LIFE CYCLE OF THREE CULTURED GENERATIONS OF SPINELESS CUTTLEFISH, *SEPIELLA INERMIS* (FÉRUSSAC & D'ORBIGNY, 1848)

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ABSTRACT

Spineless cuttlefish, *Sepiella inermis*, was cultured through three generations from F1 to F3. Eggs were deposited as single eggs, round in shape and black in colour. The incubation period was 12.6 days at 28 °C. Hatchlings were planktonic in contrast to benthic hatchlings of other sepiid cuttlefish. Mantle length was 0.43 cm and body weight 0.04 g. Hatchlings fed on live mysids and postlarvae of penaeid shrimp. They changed into benthic form after 5 days of age and entered the juvenile stage. The spineless cuttlefish were sexually mature after 60 days and mating was observed after 70 days of age. Daily growth rate was 2.43 % in mantle length and 5.54 % in body weight. The overall growth was not different among the three generations. Spawning occurred at the age of 87 days, and about 500 eggs were laid by one female. The average life span was 116 days due to mortality of both sex after spawning. Largest final size was 7.86 cm mantle length, and 63.78 g body weight. Maximum life span was 149 days.

INTRODUCTION

Spineless cuttlefish is the only species of the family Sepiidae occurring in estuarine areas in shallow depths to about 20 m. In Thai waters, it is mostly captured by small scale fishing gear. The name „spineless" comes from the unique character of the cuttlebone which is without spine at the tip. There is an anal gland and pore at the posterior tip of the mantle. The function of this gland is unknown but Nabhitabhata & Polkhan (1983) observed release of brown fluid from anal pore after abrupt change to low salinity.

Aquaculture has been studied on laboratory scale (Boonprakob *et al.* 1977) and large scale (Nabhitabhata *et al.* 1984, 1985). However, the small final size seems to be disadvantageous to aquaculture interests because an optimum size of 200 g is necessary for frozen product processing and packaging. The high tolerance to variation of environmental conditions makes the spineless cuttlefish biologically interesting but little is known about the behaviour and life cycle of the species. This study describes culture through three generations.

MATERIALS AND METHODS

Spawners of spineless cuttlefish were collected live from push net operated near shore and in Bang Pa-kong estuary. The cuttlefish were transported to the hatchery and kept in a 2 m^3 concrete tank at a male to female ratio of 1:2. They mated and spawned in the tank, attaching their egg capsules in clusters to nylon net used as artificial substratum. Eggs were collected, aerated, and left to hatch in plastic baskets of 0.2 cm mesh size. Temperature was controlled by means of a water flow-through method at a rate of 1 l min^{-1}. Light was reduced with camouflaging net to prevent algal growth. Ongrowth was conducted in 2 m^3 concrete tanks. Hatchlings were fed live mysids (*Mesopodopsis* spp.) and the postlarvae of penaeid shrimp (*Penaeus merguiensis*). After 20 days, the cuttlefish were trained to feed on dead fish meat (*Caranx leptolepis*). Size grading and water level adjustment were performed every 10 days for suitable management of feed. The density per tank had to be reduced 25 % after each grading. Growth was determined every 10 days in terms of gain in dorsal mantle length (ML, cm) and wet body weight (W, g). Daily growth (%) was calculated in terms of mantle length and weight according to Choe (1966 *in* Mangold 1983):

$$DGRL = (ML_2 - ML_1)/t[(ML_2 + ML_1)/2] \times 100$$

and

$$DGRW = (W_2 - W_1)/t[(W_2 + W_1)/2] \times 100$$

- where DGRL was daily growth rate in terms of mantle length (%), DGRW daily growth rate in terms of body weight (%), ML_1 initial mantle length (cm), ML_2 final mantle length (cm), W_1 initial weight (g), W_2 final weight (g), and t was numbers of days (10 days period).

