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HABITAT SELECTION AND INTER YEAR CLASS INTERACTION OF YOUNG COD (*Gadus morhua*) IN AQUARIA

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ABSTRACT

Gjøsæter, J. 1987. Habitat selection and inter year class interaction in young cod (*Gadus morhua*) in aquaria. Flødevigen rapportser. 1, 1987: 27-36.

Groups of five small (12 - 18 cm) cod were kept in aquaria with two compartments, one with sand and one with stones and algae. When alone, the small fish usually spent most of the time in the compartment with stones and algae. When one large cod (25 - 38 cm) was introduced, different constellations occurred. When the big fish stayed in one compartment for some time, the small ones usually stayed in the other one. When the big fish frequently moved between the compartments, the small fish preferred to stay in the compartment with algae where they often were hiding. In one experiment the big fish stayed hidden among the algae, and the small fish apparently were not affected by its presence.

Some small fish were eaten by the big fish during the experiments.

INTRODUCTION

Cod is a cannibalistic species, and in some areas a considerable proportion of the recruits are eaten during their first year of life (e.g. Daan 1973). The first year classes also to some extent share the same diet as the older fish, and are therefore potential competitors (see Gjøsæter (1986) for a recent review). In some areas the year classes are segregated by depth and other environmental factors (Riley and Parnell 1984), but there are also many examples where they have been caught together in beach seines (e.g. Tveite 1971) and in Danish seines

(Godø et al., in press). This does not, however, necessarily mean that they occur in the same habitats in these areas, as a beach seine will usually cover areas with different types of bottom. Therefore, it is not known to what extent they compete for food, or how important the predator-prey relationship is.

An analyses of cod caught in beach seine at the Norwegian Skagerrak coast has shown that there is no correlation between the number of 0-group and I-group found at a station (Gjøsæter and Danielssen in prep). This suggests that they are selecting different habitats.

One approach to the study of habitat selection is to keep fish in aquaria where they can choose between different habitats. By keeping different age groups together it can also be analysed how they react to each other and how they may modify each others habitat preferences.

This paper analyses how young cod distribute in an aquarium with two compartments, one with sandy bottom and one with stones and algae. These two bottom types were chosen as they are very common in the areas were the cod is found.

MATERIALS AND METHODS

The small fish (< 20 cm) used in the experiments were reared at Austevoll in a large outdoor basin (6x104 m3) during the summer of 1984, and brought to Flødevigen during the winter of 1984/85. At Flødevigen the fish were kept in large tanks (2500 l) until the experiments started in February 1985. In these stock tanks, the fish were fed a paste of minced fish and shrimps with vitamins added. The large fish used (> 20 cm) were caught at sea and kept in large tanks at Flødevigen for about a year before the experiments started. These fish were partly fed with the same paste as the small fish, and partly with pieces of mackerel.

The experimental setup is shown in Fig. 1. The experiments were carried out in an aquarium divided into two compartments each measuring 180 x 60 x 80 cm (length x width x height), with an opening 20 x 30 cm between them (Fig. 1). In one compartment

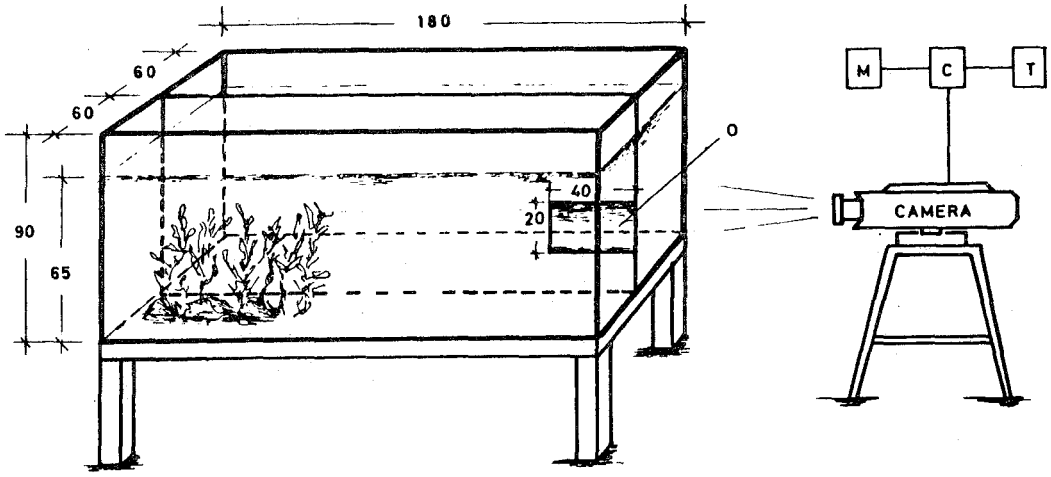

Fig. 1. The aquarium and observation system used in the experiments. M: monitor, C: control unit for video camera, T: video tape recorder, O: opening between compartments.

