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SEXUAL EXPERIENCE IN COD (*Gadus morhua* L.) AND HADDOCK (*Melanogrammus aeglefinus* L.)

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ABSTRACT

In the last three years cod and haddock raised from eggs in the laboratory have spawned. Both species matured at an age of two years under laboratory conditions.

The preliminary results indicates that the females of both cod and haddock spawning for the first time had problems with releasing their eggs. If females managed to release their eggs, usually a very small proportion of eggs were fertilized. For older and wild matured haddock kept in the same type of tanks the proportion were much higher and stable. The egg size for the laboratory reared cod were smaller compared to the egg size of older cod. In reared first time spawners of haddock the egg size were close to the observed egg size of wild haddock.

INTRODUCTION

In 1976 cod in large numbers were for the first time successfully reared in the laboratory at Statens Biologiske Stasjon Fløddevigen, Arendal. Since then several groups of cod and two groups of haddock have been reared in laboratory. In 1978 the first group of reared cod matured and these fishes were stripped giving fertilized eggs producing another group of reared cod and in the following years spawning of reared cod tool place each year. It was, however, observed that reared female cod had problems with releasing their eggs in connection with their first spawning period. In one of the groups all of the mature females died during their first spawning period. It was also observed that the females could be helped through their first spawning period if they were stripped. The following spawnings seems to go better. The question arised, what kind of problems do reared cod have during their first spawning period. A pilot experiment was therefor made in 1983 in order to get more information of the rate of fertilization of the eggs, the volum and number of eggs spawned and the eggdiameter throughout the first spawning period of reared cod and haddock in the laboratory, compared to wild matured cod and haddock.

MATERIALS AND METHODS

Two groups of cod (group 1 and 2) and one group of haddock (group A) were raised in the laboratory. The third group of cod (group 3) was raised in an outdoor basin and transferred to the laboratory at an age of 4 months. They all hatched in separate tanks in April 1981 and from the first feeding stage till the age of 4 months the larvae were fed on natural zooplankton. At an age of 4 months the diet were changed to shrimps, krill, sprat and mackerel (stored frozen), added a vitamin mixture.

Up to an age of $2^{1}/2$ months the larvae were raised in black cylinders of 50 litre, then they were transferred to square tanks of 500 litre. From an age of 10 months the juveniles were kept in separate rectangular tanks of 2000 litre. The number and size of the matured fishes in each tank (and group) are given in

Table 1 and 2. At the time for spawning an egg collecting device were connected to each tank as shown in Fig. 1. The spawned egg were collected every morning from the egg collecting device and examined for fertilization, egg diameter and spawned volume of eggs. The egg volume of 1 ml were set to 400 eggs (MOKSNESS and RIIS-VESTERGÅRD 1982), both for the cod and the haddock. No attempts were made to sample possible dead eggs from the bottom of the tanks.

Two groups of wild haddock (group B and C, Table 2) kept in the same type of tanks, were fished with long line in the end of January 1983 and transferred to the laboratory. They were fed with the same kind of food as the reared cod and haddock.

During the spawning period a photoperiod were kept on 15 hours light and 9 hours dark with 30 min. dimmed light in the morning and in the evening. The light intensity were 100 lux during day-time and below 5 lux during the night. In the period from April 1981 to June 1983 the salinity were stable between 33.8 and 34.3^{o}/oo, while the temperature varied between 4^{o}C in April and 12^{o}C in September/January. During the period from February till June 1983 the temperature were kept between 4.8 and 5.8^{o}C.

In all groups the totale length (TL) were measured. The calculated number spawned by each female haddock were found by using the coefficient of fecundity (F) by RAITT (1933) for North Sea haddock: $F = 0.2032 \times TL^{3.84}$.

