



BRIEF COMMUNICATION

Herring as cannibals

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Egg cannibalism near the sea bottom was observed in herring *Clupea harengus* at the end of the spawning season. About 10% of the individuals had consumed eggs and egg feeders were predominantly spent males.

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Herring *Clupea harengus* L. are unique among marine clupeoids in having demersal spawning (Blaxter & Hunter, 1982) and eggs may be deposited on the spawning grounds in large numbers (Høines *et al.*, 1995). Predation on herring eggs by gadoids is well documented (Torensen, 1991), and haddock *Melanogrammus aeglefinus* (L.), cod *Gadus morhua* L., saithe *Pollachius virens* (L.) and pollack *Pollachius pollachius* (L.) may abandon their normal diets during the herring spawning season, feeding exclusively on herring eggs (Høines *et al.*, 1995).

Cannibalism on larvae has been reported in herring (Fuiman, 1989; Laine *et al.*, 1997), and egg cannibalism is not uncommon in pelagically spawning clupeoids (Valdes *et al.*, 1987). Both feeding strategies can be combined with predator defence (Magurran, 1993). Cannibalism on eggs for a demersal spawner such as herring, however, is associated with high risk as the reduced number of escape routes and lower mobility make them vulnerable to predation on the sea bed (Axelsen *et al.*, 2000). Herring normally leave the spawning grounds shortly after spawning to resume feeding in other areas (Nøttestad *et al.*, 1996).

This study was conducted on a herring spawning ground (59°15' N; 05°07' E) off Karmøy in southern Norway, using the R/V 'Hans Brattstrøm'. Two herring samples were collected with gillnets (25 m long by 4 m high; mesh size: 37 mm when stretched with a 5 kg force) set on the sea bed overnight. The soak time was 11 h 45 min and 10 h 50 min for samples one and two, respectively. Both samples were obtained from the same location at the end of the spawning season (Johannessen *et al.*, 1995) on 2 April ($n=16$, all fish sampled) and 3 April, 2000 ($n=100$, subsample). Total length (L_T), wet mass (M), stomach content and gonadal mass (M_G) and maturity (scale: 1–8) (Anon., 1962) were determined. Two distinct groups of egg feeders were identified: individuals with one or two eggs in their stomachs (termed single-egg feeders), and individuals with many (>20) eggs in their stomachs (mass-egg feeders). The condition factor K was calculated as $K=100(M - M_G)L_T^{-3}$, where mass is in g and L_T is in cm. A remotely operated vehicle (ROV) equipped with five high-resolution video cameras was used to study deposited eggs, spawning substratum and bottom topography.

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Layers of fertilized eggs of up to 5 cm thickness were observed on the bottom, which for the most part consisted of stones and gravel, and some dispersed eggs were suspended above the bottom due to the current. Of the total of 116 herring, 12 had eggs in their stomachs: eight were single-egg feeders and four were mass-egg feeders (second sample: seven single-egg and three mass-egg feeders). The largest number of eggs recorded in a single stomach was 4320. Other food items, mainly copepods, were found in eight stomachs. The proportion of stomachs with other food items was higher among cannibals (six of 12) than among non-cannibals (two of 104) ($\chi^2_1=38.73$, $P<0.001$).

Cannibals were more abundant in spent (nine of 26) than in running or maturing individuals (three of 90) ($\chi^2_1=21.28$, $P<0.001$). There was no significant deviation from equal distribution between the sexes in the non-cannibal group (binominal distribution, $P=0.5$, $a>0.15$), but a marked overrepresentation of males in the cannibal group (11 of 12, $a<0.005$). No difference in L_T was found between non-cannibals and cannibals (two-sided t -test, non-cannibals *v.* single-egg feeders: $P=0.251$; mass-egg feeders: $P=0.566$; all cannibals: $P=0.545$).

Condition factor was higher for cannibals than for non-cannibals when isolated from gender related differences (two-way General Linear Model (GLM) ANOVA; $P=0.022$ for single-egg feeders and $P=0.054$ for mass-egg feeders). The effect of cannibalism on K could not be isolated as nine of 12 egg feeders were spent; spent herring have a higher somatic condition factor probably as a result of water uptake in muscle tissues as a compensation for the loss of water with spawning products (A. Slotte, unpubl. data).

In the present study it was found that herring may adopt egg cannibalism at the end of the spawning season. Some single-egg feeders may have taken in dispersed eggs passively, but the large numbers of eggs in the stomachs of mass-egg feeders are probably a result of active food intake close to the bottom. Cannibals had also consumed other types of food, suggesting that egg cannibalism is part of an opportunistic feeding strategy.

Eggs are abundant and easily accessible on the spawning grounds (Høines *et al.*, 1995), but feeding on the bottom is a high-risk strategy for herring (Axelsen *et al.*, 2000) as predators aggregate at the spawning grounds (Høines *et al.*, 1995). The prevalence of post-spawners among the egg cannibals is thus in agreement with other results showing that spent herring are more risk prone than maturing and running individuals and start feeding shortly after spawning (Stacey & Hourston, 1982; Nøttestad *et al.*, 1996). The reason for the prevalence of males among the egg feeders is less obvious. Little is known about gender related dimorphisms in herring spawning behaviour (Blaxter & Hunter, 1982) and differences in risk taking between males and females.

Stomach analyses are conducted routinely during herring spawning stock surveys, so why has egg cannibalism not been observed before? Cannibalism should only be expected if other food is scarce and if the predation pressure on egg feeders is relatively low (Axelsen *et al.*, 2000). Nevertheless, if common, cannibalism should have been reported earlier. Herring egg consumption may be part of a feeding strategy adopted by late spawners. Postponed spawning means less time for feeding before the winter, and egg cannibalism may be a way to compensate for the prolonged period without food.

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