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by A. P. Ivanov, E. V. Soldatova & M. B. Trushinskaya

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THE MIGRATORY CASPIAN HERRING

by A.P. Ivanov, E.V. Soldatova, M.B. Trushinskaya

The investigations on the migratory Caspian herring were directed towards obtaining fishbreeding information on adult herring, as well as the biological characteristics of young herring, which would facilitate the future working out of biological techniques for artificial breeding of this valuable commercial fish under conditions of a flight of hydroelectric stations and regulated water flow on the Volga River.

The following problems were included in the investigations: ascertaining the spawning periods of herring; determining the numerical ratios between males and females, including also the stage of maturity of their reproductive products; determining the age composition of herring schools; determining the diet of young herring; and the principal distinguishing marks which would serve to define members of different species.

These investigations were carried out in two stages: in June-July in the section of the Volga from Volgograd to Saratov, and in August in the Volgograd district, in the upper reach of the Volgograd hydroelectric station.

Adult herring were caught from a boat using a 200 metre drift net (mesh size 40 mm). From the individuals that were caught scales were taken to determine the age (according to the method of N.I. Chugunova, 1959) and the number of spawning rings; the length of the body was measured (the distance from the tip of the snout to the end of the median rays of the caudal fin); they were weighed and the stage of maturity of the reproductive products of the brood stock was determined (according to the scale of K.A. Kiselevich, 1923).

The young herring were caught from the dam of the Volgograd H.E.S. using a "spider" type net. The young herring caught were measured, weighed, the species was determined and the character of food ascertained.

Spawning Run, Sexual Composition  
and Stage of Maturity of Reproductive Products of Herring

The first few herring appeared at Volgograd at the end of May, but the intensive run of herring in this district began on the 8th of June and reached its maximum in the second half of June. After continuing for ten days in July the run began to weaken, and was finished by the first of August. The length of the spawning run was nine weeks. The total number of adult herring was moved in 1964 into the upper reach of the Volgograd H.E.S. and on to the district of Saratov was 885 thousand herring.

The analysis of the sexual composition of those schools of herring which migrate to spawn shows that in the catches the females predominated. Nonetheless their number increased every day as schools of later runs arrived. The number of females in the schools was 1.4 to 3.7 (on average 2.5) greater than males.

To determine the stage of maturity of the reproductive products of the adult herring for the purpose of determining their physiological preparedness to spawn, 505 individuals were analyzed. By far the greater number of males (70%) had mature reproductive products. The sperm of these males was running out freely at the slightest pressure on their bellies. But mature females were not observed among the individuals caught. Their reproductive products were in the IV and IV-V stages of maturity. Moreover no part of the roe was discharged from the ovaries and membranes.

Spawning of herring was not observed in the Saratov district in 1964. All their schools bypassed this district and went on to spawning grounds situated higher, where they spawned. On the other hand the possibility is not ruled out that some individual herring spawned in the reservoir before coming to the Saratov district.

In the lower reach of the Volgograd H.E.S., as was noted by V.V. Vogovskaya (1967), spawning was going on from the dam to Zam'yan (June-July), but was intensive in the section from Svetlyi Yar to Kamennyi Yar. Maximum spawning was noted on July 3rd at Svetlyi Yar at a water temperature of 20.4°C. On the lower stretches of the river (Streletskoe - Enotaevsk and Kopanovka - Chernyi Yar) spawning of herring was insignificant.

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#### Age and Size Composition of Adult Herring

The age composition of the adult herring caught in June was made up of fish of age 2+ and 3+ (2+ 61.1% and 3+ 38.9%). Observations in July-August showed that the number of 3+ fish in the herring schools increased, while some 4+ individuals were added.

For the whole spawning period of the run of herring schools in the spawning grounds above the Volgograd H.E.S. the following age composition of the brood stock was found (in %).

2+.....	27.5
3+.....	62.3
4+.....	10.2

The herring schools, therefore, consisted basically of adults of age 2+ and 3+, and their respective average lengths were 35 and 37.4 cm. The average length of herrings aged 4+ was equal to 41.4 cm. The bulk of the female herring were between the limits of 32-38 cm (Table 1). The males were shorter than the females: their main group consisted of individuals 28-36 cm long.

Table 1

The Average Linear Measurements of Adult Herring  
in the Area from Volgograd H.E.S. to Saratov

Length, cm,	Quantity of individuals (in %)	
	Females	Males
28-30	7,2	14,8
30-32	11,2	20,3
32-34	18,4	36,5
34-36	30,4	17,6
36-38	21,6	9,4
38-40	8,8	1,4
40-42	2,4	-

In the adult herring weighed before spawning, the average weight was 580 gr. for the females (maximum 820 and minimum 350), and 425 for the males (maximum 550, minimum 330).

