Entry of Immature Cuttlefish *Sepia esculenta* into Basket Traps

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In the present study, trapping experiments and observations on the behavior of immature cuttlefish *Sepia esculenta* towards the traps were made under field and laboratory conditions. Trapping experiments clearly demonstrated the entry of immature cuttlefish into the basket traps. The entry rate was significantly higher in immature than in mature cuttlefish studied in the same laboratory conditions. When entering and leaving the trap, cuttlefish swam straight primarily with arms in front, thus suggesting their active movement. After entry, cuttlefish remained stationary at the bottom. Females stayed in the trap longer than 3 days, while males left within 3 days. The existence or the position of branches did not influence the entry of cuttlefish into the traps. These results may rule out the possibility that spawning is a motivation for the entry of cuttlefish into the traps.

Key words: cuttlefish, basket trap, sexual maturation, behavior, catching process

Cuttlefish basket traps are often regarded as fishing gear which exploits only spawning cuttlefish as attributed by numerous cases of cuttlefish laying their eggs on the traps during spawning season.^{1–2)} However, such a phenomenon has not yet been scientifically proven.

Watanuki *et al.*³⁾ presented evidence from the catch analysis for *Sepia esculenta* in basket traps where a majority of the females caught at the start of the fishing season were sexually mature but not ready to spawn. Furthermore, minimal occurrences of immature females and solitary males were reported in trap catches. Thus, it seems unlikely that spawning is a motivation for the entry of cuttlefish into the traps.

To add to the knowledge of the catching process of basket traps, the present study was designed to evaluate the catching effectiveness of traps for immature cuttlefish. Observations on the behavior of immature cuttlefish around and within the commercial traps were made under field and laboratory conditions. Three different traps were used in the laboratory to test the effectiveness of the branches attached to the traps in attracting immature cuttlefish.

If the immature cuttlefish actively approach and enter into the basket traps, the results may disprove the basic assumption of traps catching only spawning cuttlefish.

Materials and Methods

Field Experiment

A trapping experiment and underwater observations of *Sepia esculenta* were carried out earlier than the spawning season on November 7–30, 1991, in Ariake Sound

(32°34'N, 130°25'E). Two types of commercial traps, foldable and cylindrical (Figs. 1 and 2), were placed on the sandy bottom 7 m deep at an interval of 4 m. An underwater TV camera (Hitachi-Zosen, Eye-Ball, 100 V AC) submerged between the traps was connected to a control box, a TV monitor, and a video tape recorder, set up on a floating pier of Kumamoto Prefectural Fisheries Research Center. Two 150 W halogen lamps were installed in the TV camera for night observation. The behavior of cuttlefish towards the traps was video-recorded throughout the experiment.

The cuttlefish that entered the trap were harvested after 3 to 4 days, identified by species, and dissected for gonadal studies. Sexual maturity was determined by naked-eye observations and gonad index (GI). The GI was calculated as follows:⁴⁾

$$\text{Female: GI} = \{ \text{Weight of oviduct and ovary (g)} / \text{DML}^3 \} \times 10^7$$

Fig. 1. Cylindrical trap used in the field experiment. A funnel-shaped entrance is attached during the experiment.

Fig. 2. Three types of foldable trap used in the laboratory experiments.

Male: $GI = \{ \text{Weight of testis, spermatophore gland and Needham's sac (g)} / \text{DML}^3 \} \times 10^7$

where DML is dorsal mantle length in mm.

Two observed females that had very small nidamental glands and small GI values of 1.33 and 1.75 were considered immature. Preliminary data suggested that the GI (mean $\pm$ standard deviation) of matured specimens collected from the spawning period, December 1990 to June 1991, was 54.63 ± 13.71 ($n=508$) for females and 40.08 ± 8.75 ($n=407$) for males.

Surface water temperature ranged from 17.9–19.7°C during the experiment.

Laboratory Experiment

S. esculenta (87 to 129 mm in DML) jigged on November 6, 1991, were used. A total of 30 cuttlefish of a 1:1 sex ratio were initially anchor-tagged on mantles for individual identifications. The tagged cuttlefish were introduced into a rectangular tank (5 $\times$ 3 $\times$ 1 m, 0.8 m water deep) with flowing seawater at 17.5–19.8°C. They were fed with sand crab *Hemigrapsus sanguineus* twice daily at 09:00 and 18:00 during the experiments. The original cuttlefish remained alive in good condition throughout the duration of the experiments. The gonadal studies made after the experiments showed that all the cuttlefish used were classified as immature. Females were found to have small transparent nidamental glands and poorly developed ovaries. Males had empty spermatophoric sacs and small translucent testis. The GI was 1.63 ± 0.56 for females and 3.72 ± 1.51 for males.

