RESTRICTED

International Commission for the Northwest Atlantic Fisheries

Serial No. 3293
(D.c.5)

ICNAF Res.Doc. 74/68

ANNUAL MEETING - JUNE 1974

A preliminary investigation of the food of larval herring from Georges Bank

by

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The alimentary tracts of larval sea herring (*Clupea harengus harengus* L.) from northeastern Georges Bank, between 41° 20' -- 42° 15' N and 66° 50' -- 67° 40' W, were examined as part of the continuing investigation of factors controlling larval survival and subsequent recruitment to the herring fishery. The specimens studied were collected from September 25 to October 6, 1970, during cruise 70-5 of *Albatross IV*. This cruise, a cooperative effort between the United States, Canada, and U.S.S.R., was designed partly to study the pelagic herring larvae in relationship to a known spawning bed and involved subsurface observations of herring egg beds with a submersible, *Pisces I* (Graham and Chenoweth, 1971).

The herring larvae were taken from 50 samples, each collected by a 20 cm diameter Bongo net with mesh aperture of .366 mm. This net, which was one of a pair of 20 cm Bongos, was towed at 5 knots in a step oblique mode: 5 minutes at 30 m depth (or 20 m in shallower water), then 5 minutes at 20 m, and finally 5 minutes at the surface. Depth of water at the plankton stations varied between 31 and 259 m. The stations were scattered throughout the sampling rectangle but were more concentrated over the spawning beds, approximately in the center of the rectangle. Most of the plankton samples were taken at night.

The fifty samples provided about 16,500 herring larvae, most of which were less than 9 mm in standard length. Approximately 83% of all the larvae were between 6 and 8 mm long and probably represented larvae up to about 10 days old. Their spatial distribution indicated that they originated from the spawning bed under study.

The larvae were examined under 10-30X magnification with a stereo microscope. The herring larva's food is passed to the posterior half of the gut as soon as it is swallowed (Blaxter, 1965). The food item can often be seen through the gut wall and, except for very small items such as copepod eggs, appears as a swollen vacuole or blister in the gut. The gut wall is stretched thin in this area, and many specimens were found with the food item in the process of rupturing directly outward through the gut wall. The dissected guts with their food items were glycerine-mounted on covered slides and examined under 100-400X magnification with a compound microscope.

Only a small fraction of the larvae, 166 larvae from 20 of the 50 samples, had guts containing food items. The percentage of larvae containing food in each of these 20 samples ranged from 1 to 50%, the average being only 3% In the remaining 30 samples all larvae had guts empty, severely damaged, or even completely torn away. Commonly one third or more of the larvae had lost their gut. Many larvae had undoubtedly lost their gut contents through rupture of the thin gut wall surrounding the food items.

If all intact larvae in the 50 samples are considered, the percentage containing food items would not have exceeded 5%. However, the fact that all samples with damaged larvae also contained no larvae with food in their gut is a strong indication that such samples do not provide a valid measure of the proportion feeding.

Even in the samples with undamaged specimens mechanical stress may be an important factor associated with the observed low percentage of larvae containing food items. Obviously, netted larvae are under great stress and possibly it is the rule rather than the exception that the gut contents are regurgitated or defecated when larvae are being caught or handled or, if still alive, even as they are being preserved. In this regard Rosenthal and Hempel (1970) have observed that some herring larvae in aquaria will suddenly defecate their gut contents upon being disturbed.

Other investigators have reported very low percentages of larvae with food in the gut (reviewed by Blaxter, 1965), and there are also indications that herring larvae reduce feeding at night. Half of the 20 samples with undamaged larvae was collected at night and the other half was collected during daylight. Approximately twice as many larvae were caught at night, but the numbers found containing food items were similar during both times of the day (Table 1). The overall percentage containing food items was 2.5% during the night and 5.0% during

Table 1. Numbers of Herring Larvae Containing Food Items in 20 Plankton Samples without Larval Damage

Day				Night			
Sample	With food items	Larvae examined	%	Sample	With food items	Larvae examined	%
1	1	2	.50	11	1	5	.20
2	1	3	.30	12	1	11	.09
3	1	4	.25	13	2	43	.05
4	1	12	.08	14	11	64	.17
5	2	18	.11	15	1	90	.01
6	6	27	.22	16	9	270	.03
7	5	32	.16	17	8	500	.02
8	9	280	.03	18	12	550	.02
9	26	320	.08	19	21	940	.02
10	26	860	.03	20	22	1050	.02
Totals	78	1558	.050		88	3523	.025

the day. While this difference may be significant, indicating reduced feeding at night, the day-night percentages among the larger samples of similar size are much more similar. The differences could have arisen from errors in sampling. Each sample in these day-night series was collected at a different location. It appears that stress during capture, rather than feeding behavior, is the main cause of the low incidence of gut contents.

Food items found in the larval herring were copepod eggs, copepod nauplii, copepod juveniles, adult copepods, and bivalve mollusc larvae. The adult copepods were Oithona, Paracalanus, and Pseudocalanus. The bivalve larvae were similar to those described by Stafford (1912) as Pecten magellanicus (Placopecten magellanicus, the sea scallop), having nearly equal shell length and depth; they did not appear similar to Stafford's figures of other common bivalve larvae (Mytilus, Ostrea, Venus, or Mya). The most common items were copepod eggs and bivalve larvae, with fewer copepod nauplii and juveniles, and still fewer adults of small copepods. The few food categories found probably reflected the relatively limited area sampled, duration of sampling (12 days), and lengths of larvae captured (5-18 mm; most 6-8 mm). Usually only one food category was found in any one herring larva, suggesting either food patchiness, or that once feeding had begun on one type of food it was continued for a time even if other categories were available. No fine-mesh-net zooplankton samples were examined to determine the relative natural abundance of the observed, as well as possible, food organisms.