Gross feed conversion efficiency (%) was calculated from the amount of feed and body weight gain:

$$GFCE = (W_2 - W_1)/F \times 100$$

- where GFCE was gross feed conversion efficiency (%), and F was total feed consumed on wet weight basis (g).

Growth in terms of length-weight relationship was determined by a logarithmic equation; weight-age relationship by an exponential equation in the early growth phase, and a logarithmic equation in the following phase:

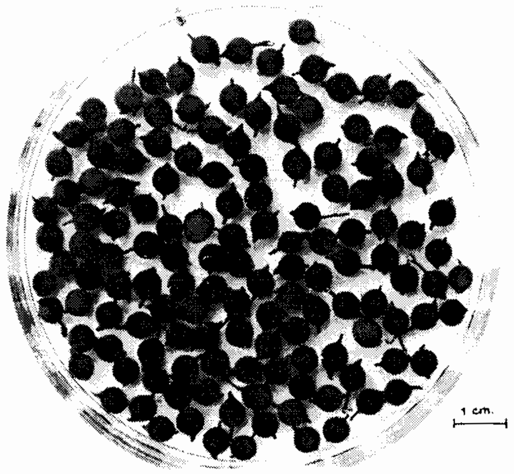
$$W = a_1 ML^{b_1}$$

$$W = a_2 e^{b_2 T}$$

$$\text{and } W = a_3 T^{b_3}$$

- where a was the constant elevation, b the slope, T the age (days).

Aspects of biohistory were studied by observation and recorded as drawings, still photos, and video. Preference behaviour and growth in different environments were studied according to Nabhitabhata & Polkhan (1983).



Figgure 1. Egg capsules of the spineless cuttlefish.

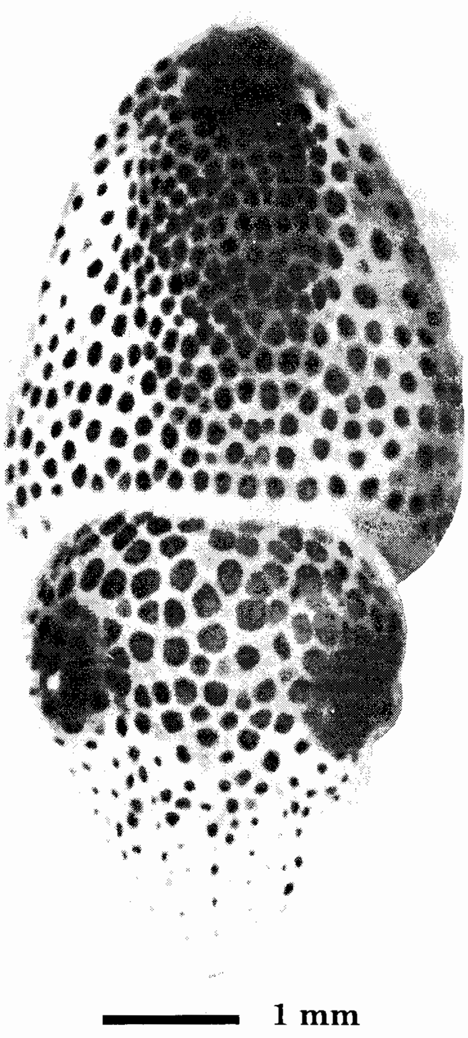
RESULTS

Eggs and incubation

The egg capsule of spineless cuttlefish was single and attached in clusters to underwater substratum. The capsule was black in colour, opaque, round in shape with tip and stalk (Fig. 1.) In the egg cluster, the egg stalks were twined to the substratum (*e.g.*, net, tree branch, sea fan) and also to each other at the outer side of the cluster. White colour egg capsules were also observed as a result of abnormal coating without ink. Differently coloured capsules did not affect the embryonic development. White capsules mostly revealed that the female was not healthy and was likely to give weak offspring. The egg capsule turned larger and more transparent and reached its largest size near the time of hatching.