To examine the effectiveness of branches attached to the traps in attracting cuttlefish into the traps, a series of experiments was done; November 7–15, November 16–De-

cember 4, and December 4–8, 1991, by placing one or two foldable traps in a tank. Two of the traps were attached with branches of bush clover *Lespedeza* on both sides of the entrance (E-trap) or at the center of the trap (C-trap). The other one without attachment was used as a control (Fig. 2).

In the first trial, the E-trap was placed at the center of the tank at 16:00 on November 7. The trap was neither hauled nor emptied during the observation period. All activities of the cuttlefish near the trap entrance including the time of entry and exit were recorded with a video-camera (Victor, GR-S 55) fixed above the tank. The obtained records were examined through a TV monitor.

During the day time, natural light was introduced into the tank through the skylight of the laboratory. At night, the tank was illuminated with a 300 W halogen lamp hung approximately one meter high over the tank edge. Light intensity on the water surface was measured using a photometer (YU'FUNG-1065) every hour each day.

The E- and Control-traps (the second trial) and the E- and C-traps (the third trial) were placed on both short sides of the tank at 16:00 on the first day of each trial. Traps were kept in the tank continuously during the trials. The second trial tested whether the branches attached exteriorly would elicit the cuttlefish entry into the trap. The third trial tested whether the catch was increased by placing branches inside the trap. The number of cuttlefish in the traps was counted at 16:00 daily.

Results

Field Experiment

The TV camera covered an area within a 3 m radius and well produced distinct pictures day and night.

Two cuttlefish came into the camera sight during the observation period of 24 days. The first one (98 mm in DML) appeared in front of the entrance of the foldable trap at 20:03 on November 10, then, immediately, approached and entered the trap in a straight movement with arms in front. The second one (105 mm in DML) found at 15:20 on November 18 hovered before the foldable trap entrance for approximately five minutes and slowly entered the trap. After entry, both cuttlefish did not attempt to escape but stayed almost motionless at the bottom center for 3 to 4 days. No predator-prey related activities were observed between trapped cuttlefish and other fish.

Laboratory Experiment

In the first trial, 7 females and 9 males entered the trap. When entering the trap, cuttlefish were found consistently as solitary individuals and a majority (81%) swam straight and forward at approximately 5 cm/s. This behavioral pattern was similar to those observed in the field. Eight cuttlefish swam freely close to the bottom and entered the trap; five approached the trap then crawled into the trap; three slowly milled around the trap until the entrance was found. Many others were at the bottom surrounding outside the trap, keeping a distance of 5 to 20 cm. No mutual contact between individuals inside and outside the trap was observed.

Once inside the trap, cuttlefish spread out individually and either remained stationary at the bottom or moved rel-

Table 1. Number of immature cuttlefish in E-trap during the 8-day immersion (the first trial)

Set duration (days)	No. of cuttlefish in trap		
	Total	F	M
1	3	3	0
2	5	4	1
3	7	6	1
4	6	5	1
5	5	4	1
6	6	4	2
7	8	4	4
8	10	4	6
Total	50	34	16

actively slower than those outside. The number of remaining cuttlefish ranged from five to seven in the 2- to 6-day-submerged trap, but turned to an asymptote after 7 days (Table 1). Ten cuttlefish were observed as the highest catch in the 8-day-submerged trap. The sex ratio in the trap changed with increasing submerged time. A tendency towards a higher proportion of females in the first 7 days but biased toward males in the last day was observed. Males were always trapped with females.

Of the 16 cuttlefish that entered, 3 females and 3 males left the trap with arms foremost. All females stayed in the trap longer than 3 days with a maximum of 6 days, while males within 3 days. There was no re-entry of the same cuttlefish till the end of the experiment.

Entry and exit of cuttlefish occurred primarily (77%) during the night (17:00~07:00) at light intensity of $5 \times 10^0 \sim 5 \times 10^1$ lx. However, a smaller number of cuttlefish entered and exited the trap during daylight (07:00~17:00) at $4 \times 10^2 \sim 4.5 \times 10^3$ lx.

In the second trial, the total number of cuttlefish that appeared in E- and Control traps did not show a significant difference (95% confidence interval of the mean $\mu_{.95}$ was 2.69–3.43 for E-trap and 1.98–2.90 for Control trap). However, males occurred frequently in the E-trap ($\mu_{.95}$ for females 0.81–1.31, males 1.68–2.90), whereas females preferred the Control-trap ($\mu_{.95}$ for females 2.12–2.32, males 1.11–1.77) (Table 2). A higher proportion of males in the E-trap was contrary to the findings of the first trial with females dominating over males. Though there seemed to be an effect of the branches on trap catches for males, cuttlefish showed little or no interest in branches when entering the trap.