RESULTS

The length and number of fishes in the different groups varied as shown in Table 1 and 2. The mean length of the fishes in group 3, raised in an outdoor basin, were more than 7 cm longer than the cod in group 1 and 2, which had a mean total length from 37.2 to 40.2 cm. In the group of raised haddock (group A) the length varied between 27 to 29 cm, while the two groups of wild haddock the length in group B varied from 33.0 to 45.0 cm and in group C from 45.5 to 58 cm. The number of cod was highest

in group 2 with 32 fishes and lowest in group 1 with 19 fishes. In the three groups of haddock the number of fishes were 4 in group C, 8 in group A and 28 in group B. The mean number of eggs in one group of cod (group 1) and the three groups of haddock are also shown in Table 1 and 2. Each of the 10 females of cod in group 1 released a calculated mean number of 190 800 eggs, while the calculated mean number of eggs from haddock were 32 000 (group A), 92 800 (group B) and 774 800 (group C).

The overall mean egg diameter for the different groups of cod and haddock are shown in Table 4 and 5. In cod the mean egg diameter were as low as 1.15 and 1.19 mm in group 1 and 3 respectively, while in group 2 it was 1.31 mm. In the only group of reared haddock (group A) eggdiameter was 1.33 mm and in the two groups of wild haddock were 1.39 and 1.34 mm, group B and C respectively.

Fig. 2 shows the percentage of fertilized eggs in the three groups of raised cod. During the whole period from the beginning of March to the end of May the fertilization rate varied from 0 to 100 percent in all three groups. The results indicates an increase in the fertilization rate during March. The percentage of fertilization of eggs in the three groups of haddock are given in Fig. 3 and 4. While the fertilization rate was stable above 90 percent in group C, it varied between 0 to 90 percent in group A (Fig. 3). Also in the reared group of haddock (group A) the results indicates an increase in fertilization rate during the first part of March. In group B (Fig. 4) the fertilization rate varied between 30 to 100 percent. The density of haddock in group 8 were much higher than the density in the other groups of haddock, as given in Table 3. The density in the three groups of cod were also high, from 9.5 to 16 animals per m^3.

DISCUSSION

If any sexual "learning" in cod and haddock is necessary to get a high degree fo success during their first spawning period is not known. The three groups of raised cod and the one group of raised haddock (group A) had a rather high growth compared to

wild cod and haddock. The main reason for this growth might be better temperature and feeding conditions for the reared fishes. The reared cod and haddock matured at an age of 2 years at lengths from 30 to 51 cm and 27 and 29 cm, respectively. It has been reported that cod in the Norwegian Skagerrak Coast usually are matured at an age of 3 to 4 years or 35 to 45 cm (DANNEVIG 1954) and haddock in the North Sea are matured at an age of 3 to 5 years or 23 to 29 cm (THOMBSON 1924 and 1929) and in Norwegian coastal water at an age of 2 to 4 years or 28 to 32 cm (BLACKER 1971). The results shows that the raised cod and haddock do have the same length as the wild cod and haddock at first spawning, but the raised fishes got mature at least 1 or 2 years earlier than the wild ones. However, as Fernø, Univ. of Bergen (pers. comm.) remarks that even if the reared fishes had a better growth than the wild ones do not mean that they were fully developed with respect to hormone system or spawning behaviour. For example, if the sound making muscles in the reared males are not sufficiently developed at an age of two years, this might disturb the spawning. Males, both of cod and haddock make sounds in connection with spawning as described for haddock (HAWKINS et al. 1967 and HAWKINS and RASMUSSEN 1978) and for cod (BRAWN 1961). The sound making muscles are observed getting filled with blood during the spawning season and are easely seen in the males (P.T. HOGNESTAD, Statens Biologiske Stasjon Flødevigen, pers. comm.). No attempts were made during the experiments to observe the sound or observe if their drum muscles were fully developed.

It is known that temperature, salinity and photoperiod are important for the onset of spawning in fishes. Both observed temperature and salinity during the spawning period were within what have been observed for cod and haddock in the field (EGGVIN 1932 and SAVILLE 1956). The photoperiod and the light intensity in the experiment were constant during the experiment, while in the sea these parameters will vary with time and depth. However, it is difficult to see how these three parameters might have influenced in the egg diameter, fertilization rate and number of eggs released from the reared females.