The incubation period was 8-19 days, on an average 12.6 ± 4.1 days, at about 28 °C. Hatching mostly occurred at night and hatching rate was normally more than 90 % in the hatchery. Hatching rate might be lowered because of unfertilised eggs, abnormal embryonic development (about 1-2 %), growth of algae and fungi on egg capsules which interfere with transfer of oxygen. Brief change of temperature and salinity and mechanical stimuli caused premature hatching, and resulted in unhealthy hatchlings.

Hatchling and juvenile
Hatchlings of spineless cuttlefish were planktonic which is unique compared to benthic forms of other sepiid cuttlefish (Fig. 2). They hatched out with external yolk sac of smaller size than their own head. The yolk sac separated the first day after hatching. They swam hovering at an angle of 60-80° to the floor. Chromatophores functioned, and their normal colour pattern was dark brown,



Figgure 2. Hatchling of the spineless cuttlefish.

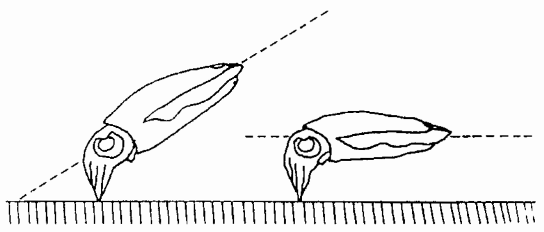


Figure 3. Diagram showing "hold" behaviour of young spineless cuttlefish.

white or transparent with a dark red spot marking the anal gland at the posterior tip of dorsum. The size of the anal gland was comparatively large, its diameter more than 10 % of the mantle length.

At 3 days of age, hatchlings dived to the floor and entered into the benthic juvenile stage. The young cuttlefish „held" on to the floor, using the tip of arms. They touched the floor while head and mantle still hovered at an angle of 20-30° to the floor (Fig. 3). The colour pattern was dark brown with dark red anal gland. After 5 days of age, the young completely turned into benthic forms, lying on the floor. At this age, the cuttlefish did not burrow into the substratum, but preferred lying under shelter. The tentacles began to function. The arms were comparatively short but strong enough to catch prey twice of the mantle length in size. Prey organisms were seized and bitten at the joint between carapace and abdomen. Only the flesh of prey was eaten. Hard structures were left on the bottom. Up to 10 days of age the daily feeding rate of hatchling was 19.80 % body weight, and feed conversion efficiency 60.61 %.

Adult colour pattern and behaviour
The normal colour pattern of the cuttlefish turned darker after 20 days of age and after 60 days the colour pattern allowed sex recognition. Male colour pattern was dark brown with white and orange spots on dorsum along the inner side of fins. The mantle of male was more slender than of female and fins were wider and longer. Female colour pattern was dark brown, but lighter shade

Table 1. Growth of spineless cuttlefish, *Sepiella inermis*, in terms of dorsal mantle length (cm; average value of 6 batches).

Age	Mantle length	Length increment				Daily growth rate
days	cm	cm	cm/day	%	%/day	%
0	0.43	-	-	-	-	-
10	0.86	0.43	0.04	100.00	10.00	6.67
20	1.41	0.55	0.06	63.95	6.40	4.85
30	2.00	0.59	0.06	41.84	4.18	3.46
40	2.60	0.60	0.06	30.00	3.00	2.61
50	3.12	0.52	0.05	20.00	2.00	1.82
60	3.82	0.70	0.07	22.44	2.24	2.02
70	4.61	0.79	0.08	20.68	2.07	1.87
80	5.70	1.09	0.11	23.64	2.36	2.11
90	6.10	0.40	0.04	7.02	0.70	0.68
100	6.33	0.23	0.02	3.77	0.38	0.37
110	-	-	-	-	-	-
120	-	-	-	-	-	-
130	6.82	(0.49)	0.02	(7.74)	0.26	0.25
mean	-	0.59	0.06	33.33	3.05	2.43
S.E.	-	0.07	0.01	9.18	0.88	0.59

Table 2. Growth of spineless cuttlefish, *Sepiella inermis*, in terms of body weight (g; average value of 6 batches).

