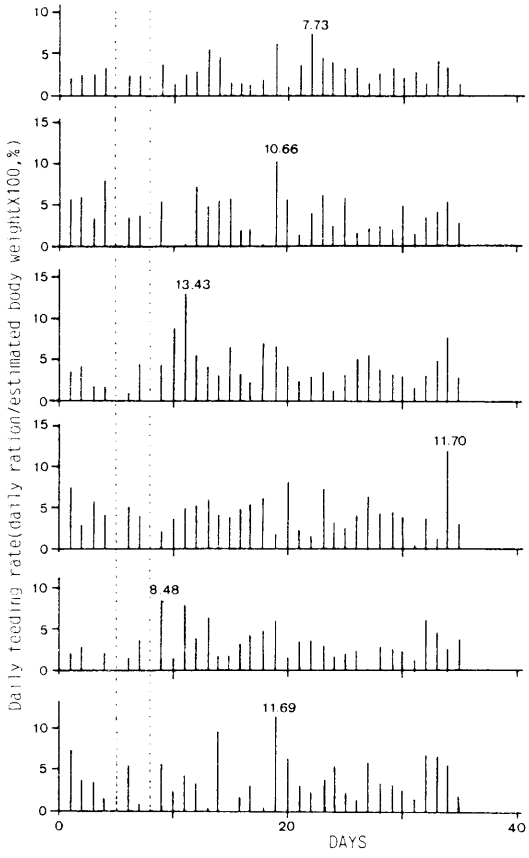

Fig. 4. A series of daily feeding rates (DFRn) for six live squid during the 38- or 39-days period. Dotted lines denote the starving date for a different experiment. Each column indicates a squid identified by thin vinyl color ribbon tag and figures represent the maximum daily feeding rate in each squid. DFRn = Rn/Wn, and Wn = Wi + (Wf − Wi)/t × Tn, where Rn (g): ration at each date, Wn (g): estimated body weight at each date, Tn: date from the initial day of this experiment, Wi (g): initial body weight, Wf (g): final body weight.

Table 2. Summary of feeding and growth for six live squid during the 38- or 39-day feeding experiment.

Squid identifid by tag	TR	TRY	TYY	TGB	MB	MRR	
Days	38	38	39	38	38	38	Mean
Sex	♀	♂	♀	♂	♂	♂	
Initial body weight (g)	257	398	411	246	388	338	339.7
Final body weight (g)	350	488	552	324	456	402	428.6
Increment of weight (g)	93	90	141	78	68	64	89.0
Daily increment of weight (g/day)	2.45	2.37	3.62	2.05	1.79	1.68	2.33
Daily growth rate of weight (%)	0.81	0.53	0.75	0.72	0.42	0.46	0.62
Initial mantle length (mm)	234	246	263	231	255	242	245.2
Final mantle length (mm)	250	269	270	243	270	260	260.3
Increament of length (mm)	16	23	7	12	15	18	15.2
Daily increment of length (mm/day)	0.42	0.61	0.18	0.32	0.39	0.47	0.40
Daily growth rate of length (%)	0.17	0.24	0.07	0.13	0.15	0.19	0.16
Total ration (g)	384.2	619.8	698.1	368.2	417.6	389.9	479.6
Mean daily ration (g)	10.11	16.31	17.90	9.69	10.99	10.26	12.54
Daily feeding rate (%)	3.33	3.68	3.72	3.40	2.60	2.77	3.25
Food coversion rate (%)	24.2	14.53	20.22	21.16	16.29	16.37	18.80