the bottom was covered with 1 - 2 cm of sand taken from the sea. The other compartment contained stones of 5 - 20 cm diameter with tufts of brown algae (mainly knotted wrack *Ascophyllum nodosum*) 20 to 40 cm high. The aquarium was kept in a separate room and observed using a video system. During working hours (0800 - 1545) observations were usually made once an hour. No systematic observations were made outside working hours. For each observation it was recorded in which compartment the fish were present and whether they were hidden among the algae or not. A fish was classified as hidden if it could not be seen on the video monitor. No observer was present in the aquarium room except when the fish were fed once a day. Food was given in both compartments, near the opening between them.

A 60 W bulb was placed over the center of each compartment of the aquarium, approximately 80 cm over the water surface. This light was automatically regulated to give cycles of 15 h light and 9 h darkness.

Four experiments were carried out as shown in Table 1.

Table 1

Experiments with habitat selection. Length of fish used in parenthesis

Exp	Part	Big fish	Small fish	Date
1	1	0	5 (13.5-15.5 cm)	8 - 13 Feb.
	2	1 (25 cm)	5	13 - 18 Feb.
	3	0	5	18 - 21 Feb.
2	1	0	5 (14 - 16 cm)	26 - 28 Feb.
	2	1 (30 cm)	5	28 Feb. - 1 March
	3	1	3-2	4 - 8 March
3	1	0	5 (12 - 18 cm)	15 - 19 March
	2	1 (38 cm)	5	19 - 22 March
	3	1	4	27 - 28 March
	4	0	4	1 - 2 April
4	1	0	5 (14 - 17 cm)	9 - 12 April
	2	1 (35 cm)	5	15 - 19 April
	3	0	5	23 - 26 April

RESULTS

Experiment 1

Part 1, small fish only.

Five I-group cod, 13.5 - 15.5 cm, were released in the compartment with sand in the experimental aquarium 8 February. The fish soon swam between the two compartments, and after three hrs and until a bigger fish was released five days later, they spent most of the time in the compartment with stones and algae (Table 2). After two days the fish started feeding.

Part 2, small and big fish.

A big fish (25 cm) was released in the compartment with sand. After some movements between the compartments during the first days it stayed in the compartment with algae (Table 2). In

Table 2

Number of observations and percentage distribution of fish in the aquarium

Exp. no.	%	No. obs.	Small fish Sand	Small fish Algae open	Small fish Algae hidden	Big fish Sand	Big fish Algae open	Big fish Algae hidden
1	1	16	10	90	1			
	2	26	35	62	4	8	35	57
	3	19	19	81	0			
2	1	29	30	70	0			
	2	19	5	68	26	58	42	0
	3	46	28	45	27	22	78	0
3	1	26	30	70	0			
	2	21	56	43	1	71	29	0
	3	10	0	33	68	100	0	0
	4	14	36	34	30			
4	1	26	69	31	0			
	2	41	6	90	4	100	0	0
	3	10	2	56	42			
Total		303	27	63	10	55	36	9

15 of 26 observations it was hidden among the algae. The big cod did not eat, while the small fish ate during this period too.

The small fish were more often in the compartment with sand when the big fish was present than when they were alone (Table 2). They were also significantly more often on the same side as the big fish when this was hidden than when it was active (Table 3). Aggressive behavior from the big fish were seldom observed, and the small seldom showed avoidance.

Table 3

Distribution of small fish when big fish is active and hidden

Compartment	Small fish in same compartment	Small fish other
Big fish active	22	33
Big fish hidden	57	18

Part 3, small fish only.

When the big fish was removed 18 February, the small cod were again more frequently found in the compartment with algae.

Experiment 2

Part 1, small fish only.

Five I-group cod, 14 - 16 cm, were released into the compartment with sand on 26 February. During the first day they moved much between the compartments, for the next two days they stayed mostly in the compartment with algae (Table 2). The fish started feeding after two days.

Part 2, small and big fish.

A big cod (30 cm) was released into the compartment with sand on 28 February. During the first days it spent most of the time in the compartment with sand (Table 2) but made frequent short visits into the compartment with algae. The small fish stayed mainly in the compartment with algae during this period, and were often hiding. However, the big fish was not observed attacking the small ones. Both the small and the big fish were feeding.

Part 3, small and big fish.

Between 1 and 4 March two of the small fish were eaten. The first day of this part of the experiment both the big and the small fish frequently moved between the compartments (Table 2). The small fish did not eat. Apparently they were frightened by the big one.