Age	Body weight	Weight increment				Daily growth rate
days	g	g	g/day	%	%/day	%
0	0.04	-	-	-	-	-
10	0.44	0.40	0.04	1000.00	100.00	16.67
20	1.12	0.68	0.07	154.54	15.45	8.72
30	1.84	0.72	0.07	64.29	6.43	4.86
40	3.46	1.62	0.16	68.04	8.80	6.11
50	5.63	2.17	0.22	62.72	6.27	4.77
60	9.96	4.33	0.43	76.91	7.69	5.56
70	17.67	7.71	0.77	77.41	7.74	5.58
80	29.26	11.59	1.16	65.59	6.56	4.94
90	36.62	7.36	0.74	25.15	2.52	2.23
100	40.22	3.60	0.36	9.83	0.98	0.94
110	-	-	-	-	-	-
120	-	-	-	-	-	-
130	48.21	(7.99)	0.27	(19.87)	0.66	0.60
mean	-	4.02	0.39	162.60	14.84	5.54
S.E.	-	1.19	0.11	93.87	8.61	1.33

than that of male, with smaller white spots and without orange spots. The mantle of female was wider and fins narrower and shorter than of male.

In strong current, the spineless cuttlefish hovered or „held on" to the floor in schools. Schooling behaviour was also exhibited in prey searching and enemy fleeing. The adult began to burrow in the substratum after 30 days of age. Burrowing behaviour was deeper in sand than in mud. Aggressive behaviour was prominent since cannibalism was found where feed was short in supply. Biting also occurred when cuttlefish were handled by man, and to other males in connection with sexual activity. Cuttlefish could seize and eat prey while hovering in the water column, as well as on the substratum. The prey was seized by using the tentacles and then transferred to the arms. In the culture tank, cuttlefish changed to use arms only in seizure of dead feed without the positioning step of feeding behaviour.

Growth

Highest growth rate of spineless cuttlefish was in the first ten days. Hatchlings of 0.43 cm mantle length and 0.04 g body weight grew to juvenile of 0.86 cm and 0.44 g (Tabs. 1, 2). During this period, the length increment was 100 % with a daily growth rate of 6.67 %. Weight increment was 1,000 % with a 16.67 % daily growth rate. Length increment was still higher than 20 % in every 10 days period, or more than 2 % day^{-1} after 10 to 80 days of age (5.70 cm). Weight increment was also higher than 50 %, corresponding to 5 % day^{-1} in the same period (to 29.26 g). Daily growth rate was more than 1.0 % in mantle length and more than 4.0 % in weight. Growth was lower during the mating and spawning period after 80 to 130 days of age. On average the overall length increment was 3.05 % day^{-1} and overall weight increment 14.84 % day^{-1}. Calculated for the whole life cycle, the daily average was 2.43 % length increment, and 5.54 % weight increment.

Table 3. Growth comparison of 3 generations of spineless cuttlefish. (Average value from 2 batches in each generation; no data was obtained from F1 after 40 days during mating and spawning of the cuttlefish).

