RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No.2584
(D.c.5)

ICNAF Res.Doc.71/92

ANNUAL MEETING - JUNE 1971

Immunogenetic studies of herring from Georges Bank and the American Shelf

by
V.S.Zenkin
AtlantNIRO

Abstract

In 1968-1970, a study of the frequency of occurrence of the A-system blood groups was made in Atlantic herring from Georges Bank and the American Shelf. Analysis of the frequency of occurrence of the blood groups (phenotypes A_1, A_2 and A_o) in 4,765 specimens showed that pre-spawning and spawning herring from northern Georges Bank could be divided into two groups based on the number of blood phenotypes (with three and two phenotypes).

In November-April feeding herring from the American Shelf can also be divided into two groups based on the frequency of occurrence of the blood phenotypes, one of which appears to be identical with Georges Bank herring (three phenotypes group).

Introduction

Studies of herring populations by hereditary blood factors (erythrocyte antigens) were carried out in the Gulf of Maine and in the Northwest Atlantic (Sindermann and Mairs, 1959; Sindermann, 1962; Ridgway et al., 1969), in the North Sea (de Ligny, 1962; Altukhov, Truveller, Zenkin, Gladkova, 1968; Truveller, 1969), and in the Baltic Sea (Zenkin, 1966, 1969 a and b). Erythrocyte antigene "C" in herring from the Gulf described by Sindermann and Mairs (1959), and antigene "A" in herring from the North Sea (Altukhov et al., 1968) and from the Baltic (Zenkin, 1969b) are identical and the system of blood groups in Georges Bank herring is similar to A-system in herring from the North and Baltic Seas, and is also 3-allelic (Zenkin, 1971).

The present paper is an attempt to determine the local groups of herring in the Northwest Atlantic based on studies of the frequency of occurrence of the blood groups.

Material and Methods

Immunogenetic studies of herring from the Northwest Atlantic were carried out in 1968-1970 in two main fishing areas, Georges Bank and the American Shelf (Fig. 1), on board the research vessels BMRT Gizhiga and SRTM Aliot. Samples of herring from the trawl catches for the analyses were taken in various seasons and each contained 100 specimens. A total of 4,765 specimens was studied. All the samples underwent a full biological analysis (length, sex, maturity stage of the gonads, fat and stomach content and weight were determined). Otoliths were also taken from some samples for age reading.

Blood groups in herring were determined by haemoagglutination reaction of its erythrocytes with the standard human blood serum of ABO - system (groups B, AB, O), serum of lobster (Homarus americanus), immune anti-herring serum of rabbit and absorbed anti-herring serum of rabbit. Haemoagglutination reaction was conducted on the slide in a humid chamber (Petri dish) at room temperature and estimated under microscope (Object glass x 8, sight glass x 10) by five-grade table, where "-" indicated the absence of reaction, and "+", "++", "+++", "++++" indicated various degrees of erythrocytes sticking together.

Chi-square method was employed for estimation of genetic balancing in the analysed populations from which samples of herring were taken, and for comparison between the different groupings by frequency of blood phenotypes, according to the Hardy-Weinberg law and four-field table (Tikhonov, 1965).

Results

Three blood groups - A_1, A_2, A_o phenotypes - were revealed in the pre-spawning Atlantic herring, as well as in herring from the North and Baltic Seas during immunogenetic studies conducted in 1968 on the spawning grounds of the northern Georges Bank slopes (Zenkin, 1971). Pre-spawning Georges Bank herring appeared to be heterogeneous by frequency of occurrence of the blood groups. Two groups of pre-spawning and spawning herring were singled out by number of the blood phenotypes: one group was characterized by the presence of all the three blood phenotypes, the other by two, A_1 and A_2, phenotypes only. Checking on conformity of the observed and theoretically expected phenotype number according to the Hardy-Weinberg distribution for the Mendelian population showed that a group of herring with three blood phenotypes was genetically balanced by genes controlling the blood groups ($\chi^2 = 2.3796$). A hypothesis of 3 - allelic A-system blood groups in Atlantic herring is supported by the same calculation. This calculation was a failure for a second grouping due to the absence of individuals with A_o blood phenotype. But when these two groups were combined and considered as a single whole, the calculation indicated an increase of the value of χ^2 up to 38.0147 ($\chi^2 > 3.841$). This is an evidence of disturbance of the genetic balance of this grouping and indicates a mixed nature of its composition (Table 1, s. unit 1).

All the material on the blood group distribution and frequency of occurrence of the genes in herring from Georges Bank and American Shelf is combined by areas and date of analyses and is given in Table 1.

It is evident from Table 1 that the two groups of herring which were found on the spawning ground in 1968 can be found on the northwest slopes of the Georges Bank in 1969 and 1970. Thus, both groups of herring which differ by number and frequency of blood phenotypes have been observed in the Georges Bank area for a period of 3 years.

In November-December 1969 and in March-April 1970, two groups of herring with different frequencies of the blood phenotypes were also recorded on the American Shelf south of Nantucket Island (Table 1, sampling units 4 and 5). Frequency of occurrence of one group (s. units 4 a) was identical with that of the Georges Bank herring (s. unit 1a). According to the data obtained by Zinkevich (1970) this may be Georges Bank herring which migrate in winter to the Nantucket area.