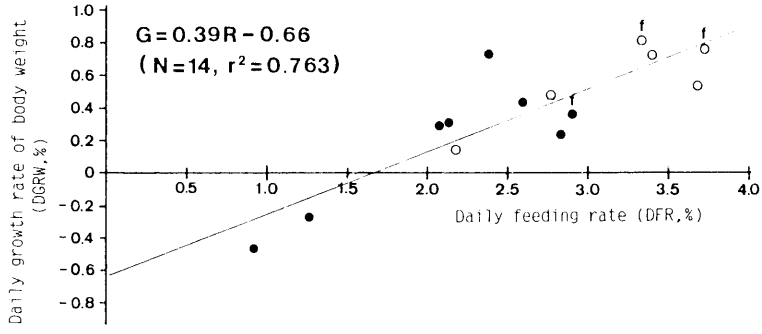

Fig. 5. Relationship between daily growth rate of weight (DGRW) and daily feeding rate (DFR) for 14 live squid over a 16 days period on fish fillets at a mean temperature of 15.6°. Solid and open circles denote the values of 8 live squid for 16 days and 6 live squid during the 38- or 39-day experiment, respectively. The letter f above circle represents female. Range of initial body size: 232 to 271 mm in mantle length and 246 to 411g in weight, range of final body size: 237 to 290 mm in mantle length and 262 to 602g in weight.

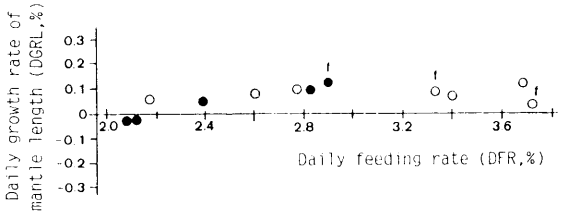

Fig. 6. Relationship between daily growth rate of mantle length (DGRL) and daily feeding rate (DFR) for 14 live squid over a 16 days period.

Discussion

Maintenance and handling of T. pacificus

In the past, long term maintenance of *T. pacificus* was difficult because of some problems including the handling methods for both collection and transport of live squid from the field to the laboratory. Miklich and Kozak (1971) maintained juveniles and adults of *T. pacificus* in aquaria for up to 35 days. In Japan, Flores *et al.* (1977) kept adult squid fed with pieces of shrimp and sardine fillet for up to 50 days, and Soichi (1976) maintained young squid fed on juvenile mullet, *Mugil cephalus* and sliced anchovy for up to 59 days in the aquarium. Recently, Sakurai (1987) reported the longest rearing record of this adult squid for 82 days in the aquarium and the total period of exhibition was 160 days a year, from July to December, when the squid were available.

More recently, we have established a raceway tank (Yang *et al.*, 1983) for the maintenance and breeding experiments of *T. pacificus* at the Usujiri Fisheries Labortory, Faculty of Fisheries, Hokkaido University, starting in 1988. Using this raceway tank, the maturation process and mating behavior (Sakurai *et al.*, 1990), and the validation of daily increments in statoliths of *T. pacificus* (Nakamura and Sakurai, 1990, 1991) have been reported. In the maintenance of this species, we paid attention to the handling of live squid as follows. The squid are scooped out of the sea together with a certain volume of water, and placed in individual plastic bags, then transferred to a tank on a truck. To avoid stress they are never taken out of the water. In the truck tank a maximum of 100 adult animals per ton of water are carried. As described in this report, we also paid attention to water quality, light condition and acclimation from live food such as small fish fillets and similar items. However, surviving individuals were gradually decreasing in number during these maintenance periods. The cause of death of animals mainly stems from skin damage, and these injured squid did not take food and finally died. On the contrary, cannibalism as intraspecific competition (O'Dor *et al.*, 1980) was not observed during this experiment. This phenomenon probably indicates that number of the individuals was relatively small compared to the holding capacity of the tank (12,000ℓ), their body sizes were similar and food provided every day.

For anesthetizing live squids, 3% urethane in seawater for *Illex illecebrosus* (O'Dor *et al.*, 1977, 1980) and a solution of 1.0 to 1.5% ethanol in seawater for loliginid squids (Hanlon *et al.*, 1983) have been used. In these anesthetic procedures for body size measurement and tagging, recovery from anesthesia takes some time; *e.g.* four to five minutes for recovery from light urethane anesthesia in *Illex illecebrosus* (O'Dor *et al.*, 1977) and 30 to 180 seconds until squids resume swimming in loliginid squids (Hanlon *et al.*, 1983). On the contrary, *T. pacificus* after a cold anesthesia immediately recovered and swam off while sinking to the bottom and no squids died from this handling. An anesthetic effect by directly immersing squids into cold seawater of 0 to 3°C has never been reported. We consider that this anesthesia by cold seawaer acts in depressing the active metabolism and stopping the respiratory movement of the mantle muscles in very a short time.