	F1				F2				F3			
	Length (cm)		Weight (g)		Length (cm)		Weight (g)		Length (cm)		Weight (g)	
Age (days)	Average	Sd.	Average	Sd.	Average	Sd.	Average	Sd.	Average	Sd.	Average	Sd.
0	0.41^{a}	0.03	0.05^{d}	0.02	0.46^{b}	0.06	0.04^{d}	0.02	-	-	-	-
10	0.70^{a}	0.08	0.49^{d}	0.17	0.93^{b}	0.20	0.42^{d}	0.20	-	-	-	-
20	1.61^{a}	0.13	1.21^{d}	0.32	1.51^{a}	0.20	0.89^{e}	0.30	0.95^{b}	0.16	1.34^{d}	0:19
30	2.20^{a}	0.19	2.30^{d}	0.80	2.01^{b}	0.24	1.78^{e}	0.67	1.84^{c}	0.15	1.55^{e}	0.33
40	2.44^{a}	0.31	2.97^{d}	0.77	2.71^{b}	0.26	3.90^{e}	1.10	2.58^{ab}	0.47	3.36^{de}	1.28
50	-	-	-	-	3.27^{a}	0.36	6.74^{d}	2.68	3.06^{a}	0.31	5.12^{d}	1.43
60	-	-	-	-	4.17^{a}	0.67	12.44^{d}	4.97	3.72^{a}	0.38	9.27^{d}	2.44
70	-	-	-	-	4.59^{a}	0.56	17.62^{d}	4.03	4.63^{a}	0.31	17.74^{d}	4.13
80	-	-	-	-	5.90^{a}	0.55	33.71^{d}	7.34	5.34^{b}	0.43	21.63^{e}	4.23
90	-	-	-	-	6.26^{a}	0.71	39.30^{d}	12.11	5.68^{a}	0.60	29.93^{d}	8.45
100	-	-	-	-	6.50^{a}	0.82	40.51^{d}	11.43	5.99^{a}	0.46	40.34^{d}	13.03

The body size of F2 was larger than of F1 in terms of mantle length ($P<0.05$) but the weight was not different ($P>0.05$) from hatching to 10 days of age (Tab. 3). After 20 to 30 days of age, the size of F1 and F2 was larger than F3 in length, but F1 was larger than F2 in weight. After 30 days, the mantle length of F1 was larger than F2, and F2 larger than F3 ($P<0.05$) but the weights of F2 and F3 were not different ($P>0.05$). After 40 days, the size of F2 was largest and not different from F3 ($P>0.05$) and F3 was not different from F1 ($P>0.05$). After 50 days, the size was not different in F2 and F3 ($P>0.05$) except after 70 days of age where the size of F2 was larger ($P<0.05$).

Growth of the spineless cuttlefish was allometric after 30 days of age (mantle length 2.5 cm). The relationship between mantle length and weight (Fig. 4) was:

$$W = 0.24\ ML^{2.75}\ (n = 319,\ r^2 = 0.98)$$

The early growth phase of the cuttlefish from hatching to 20 days of age was (exponential model):

$$W = 0.05\ e^{0.17T}\ (r = 0.97)$$

The growth phase was logarithmic from 20 to 100 days of age and could be fitted by the equation:

$$W = (5.13 \times 10^{-4})\ T^{2.44}\ (r = 0.99)$$

The cuttlefish was sexually mature at the average size of 3.82 cm, 9.96 g (60 days) and mating and spawning at the size of 6.10 cm, 36.62 g (90 days). After 130 days of age, the mantle length averaged 6.82 cm and the

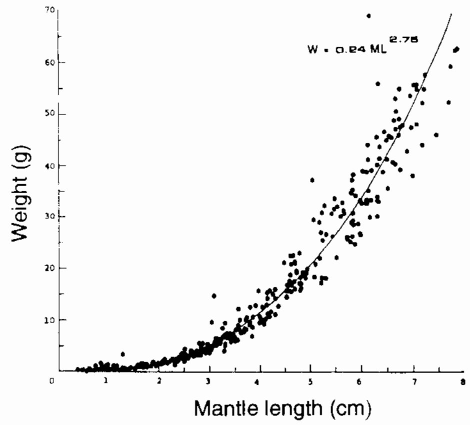


Figure 4. Mantle length-weight relationship of the spineless cuttlefish.

weight 48.21 g. Largest final size was 7.70 cm, 52.56 g in male (126 days) and 7.86 cm, 63.78 g in female (105 days).