The mean egg diameter (1.15, 1.19 and 1.31) of the released eggs in the three groups of raised cod were much lesser than observed in the field (1.38) on eggs from a spawning population of Arctic cod (SOLEMDAL and SUNDBY 1981). The egg diameter from the group of raised haddock were not significant different from the eggs of the wild haddock. However, it is assumed that the younger spawners do release smaller eggs than older spawners. The observed mean number of eggs spawned by each female haddock, 32 000, 92 800 and 774 800 in group A, B and C respectively, are low, except for group C, compared with a calculated mean number of 73 300, 291 100 and 819 100 eggs for the three groups respectively. It was observed in the three groups of cod, that when females were stripped, usually a lot of dead eggs came out first. If the females release their dead eggs, these will sink to the bottom of the tanks and thereby be undetectable. The observed fertilization rate of eggs from the reared cod and haddock (0-100%) were low compared to wild cod and haddock as observed in the spawning basin on cod (unpubl. data) and haddock (above 80%, MOKSNESS 1983) and in the same kind of tanks in the laboratory for haddock (above 90%, group C). A possible explanation for the variation in fertilation rate in the different experiments (group 1, 2, 3, A and B) might be the rather high denstity of fishes in these experiments (Table 3).

However, in wild fishes the first spawning, refering to Y. ESPMARK, Univ. of Trondheim (pers. comm.) seems to be that in species like cod and haddock the behaviour of reproduction are the most stable one, like the timing of schooling in herring.

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Table 1. The three groups of cod, with the number of fishes (N), the mean totale length ($T\bar{L}$) with standard deviation, minimum and maximum length and the mean number of eggs released of the females (#/♀)

Group	Sex	N	$T\bar{L}$ (cm)	SD	Min	Max	#/♀
1	♀	10	37.2	3.5	30.0	42.0	190 800
	♂	9	39.1	2.9	35.0	43.0	
2	♀/♂	32	40.2	3.7	34.0	48.0	
3	♀/♂	23	47.1	2.3	42.0	51.0	

Table 2. The three groups of haddock, with the number of fishes (N), the mean totale length ($T\bar{L}$) with standard deviation (SD), minimum (Min) and maximum (Max) length and the mean number of eggs released from each female (#/♀)

Group	Sex	N	$T\bar{L}$ (cm)	SD	Min	Max	#/♀
A	♀	4	28		27	29	32 000
	♂	4					
B	♀	15	40.1	4.3			92 800
	♂	13	39.2	3.7			
C	♀	3	52.5		45.5 46.0	58.0	774 800
	♂	1	60.0				

Table 3. The density of fishes per m^3 in the different experiments

Specie	Experiment	Density/m^3	
Cod	1	9.5	
	2	16.0	
	3	11.5	
Haddock	Spawning basin	2.2	Moksness 1983
	A	4.0	
	B	14.0	
	C	2.0	

Table 4. The mean eggdiameter ($\bar{x}$), with standard deviation (SD), minimum and maximum diameter observed from the cod experiments. N = number of egg measured

Group	N	Min	$\bar{x}$	Max	SD
1	1019	1.02	1.15	1.26	0.04
2	1390	1.13	1.31	1.44	0.04
3	1381	1.01	1.19	2.05	0.07

Table 5. The mean eggdiameter ($\bar{x}$), with standard deviation (SD), minimum and maximum diameter observed in the haddock experiments. N = number of egg measured

Group	N	Min	$\bar{x}$	Max	SD
A	556	1.16	1.33	1.53	0.06
B	829	1.28	1.39	1.51	0.04
C	2735	1.10	1.34	1.65	0.07