Physiological Condition of the Adult Herring after Spawning

Death of the migratory herring after spawning is a fairly rare occurrence, as was established by D.F. Zamakhaevyi (1940).

In August of 1964 we noticed in the upper reach of the Volgograd H.E.S. a great amassment of herring that had finished spawning - blackback shad. All the males and females had finished spawning and had reproductive products of stage II maturity. The main part of the blackback brood stock consisted, as before spawning, of 2- and 3- individuals. Of these 83.3% females and 93.3% males were spawning for the first time and 16.7% females and 6.7% males were spawning for the second time. According to the information of E. Raminskii, 18.7% of the brood stock in 1937 went to spawn a second time, and 3% a third time. (Quoted from A.N. Svetovidov, 1952).

I.P. Levanidov (1932) pointed out, that as the herring migrate to the spawning grounds the quantity of fat deposits in their bodies decreases from 18.9% off the shores of Azerbaydzhan to 15.6% in the Volga delta and 6.8% in the Saratov district. After spawning in the second half of August, 1937, in the Borozdinskii backwater, the fat content in herring, as observed by A.Y. Nedoshivin, fluctuated from 0.5% to 2.6%, and on the average 1.15%. (Quoted by A.N. Svetovidov, 1952).

We did not determine the quantity of fat deposits in the bodies of herring. Nevertheless, judging by our visual observations and the indices obtained for the weight of herring before and after spawning, the loss of fat is great. The weight of the herring had decreased on average by 36.7%, mainly on account of the expulsion of reproductive products while spawning, and due to the utilization of nourishing substances

(first of all - fat) in the period of migration to the spawning grounds. In spite of this, death after spawning was not observed. On the contrary, the herring quickly re-established its former condition through intensified feeding in the upper reach of the Volgograd H.E.S. The stomachs of blackback shad that had finished spawning may serve to confirm this. They contained from 5 to 20 young herring of a size from 4-9 cm.

#### Brief Biological Description of Young Herring

At the end of August, 1964, we conducted a catch of young herring in the upper reach of the Volgograd H.E.S., which had concentrated in large numbers at the dam. In the analysis of the young caught the following features were considered basic to establishing their species composition; 1) weight; 2) length (as per Smith); 3) number of gill rakers on the first gill arch; 4) number of vertebrae; 5) number of carinate scales; 6) shape of scales; 7) body pigmentation; 8) number of rays in the dorsal fin; 9) number of rays in the anal fin; 10) arrangement of teeth.

Under a binocular microscope the number of rakers on the whole arch was counted at once on the short and long parts, as were the vertebrae. As the first was counted the vertebra having a bony outgrowth, and as the last the one which carries the hypural bone. The carinate scales were counted under a binocular microscope from the snout to the beginning of the base of the pelvic fins and from the base of the pelvic fins to the opening of the anus. Pigmentation of the body was investigated visually - the presence or absence of spots behind the gill cover was established; and also the general character of pigmentation.



The morphological characters (length and height of the head, the diameter of the eyes, the greatest body height, etc.) were not measured, because they undergo considerable change with the growth of the young. (A.I. Dekhterova, 1940).

The analysis according to the characters chosen by us permitted us to divide the caught young into Alosa kessleri kessleri (Grinam) - the blackback shad and Alosa kessleri volgensis (Berg) - the Volga multiraker herring. (Table 2).

Table 2

The Percentage Composition of the Young Blackback Shad and the Volga Herring in the Upper Reach of the Volgograd H.E.S.

Name of Young	Length of young, in cm	Number of gill rakers	Percentage of young
<u>Alosa kessleri kessleri</u>	5.8-8.8	46-56	92.4
<u>Alosa kessleri volgensis</u>	4.6-6.2	43-48	7.6

According to the data of A.I. Dekhterova (1940) the number of rakers on the first gill arch changes from 25 to 29 in the A. kessleri kessleri and from 32 to 84 in the A. kessleri volgensis. Dekhterova holds that in herring with many rakers the number changes considerably with the growth of the young herring.

The number of vertebrae varied in the young A. kessleri kessleri caught from 52 to 54 (on the average 53), and in A. kessleri volgensis from 41 to 44 (on the average 42.3). According to the data of A.N. Svetovidov (1952) in the blackback shad the number of vertebrae varies from 50 to 54 (on the average 52.6) and in the Volga herring - from 48 to 54 (on average 51.9).

The number of carinate scales in the investigated young was as follows:

1. In A. kessleri kessleri - on the average 33 (with a variation from 32-34). Up to the pelvic fin in all the blackback shad young of the year there was the same number of carinate scales - 19; behind the pelvic fin from 13 to 15. L.S. Berg (1949) showed that the blackback shad has usually 19 carinate scales up to the pelvic fin. This may serve as a definite systematic character.
2. In the A. kessleri volgensis - on the average - 27.4 scales (17-18 scales to the pelvic fin and 10 scales behind the pelvic fin).