Mating and spawning

Spineless cuttlefish began to form mating pairs from the age of 60 days, and first mating was observed after 70 days. The mature male selected his mate, displayed dark brown colour with white and orange spots on fin, raising the pair of dorsal arms (arms I) and spreading out the other pairs. The consented female displayed small white spots on the inner side of the fins. From this stage, the male escorted his mate swimming alongside all the time. Mating behavioural pattern began when the male swam above the female, the heads in the same direction. The male grasped his mate by the arms from above and then twisted to head-to-head position for copulation afterwards. Spermatophores were fixed to the buccal region of the female. Copulation lasted about 1-5 minutes each time. The male loosened the arms of female after that and continued to escort his mate. Mating occurred several times in one day, mostly at dawn and cloudy afternoon (dim light and shading). The male defended the female from other males. The defence began with aggressive swimming to the opponent with the arms spread out. The loser turned away. If this activity failed, the defence turned more violent. The male darted to the opponent, seized and then bit at the mantle side. The defence might also occur when other females tried to attach eggs at the same site as his mate, but not as serious.

Spawning took place after 79-96 days of age, on average 87.0±5.4 days. Females preferred a branch-like substratum for attachment of eggs. Spawning occurred in the same period of the day as mating. Pilot eggs with pale black colour might be laid first in order to test the substratum. One female could spawn 1-5 times depending on the number of egg spawned each time. The total number averaged 500 eggs. Any interruption during spawning would pause the process for at least 24 hrs. The healthy female spawned dark black egg capsules and the paler the colour, the weaker the female. White egg capsules were observed from weak females. The female did not feed during spawning but she would feed between each time of spawning. She did not look after her eggs after spawning. Healthy males might turn to other females after the last spawning.

Mortality

The life span of spineless cuttlefish was tied to reproduction due to death after spawning. The age of females was 85-145 days, average 115.1±15.0 days, and the age of males was 84 - 149 days, average 117.0±20.9 days. The average age of both sexes was 116.2±18.5 days or about 2 weeks after spawning.

In the environment of aquaculture, mortality also occurred from cannibalism and disease. Cannibalism was sparked by lack of feed and different sizes of cuttlefish. Infection by bacteria caused mantle and fin rot, and dead tissue of mantle (losing transparency). Infection by protozoa, *Cryptocaryon* sp., on gills and mantle caused abnormal respiratory movement, jerked swimming near water surface and gradual death in the school within 2-3 days.

Ecology

Survival and growth of the cuttlefish was highest at 28 and 32 ‰ salinity. They could survive for at least 60 days in 24 and 36 ‰. (Fig. 5). In 20 ‰, they could survive for 20 days. They displayed highest weight increment in that period, before they died. Apart from low salinity, the cuttlefish could tolerate highly turbid water in earthen ponds at a density of 6.1 ind. m^{-2}. The optimum density of hatchling was 500 ind. m^{-2}, and 250 ind. m^{-2} after 10 and 20 days of age respectively.

DISCUSSION

The pharaoh cuttlefish *Sepia pharaonis* is normally benthic and always lies on, or burrows into the substratum. The spineless cuttlefish may hover in the water column like a pelagic cephalopod, *e.g.*, big fin squid *Sepioteuthis lessoniana* (Nahibtabnata 1978 a), or dwell on the bottom like its relatives. It is more active than other sepiid cuttlefish but a less selective feeder than the big fin squid. In culture tank, the spineless cuttlefish could be trained to accept dead feed faster than the big fin squid. The spineless cuttlefish feed on fish meat after 20 days of age at a mantle length of only 1.41 cm. The behaviour is aggressive to a higher degree than seen in pharaoh cuttlefish. The spineless cuttlefish bite individuals in the same school, as well as humans, when handled. The pharaoh cuttlefish was never found to behave like this (Nahibtabnata 1978 b). However, because of the benthic-pelagic habit, the spineless cuttlefish required less individual space or territory than big fin squid of the same size, and could be cultured at a higher density.