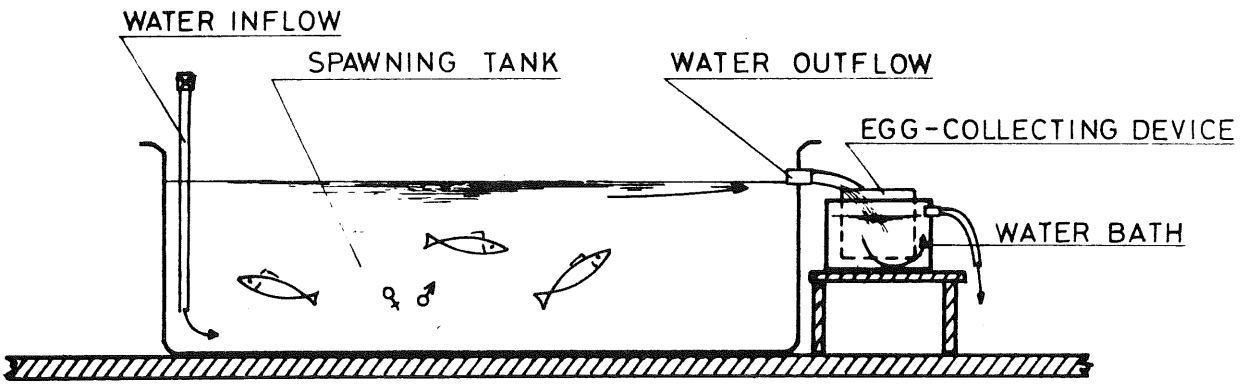

Fig. 1. Sketch of the spawning tanks

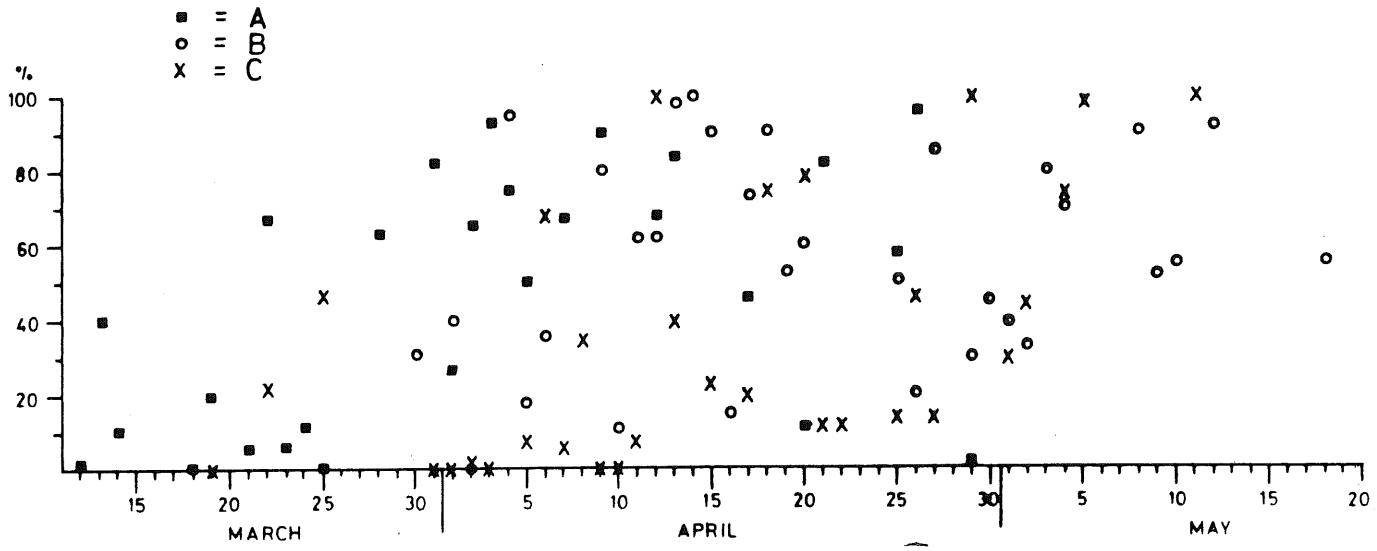

Fig. 2. The percent of fertilized eggs in three groups of first spawning female and male cod. A = group 1. B = group 2 and C = group 3