Included among the species differences of the young was the body pigmentation, i.e. the spot behind the gill cover. In A. kessleri kessleri the spot showed clearly, but in A. kessleri volgensis it was absent. Some authors (A.I. Dekhterova, 1940) remark, that the pigmentation spot behind the gill cover belongs to characters that vary. In our investigation, nevertheless, this has not been observed. Besides this, in the blackback shad there was a well-defined pigmented lateral line, which is absent in the Volga herring.

The shape of the scales was also included in the systematic characters. In the blackback shad young of the year the scales had even edges with a clearly visible "cap" on top. In the Volga herring young of the year the scale does not have such a "cap". The dimensions of the scales varied from 1 to 1.75 mm (on the average 1.42 mm).

The weight and size composition of the investigated young herring was as follows (Table 3):

1. The average weight of the blackback shad young of the year was equal to 3.2 gr. (with a fluctuation from 1.2 to 6 gr.), but the average length was 7 cm (with a fluctuation from 5.8 to 8.8 cm);
2. The average weight of the Volga herring young of the year was equal to 1.7 gr. (with a fluctuation from 0.8 to 2.3 gr.), but their average length was 5.7 cm (with a fluctuation from 4.6 to 6.2 cm).

Table 3

## Basic Indices of the Young Migratory Herring of the Volga

Indices of the young	<u>Alosa kessleri</u> <u>kessleri (Grimm)</u>	<u>Alosa kessleri</u> <u>volgensis (Berg)</u>
Weight, gr.	$\frac{3.2}{1.2-6}$	$\frac{1.7}{0.8-2.3}$
Length, cm	$\frac{7.0}{5.8-8.8}$	$\frac{5.7}{4.6-6.2}$
Number of gill rakers	$\frac{49.7}{46-56}$	$\frac{46.0}{43-48}$
Number of vertebrae	$\frac{53}{52-54}$	$\frac{42.3}{41-44}$
Number of carinate scales	$\frac{33}{32-34}$	$\frac{27.4}{27-28}$
Number of rays in the dorsal fin	$\frac{15}{13-16}$	$\frac{12}{11-14}$
Number of rays in the anal fin	$\frac{21}{18-22}$	$\frac{19.4}{18-21}$

Remarks. In the fractions: Numerator = average, denominator = range.

On opening up the young herring it was possible to see that all its internal organs were covered with a layer of fat, while the young blackback shad was better nourished than the young of the Volga herring.

In all the young of the year the stomach and intestines were filled with food, which consisted of the following organisms:

1. Cladocera (Daphnia longispina, Ceriodaphnia sp., Moina micrura, Bosmina longirostris tipica);
2. Copepoda (Diaptomus sp., Cyclops sp., Nauplii);
3. Algae (green).

The biomasses of Cladocera and Copepoda were equal in size.

The green algae constituted a considerable part of the food lump.

Nevertheless this is not yet sufficient evidence for considering that algae continue to remain a basic food item of the young herring at this stage of their development. It is possible that the phytoplankton was seized by the young herring while consuming the crustaceans, the more so as a massive growth of algae was observed in the reservoir.

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In not one of the inspected stomachs were fish larvae found. Yet it is known from the investigations of A.P. Sushkinaya (1940) and many other authors, that the young herring becomes a predator at a considerably smaller size (3.5-3.7 cm) than those which were established. The absence of predatoriness in the young herring in our case is apparently connected with the fact that the reservoir was inhabited by plankton food organisms in great quantity, which were easily available to them.

## CONCLUSIONS

1. The intensive spawning run of herring through the fish pass of the Volgograd H.E.S. into the upper reach of the hydrostation is observed during June-July, reaching a maximum in the second half of June.
2. In the Volgograd-Saratov district schools of herring are represented basically by adult herring age 2+ and 3+ herring (89.8%). At the same time it has been noted in this district that the quantity of individual herring spawning repeatedly comprises 16.7% of the females and 6.7% of the males.
3. The absence at the Volgograd H.E.S. of special structures safeguarding the passage of the fish from the reservoir while descending to the sea results in concentration of schools of young herring at the dam on the upstream side. Here they are intensively eaten by the sea gulls and predatory fish, especially by the adult herring migrating downstream after spawning.
4. The bulk (92.4%) of the young herring migrating downstream from the Volgograd reservoir are blackback shad, and the remainder (7.6%) are Volga herring.
5. The food reserves of the Volgograd reservoir ensure successful weight increase by the young herring, owing to the phytoplankton and zooplankton.

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