The planktonic life of hatchling is a unique character since the life mode of most young cephalopods largely correspond to that of the adult (Boletzky 1977). Boletzky (1977) also reported that a distinct difference between the post-hatching (planktonic) and the adult (benthic) mode of life exists in two families: in the Idiosepiidae and in many species of Octopodidae. This study adds a third family

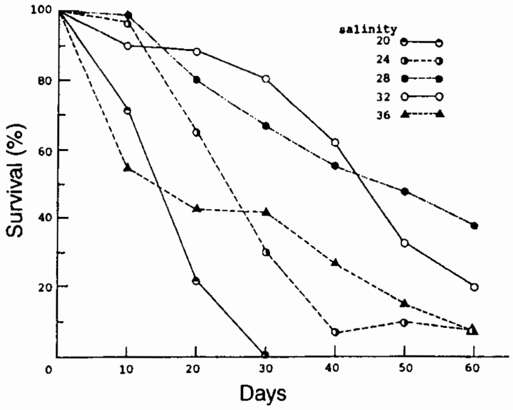


Figure 5. Survival of the spineless cuttlefish at various salinity levels.

Table 4. Growth comparison of spineless cuttlefish from hatching to 100 days of age, from two studies.

	Boonprakob *et al.* (1977)		This study	
Age (days)	Mantle length (cm)	Weight (g)	Mantle length (cm)	Weight (g)
0	0.33	0.02	0.43	0.04
10	0.56	0.08	0.86	0.44
20	0.95	0.31	1.41	1.12
30	1.87	1.60	2.00	1.84
40	2.61	3.28	2.60	2.86
50	3.21	6.62	3.12	5.63
60	4.01	11.54	3.82	9.96
70	5.12	23.33	4.61	17.67
80	5.52	26.76	5.70	29.26
90	6.13	45.15	6.10	36.62
100	6.95	61.75	6.33	40.22

to the list, the Sepiidae with the genus *Sepiella*. The „hold" or „perch" behaviour is also unique and not found in pharaoh cuttlefish.

The overall daily growth rate of 5.54 % in weight of the spineless cuttlefish was nearly as high as the 6.36 % of the big fin squid (Nabhitabhata 1996). In the first 10-days, the daily growth of the cuttlefish was 16.67 % in weight compared to 17.29 % of the big fin squid, but the feed conversion efficiency of the spineless cuttlefish was 60.61 % (Nabhitabhata *et al.* 1996) which was 8.51 % higher than the 52.10 % of the big fin squid, and 12.39 % higher than the 48.22 % of the pharaoh cuttlefish.

Boonprakob *et al.* (1977) reported lower growth of reared spineless cuttlefish (Tab. 4) in the first month (0-30 days) and higher growth in the later period. The difference might be caused by different density. Boonprakob *et al.* (*op. cit.*) conducted their laboratory study at a lower density (100 ind. m^{-2} after hatching). They fed their individually reared cuttlefish with penaeid shrimp in the grow-out period (after 30 days) in contrast to the fish meat used in this study. The former tended to be higher in nutritive value (Messenger 1977). The fish meat was used in this study in order to reduce the cost of production for future commercial purpose. Considering the growth and feed of the cuttlefish reported in the two studies, lower density might cause less competition in feeding and higher nutritive value of feed, may result in better growth during the grow-out phase. A higher density in the nursing phase might promote feeding owing to schooling habit.

The growth difference among the three generations of the cuttlefish in the first month was probably due to a slight difference in size of hatchlings and the amount of feeding. But, the growth of spineless cuttlefish was not different in F1 to F2, hence inbreeding did not show its effect on growth, at least not in 3 generations. The indifferent growth could provide a reliable supply of domesticated spawners for aquaculture (3 generations in 12 months). However, there is an unknown risk that culture through generations could result in inbreeding. Therefore, it would be better to obtain mating pairs from different populations (cultured or wild) in order to avoid potential decrease of growth due to inbreeding. From a seed-releasing point of view, this matter should be considered in order to maintain genetic variation of natural populations.