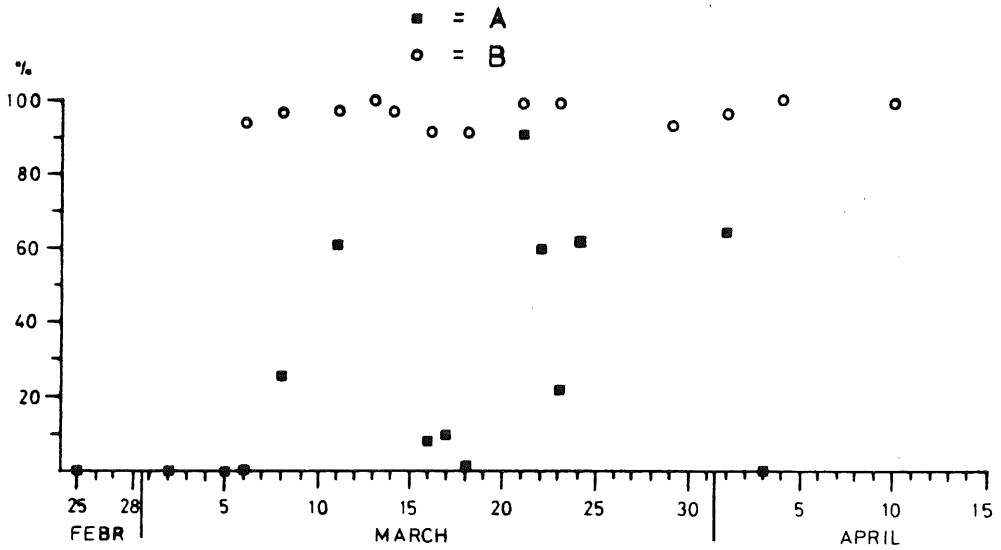

Fig. 3. The percent of fertilized eggs in (A) reared first spawning female (group A) and (B) wild haddock (group B)

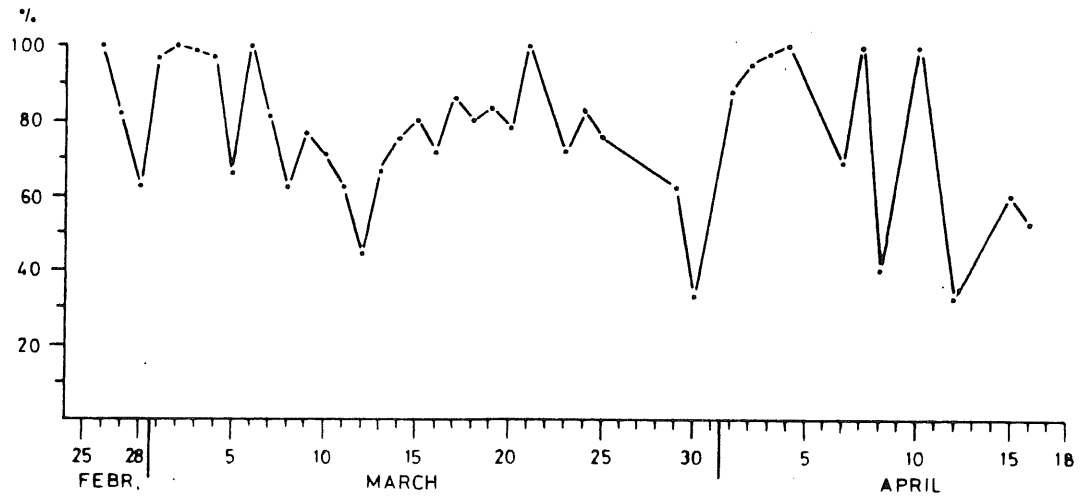

Fig. 4. The percent of fertilized eggs in group B of haddock