The larval herring containing food items ranged in length from 6 to 16 mm. The length-frequency of these larvae as well as the numbers of larvae, at each size interval, found containing each of the different food items are shown in Table 2. The size of the food items ingested was related to the size of the herring larvae (Table 3).

The smallest food, copepod eggs (0.08 mm) was the only food item found in herring less than 6.5 mm; no copepod eggs were found in herring above 7.8 mm. Bivalve larvae (0.12-0.22 mm) and copepod nauplii (0.20-0.30 mm) were the next larger food items, and were found in herring of 6.5-15 mm and 6.9-16 mm, respectively. Still larger herring (7.2-16 mm) contained the moderate sized juvenile copepods (0.40-0.80 mm) and adult Oithona (0.90-1.10 mm), while the largest food items found in the samples, the adult copepods Paracalanus and Pseudocalanus (1.0-1.3 mm), were taken only from the largest herring larvae (10-16 mm). Very few larvae larger than 10 mm were caught, so that the upper size limit of the different food items was not seen, except for copepod eggs and possibly bivalve larvae.

The maximum size of food items ingested increased more rapidly with herring larva size than did the minimum size, particularly among larvae growing from 6 to 8 mm. Therefore the size range of the food items increased rapidly with larval size (Table 4). There appears to be a clear relationship between the minimum size of herring larvae (even within the narrow range sampled) and the average food item size that is taken.

Sherman and Honey (1971) studied the feeding of larval herring in the coastal waters of Maine. Of 96 larvae collected with a Gulf III sampler and a small trawl in daytime during autumn of the years 1965-68, 57.3% had been feeding. They did not report larval damage. Sherman and Honey did not find bivalve larvae. The autumn coastal samples of larvae contained only crustaceans, mostly copepods and their nauplii. The smallest larvae (7-10 mm) consumed the smallest food items. Larger larvae (up to 20 mm) ingested larger prey and a greater range of prey sizes, thus continuing to feed on small prey. The present study on Georges Bank larvae also shows an increasing average size and range of sizes of prey, as well as increased range of prey species taken, as the larvae grow. This development of an ability to feed on a greater range of food sizes is clearly advantageous to the larvae. Increased population stability results from a broadening of the food web. The importance of food particle size has been discussed by Parsons and LeBrasseur (1970) whose studies on the feeding of zooplankton indicate that energy rations are more efficiently obtained from larger food species.

Recommendations

In continued investigations on the food of larval herring, specimens might best be collected by short duration tows. Modifications in net design and methods of handling and fixing the larvae should be tried to reduce specimen damage. Laboratory experiments using well-fed larvae, subsequently netted and fixed, may suggest ways to obtain unbiased samples of larvae containing food. Concurrent studies of the complete zooplankton population, collected with fine meshed nets or pumps, will be needed to assess the relative abundance of selected and possible food items.

Trophic studies are a most important segment of investigations seeking to understand ecological processes. Studies to date indicate an opportunistic mode in the feeding behavior of larval fish. Future studies must increasingly seek to obtain measures of growth and survival of larval fish as affected by interactions between food production and/or availability and larval densities.

Table 2. Herring Larvae Lengths and Food Items

Herring Larvae Length(mm)	Herring Larvae Number	Numbers of larvae containing the following food items: Cope-pod eggs	Cope-pod nauplii	Juvenile copepods	Adult copepods: Pseudo-calanus	Adult copepods: Para-calanus	Adult copepods: Oithona	Bi-valve larvae
6.0	2	2						
6.2	1	1						
6.3	2	3						
6.4	3	3						
6.5	4	1						3
6.6	8	2						8
6.7	12	8						4
6.8	12	8						9
6.9	8	7	1					4
7.0	24	7	1					22
7.1	6	2	1					6
7.2	12	6		1			1	7
7.3	14	15						4
7.4	6	4		1				3
7.5	16	10		1				4
7.6	4	4					2	
7.8	10	10						5
8-10	3		5					1
10-12	5			3		1	3	1
12-15	9			7		4		1
15-16	5		1	3	1	1		
Totals	166	103	9	16	1	6	6	82

Table 3. Length Ranges of Herring Larvae Containing Food Items of Various Sizes.

Food Item	Food Size (mm)	Size Range (mm) of Herring Larvae Containing Items
Copepod eggs	.08	6.0 - 7.8
Bivalve Larvae	.12-.22	6.5 -15.0
Copepod Nauplii	.20-.30	6.9 -16.0
Copepod Juveniles	.40-.80	7.2 -16.0
Oithona	.90-1.10	7.2 -12.0
Paracalanus	1.00-1.20	10.0 -16.0
Pseudocalanus	1.30	15.0 -16.0

Table 4. Size Range of Food Items Ingested

Herring Larvae (minimum size, mm)	Size Range of Food Items (mm)
6.0	.08
6.5	.08 - .22
6.9	.08 - .30
7.2	.08 -1.10
10.0	.12 -1.20
15.0	.12 -1.30

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