Maximum feeding

Maximum feeding experiments with *T. pacificus* in captivity show that mean feeding rate for single food-intake was about 5 to 7% in spite of multiple feeding opportunities, and maximum feeding rate per one time and maximum daily feeding rate in excess of 20% of body weight was very rarely observed. Moreover, when the interval between first and third feeding (5h) is longer, multiple feeding tends to increase. Okutani (1983) indicated that the food of this species varies somewhat by locality, but esentially is composed of planktonic crustaceans (such as euphausiids, *Themisto* sp., etc), fish (Myctophidae, sardines and other small species) and squid. As to daily ration and feeding times, Okiyama (1965) showed that the ration increases with growth and is 5 to 10% of body weight at its peak, and feeding activity is highest at about twilight, and decreases towards dawn. On the other hand, Hamabe and Shimizu (1966) reported that food organisms of adult squid change from planktonic organisms in young squid to fish and squid, feeding rate decreases with growth, stomach contents weight per body weight of adult animal is lower than that of young squid and varies within about 16%. They also showed that adult squids feed on demersal fish during the day at the sea bottom, but during the night they migrate to the pelagic zone and occurrence of starved adult and cannibalism then increases. Although food organisms and feeding times differ somewhat by body size, season and locality, daily feeding rates derived from our results in captivity are consistent with those observed in natural populations of adult squids. In the near future, we must examine the digestive process and maximum feeding rate for different food types such as euphausiids and squids to improve the analysis of population dynamics of *T.*

pacificus.

Feeding and growth

In *T. pacificus*, no reliable information has been available from which to estimate food conversion rate and growth efficiency (Okutani, 1983). On the contrary, O'Dor *et al.* (1980) and Hirtle *et al.* (1981) reported on feeding and growth of *Illex illecebrosus* with different food types, body sizes and water temperatures, which were examined in detail in a school of squid as a whole and in individuals, and they calculated the daily ration for maintenance and conversion rate and other variables.

Our method allows to examine the feeding and growth relationship of captive *T. pacificus*, which are identified individually and measured in term of initial body size by cold anesthesia. However, we did not examine feeding and growth at different body sizes, prey items and water temperatures. Our results show that adult squid within a certain body size range, when *T. pacificus* has slowly grown while maturing exhibit both sexes a linear relationship between daily growth and daily food intake. Nishiyama and Hamaoka (1989) reported on the caloric equivarence of summer growth increments for *T. pacificus* in the Japan Sea. They estimated that mean daily increments of mantle length and body weight of a 25 cm ML and 337g female during August were 0.3 mm and 0.9g, respectively. This body size was similar to that of our experiment of feeding and growth, but our results of increments of length and weight were 0.4 mm and 2.33g, respectively, so the increment of weight in captivity was more than twice as large as that observed in a natural population, but increments of length were very similar.

Given the lack of information on food conversion rate and conversion efficiecy of *T. pacificus*, we compared our data with those of *Illex illecebrosus* by O'Dor *et al.* (1980) and Hirtle *et al.* (1981) using the same fish diet and same water temperature of about 15°C. In *T. pacificus*, daily feeding rate (DFR), daily growth rate of weight (DFRW) and conversion efficiency of a 340g mean weight squid were 3.3%, 0.6% and 39%, respectively. On the contrary, in *I. illecebrosus* DFR, DFRW and conversion efficiency of a 232g weight animal were 6.7%, 1.9% and 35%, respectively, so conversion efficiency was very similar in both species. Also, daily feeding rate for maintenance of *T. pacificus* was 1.7%, which was consistent with that of 1.8% of *Illex*. However, DFR and DFRW of *T. pacificus* are significantly lower than those of *Illex*. It is considered that differences of body weights used in the experiments were reflected, because *Illex* is in the active growth period compared with the slow growth period of *Todarodes*.

O'Dor *et al.* (1980) indicated that estimated weight loss by starvation as well as daily feeding rate for maintenance are needed if predictions of growth or feeding rates in natural populations are to be made since such populations are feeding well below *ad libitum* rates. We could not obtain data on starvation. In addition, we need to examine the relationship between high feeding rate for daily multiple feeding and growth. Further, we must include in our study other food items like zooplankton and squid, different body sizes and water temperatures.

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