During the night between the 4 and 5 March the third fish was eaten. During the first part of the following day the big fish constantly stayed in the compartment with algae and the

small ones in the compartment with sand. All the fish took some food.

For the rest of this experiment the big fish moved constantly between the two compartments. The small fish, with very few exceptions stayed in the compartment with algae, and were often hidden. The big fish was feeding. The two small ones were obviously frightened, but one of them took some food.

Experiment 3

Part 1, small fish only.

Five I-group cod, 12 - 18 cm, were released into the compartment with sand on 15 March. The fish quickly found the opening between the two compartments, but stayed mainly in the compartment with algae during the whole period (Table 2). The fish started eating on the 18 March.

Part 2, small and big fish,

A big fish (38 cm) was released. It spent considerably more time in the compartment with sand (15 observations) than in the other compartment (6 observations). The small fish were observed 59 times in the compartment with sand and 46 times among the algae (Table 2). Although the big fish several times showed signs of aggression (rushing against the small fish), the small fish were apparently not frightened.

Part 3, small and big fish.

Between 22 and 27 March one small fish was eaten. The remaining small fish subsequently stayed in the compartment with algae, and they were usually hidden (Table 2). The big one stayed on the sand, but had some brief excursions into the compartment with algae. As it was always in the compartment with sand at the time when the observations were made, this is not recorded in Table 2. The big fish took food, while the small

ones did not. The small fish were obviously very frightened of the big one, and they quickly hid when it approached.

Part 4, small fish only.

After the big fish was removed on 28 March, the small fish partly came over to the compartment with sand, but still the majority stayed in the compartment with algae, and almost half of them were hiding (Table 2). They were still not feeding.

Experiment 4

Part 1, small fish only.

Five I-group fish, 14 - 17 cm, were released into the compartment with sand on 9 April. The first day the fish occurred equally in both compartments (Table 2). For the two following days they spent most of the time in the compartment with sand. Some of the fish took some food on the third day.

Part 2, small and big fish.

A 35 cm cod was released into the compartment with sand on 15 April. It stayed in the compartment with sand for the rest of the experimental period. It was observed that it took a few short excursions into the compartment with algae but it was never there when the position was recorded. It was clearly aggressive when one of the small fish came into the compartment with sand, and the small fish were observed among the algae about 94% of the time (Table 2). The big fish ate when fed, while the small ones did not eat much.

Part 3, small fish only.

During this period too, the small fish stayed in the compartment with algae, and partly hidden (Table 2). Two of the fish ate very actively during this period, the three others ate little or nothing.

DISCUSSION

Most of the small fish used in the experiments were less than one year old (0- and early I-group fish). Most of the big fish were between 1 and 2 years old, but some were probably three years old. All fish belonged to the size and age groups which are taken frequently in beach seines (e.g. Tveite 1972). When small fish were alone, they usually preferred the compartment with stones and algae (Exp. 1, 2 and 4). In the first parts of the experiments, before a big fish was introduced, the small fish were never hiding among the algae. When a big fish was introduced several different constellations occurred. In experiment one the big fish were hiding among the algae most of the time, and showed no signs of aggression, and the small fish apparently did not react much to the the presence of big one.

When the big fish stayed in the compartment with algae (parts of exp. 2) or in the compartment with sand (parts of exp. 3 and 4) the small fish generally stayed in the other compartment. If the big fish frequently moved between the compartments (parts of exp. 2 and 3) the small fish usually stayed in the compartment with algae, often hidden among the algae.

Therefore, it seems that the small fish generally try to avoid a habitat occupied by a bigger fish, or when that is not possible they stay where they can easily hide. In two of the four experiments one or two of the small fish were eaten by the big one. In three experiments clear signs of aggression from the big fish and fear from the small fish were observed, and for long periods this fear apparently prevented the small fish from eating. Apparently the fear was strengthened when one of the small fish had been eaten.

The environment in a small aquarium is very different from nature. The observation that small cod prefer a bottom with some vegetation fits well, however, with the conclusions based on cod samples from their natural habitats (Gjøsæter and Danielssen in prep.).

If the interaction suggested by the present experiments takes place in nature, it could be expected that in years with

many I-group cod in the littoral zone there should be 1) few O-group cod and 2) the 0-group should be small due to food competition, and because they may have to spend more time hiding and less time eating. Data from beach seines taken in the Risør-area on the Skagerrak coast from 1945 to 1985 (Tveite 1972, Gjøsæter and Danielssen in prep.) were analysed to reveal any correlation between number of 1-group cod and number or size of 0-group cod, but no significant correlation was observed. This suggests that although the mechanisms suggested above may be of importance, other factors are equally or more important in determining the number and size of 0-group cod in the littoral zone.

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