The cultured spineless cuttlefish of this study changed their normal behaviour to use only arms to seize their prey instead of using the tentacles. Tang & Khoo (1974) reported the same change and thought it was a sign of weakness. In this study the change in behaviour occurred after the spineless cuttlefish were accustomed to the feeding and culture conditions (human appearance with feed, tank environment). Another reason for the change in behaviour might be that there is less motion of dead feed compared to live feed. It was unnecessary for the spineless cuttlefish to use rapid and energy consuming motion like stretching out the tentacles. This kind of behavioural change was also found in the cultured pharaoh cuttlefish (Nabhitabhata 1978 b).

Based on inspection of testis and ovary, Boonprakob *et al.* (1977) stated that the spineless cuttlefish was sexually mature after 70 days in male and 80 days in female. Spawning was observed after 98.7 days of age. In this study, the age at maturity occurred after 60 days, and spawning after 87 days, that is about 10 days earlier. The life span of the spineless cuttlefish in this study, was about one week longer in males (117.0 to 109.7 days) and almost equal in females (114.6 to 115.1 days), and the maximum life span was about 10 days longer (149 to 138 days). However, both studies found larger size of females than of males in terms of length and weight. The body weight of females increased 1.7 fold after 60-70 days, and 0.7 fold in males during the same period because of development of the reproductive system.

Chotiyaputta (1981) also reported larger size of female from a natural stock. Average size of female was 5.57 cm, 39.04 g, and 4.94 cm, 28.11 g of male. From the cultured stock of this study, the average size of female was 6.05 cm, 35.37 g, and 5.19 cm, 25.46 g of male after 80 days. The smallest specimen reported by Chotiyaputta (1981) was 2.9 cm in length, and the largest was 9.6 cm. The smallest comparable size was 2.6-3.1 cm mantle length after 40-50 days in this study. The largest size was comparable to 9.63 cm after 100 days of age in this study. The age of specimens of Chotiyaputta (1981) should be 40 days to at least 100 days based on growth in culture of this study.

The b value of the length-weight relationship obtained from this study was 2.75 compared to 2.36-2.39 obtained by Chotiyaputta (1981) from natural stock. In this study, the model would be best fit for mantle length of more than 2.0 cm (about 30 days of age; in the logarithmic growth phase) which was a little lower than 2.9 cm the smallest of the natural stock specimens. There was no significant difference between sex in b value of the natural stock model.

Van Heukelem (1978, 1979 *in* Mangold 1987) summarised a number of environmental factors leading to early spawning at a small size in species of octopus: 1) restricted feeding; 2) short day length; 3) low light intensity and; 4) high temperature. A short day length delayed maturation in *Illex illecebrosus* (O'Dor *et al.* 1977). Mangold & Froesch (1977) investigated the gonad weight/body weight of *Octopus vulgaris* from natural stock and suggested that the gonads developed relatively independently of external factors. On the other hand, animals held in captivity over a certain period of time had gonads larger than those from animals of the same size from natural waters (Mangold 1987). The impact of environmental factors on spineless cuttlefish remain to be studied in detail.

Silas *et al.* (1985) reported the life span of spineless cuttlefish to be 1.5-2 years with a maximum mantle length of 12.5 cm. The life span was six times longer and growth was approximately 4 fold slower than the result obtained from culture batches of this study. The present culture conditions tended to induce fast growth and early maturation. Possibly there is a difference in maturation, final size and longevity of life span between estuarine and open sea population of the spineless cuttlefish. Early maturation, smaller final size and shorter life span tend to occur in the estuarine population due to environmental stress. These characteristics might be present in the spineless cuttlefish of this study since offspring came from estuarine spawners.

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