In the third trial, although more males chose the E-trap and more females, the C-trap, the differences were not statistically significant (Table 3). This indicated that the position of branches in both traps had the same effect in attracting cuttlefish.

The highest catch in traps (5 individuals) during the second and third trials was just half of that in the first trial, implying that catches were divided exactly evenly by two traps.

Discussion

The field and laboratory experiments demonstrated the entry of immature cuttlefish into the basket traps. Similar-

Table 2. Number of immature cuttlefish in E- and Control-traps during the 18-day immersion (the second trial)

Set duration (days)	No. of cuttlefish in trap					
	E-trap			Control-trap		
	Total	F	M	Total	F	M
1	5	2	3	5	3	2
2	3	1	2	3	2	1
3	3	2	1	2	1	1
4	3	1	2	2	1	1
5	4	1	3	2	1	1
6	2	1	1	2	1	1
7	3	1	2	3	2	1
8	2	1	1	2	1	1
9	2	1	1	3	1	2
10	4	1	3	3	2	1
11	3	1	2	3	2	1
12	3	1	2	3	1	2
13	3	1	2	2	2	0
14	3	1	2	3	1	2
15	4	2	2	3	2	1
16	2	0	2	1	0	1
17	3	1	2	1	1	0
18	3	0	3	1	1	0
Total	55	19	36	44	25	19
Mean $\mu_{.95}$	3.06 ± 0.370	1.06 ± 0.249	2.00 ± 0.318	2.44 ± 0.455	1.44 ± 0.326	1.06 ± 0.295

Table 3. Number of immature cuttlefish in E- and C-traps during the 4-day immersion (the third trial)

Set duration (days)	No. of cuttlefish in trap					
	E-trap			C-trap		
	Total	F	M	Total	F	M
1	2	0	2	0	0	0
2	5	1	4	3	2	1
3	3	1	2	4	4	0
4	4	2	2	5	4	1
Total	14	4	10	12	10	2
$\chi^2=2.571, df=1, p>0.05$ $\chi^2=2.667, df=1, p>0.05$						

ly, as to spawning⁵⁾ and feeding⁶⁾ behavior, most cuttlefish swam straight to the traps in the anterior visual field, indicating their active movements. This observation was supported by the statistical evidence where the entry rate for traps was higher in immature (53%) than that in sexually matured cuttlefish (30%) studied subsequently, March 10–18, 1993, in the same laboratory condition (Table 4). These results revealed conclusively that the cuttlefish would enter the traps voluntarily regardless of sex or maturation stage examined here. It is likely that the entry of cuttlefish to traps has no direct relationship with egg laying. On the commercial level, although trap fishermen only fished mature cuttlefish, this may be due to the absence of immature cuttlefish in sampling areas during their fishing which coincides the spawning season of cuttlefish.

The motivation causing cuttlefish to enter the traps is not clear. It is commonly believed by fishermen that cuttlefish are attracted more by traps baited with branches as spawning substrata than by those unbaited. Based on previous field observations, however, cuttlefish preferably laid

Table 4. Number of immature and mature cuttlefish that entered and exited the trap within the same experimental periods. Null hypothesis for proportion test: entry rates are the same between immature and mature cuttlefish

Maturity	Sex	No. of cuttlefish			Mean time of stay in trap	Differences in entry rate with mature
		used	entered	exited		
Immature	Female	15	7	3	82 h-17 m	0.42
	Male	15	9	3	27 h-41 m	2.46**
	Total	30	16	6	54 h-59 m	2.06**
Mature*	Female	10	4	1	95 h-20 m	
	Male	10	2	1	48 h-55 m	
	Total	20	6	2	72 h- 7 m	

* An experiment conducted on March 10-18, 1993, in the same laboratory condition as immatures.

** Significant at 5% level.

eggs at the branches placed outside the traps rather than inside.^{3,7)} It seems that the stimuli responsible for cuttlefish entry into the traps may be much different from those responsible for approaching the traps.

Comparison of catching effectiveness for the three different traps in the present study indicated that the position of branches did not influence the entry of immature cuttlefish into the traps. These findings, along with the nighttime entry, may rule out the possibility that cuttlefish enter traps for sheltering that hypothesized for *Cancer productus* in crab traps.⁸⁾ Cuttlefish are known to have concealment color patterns and an ability to bury in the sandy substrate.⁹⁾

Though the existence of branches was not evaluated to have an effect in attracting cuttlefish, males preferred the E-trap to the Control-trap, whereas females chose in the opposite. These results suggest that cuttlefish could visually distinguish between traps differing only in the presence of branches. Boulet¹⁰⁾ pointed out that the shape of an object is the most important factor in the determination of attacks on prey by *Sepia officinalis*. Further behavioral investigation of the cuttlefish preference for the trap shape is

necessary.

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