The other group of herring which was also observed in November-December 1969 on the American Shelf (Nantucket area, s. unit 4b) and recorded again in March-April 1970 in the Norfolk area (5) was characterized by an increased frequency of blood A_o - phenotype. This group was genetically balanced (by genes of the blood groups), and differed statistically with a high degree of authenticity ($P < 0.001$) from herring observed on the northwest slopes of Georges Bank (Table 2, s. units 5).

Statistically, authentic differences are also revealed when this group is compared with herring of a sampling unit (4a, Table 1) from the Nantucket area of the American Shelf taken in November-December 1969 (Table II, 2).

Thus, a group of herring with an increased frequency of A_o - phenotype observed on the American Shelf (Nantucket-Norfolk area) and later in May in the southern slopes of the Georges Bank differs in frequency of the blood phenotypes from the northern Georges Bank herring with which it presumably mixes in winter on the American Shelf.

Statistical comparison of the two sampling units of herring from the Norfolk area and the southern slopes of the Georges Bank (Table 1, 5) showed a good genetic balance of each unit, which was not disturbed after combining the two units into one. It seems that these sampling units do not differ statistically (Table 2, 4), thus presenting a single group of herring.

A sample of herring taken from the western Gulf of Maine and one from northwestern Georges Bank are close in blood frequency. Herring of this sampling unit are genetically balanced ($\chi^2 = 0.9988$) and there is no statistically authentic differences in blood phenotypes frequency between herring of the sampling units taken at about the same time from the Gulf of Maine and on the northwestern slopes of Georges Bank (Table 2, units 7 and 8). Although it is difficult to

draw a decisive conclusion from a single sample collected in the Gulf of Maine, we can assume that mature herring closely related to the herring spawning on Georges Bank by blood phenotypes frequency and body size occur in the Gulf in May.

Summary

Two groups of pre-spawning herring with different numbers of blood phenotypes have been found on Georges Bank. Three years of studies of Georges Bank herring have confirmed the suggestion of the existence of the two groups in the area.

Winter herring from the American Shelf can also be divided into two groups based on the frequency of occurrence of the blood groups, one of which appears to be identical with the northern Georges Bank herring (a group with three phenotypes).

Sample of herring from the Gulf of Maine and herring from northwestern Georges Bank are closely related according to frequency of blood groups.

The results of the immunogenetic studies of the Georges Bank herring populations structure are certainly of great interest and further investigations in this field are needed.

References

Altukhov, Yu. P., K.A.Truveller, V.S.Zenkin, and N.S.Gladkova. 1968. The A-system of the blood groups in Atlantic herring (Clupea harengus L.). Genetika, USSR, 4(2): 155-167.

Zenkin, V.S. 1966. About a degree of genetic identity between autumn and spring herring from the southern Baltic. Voprosy Morskoi biologii. Ed. by "Naukova dumka", Kiev, p.46-48.

1969a. A study of erythrocyte antigenes in spring herring from the Vistula Bay. Trudy AtlantNIRO, No.21, Kaliningrad, p.151-155.

1969b. Immunogenetic studies of the spring and autumn herring populations of the Baltic Sea. Coll."A National Conference of Young Scientists", PINRO, Murmansk, p.87-99

1971. About identity of "C" and "A" erythrocyte antigenes in Atlantic herring and analysis of the blood groups distribution in Georges Bank herring. Trudy VNIRO (in press).

Zinkevich, V.N. 1970. Distribution of herring on Georges Bank and in adjacent waters. Trudy AtlantNIRO, No.28, Kaliningrad, p.111-134.

Tikhonov, V.N. 1965. Genetic systems of animal blood groups. Nauka, Novosibirsk.

deLigny, W. 1962. Contribution to the serology of marine fish. Contr. 8th. Conf. Eur. Soc. Anim. Blood Groups, Liubljana (mimeo) 1 only.

Ridgway, G.J., R.D.Lewis and S.W.Sherburne. 1969. Serological and biochemical studies of herring populations in the Gulf of Maine. Contribution No.24. ICES Special Meeting.

Sindermann, C.J. 1962. Serology of Atlantic clupeoid fishes. Amer. Nat., 96(889): 225-231.

Sindermann, C.J. and D.F.Mairs. 1959. A major blood groups system in Atlantic herring. Copeia, 1959(3): 228-232.

Truveller, K.A. 1969. A study of blood groups in herring (Clupea harengus L.) from the North Sea in connection with the problem of race differentiation. ICES Special Meeting, Contribution No.32.

a2

Table I Samples of herring combined by areas and frequencies of the blood groups and genes, in sampling units (1968-1970).

S.unit No.	Sampling Area	Date	Sample No.	Fish No.	Frequencies Phenotypes A_1	A_2	A_o	Genes A_1	A_2	A_o	x^2
1	2	3	4	5	6	7	8	9	10	11	12
1	Georges Bank northern area: a)	22.08-18.09.68	12	650	0.9478	0.0246	0.0276	0.8194	0.0622	0.1407	2.3796
	b)	2.09-18.09.68	8	450	0.9510	0.0490	0.0000	-	-	-	-
	Σ		20	1100	0.9491	0.0345	0.0164	0.8203	0.0936	0.0846	38.0147
2	Georges Bank north-west area	11.09-26.09.69	4	265	0.9546	0.0189	0.0265	0.8108	0.0493	0.1395	0.8088
			2	150	0.9533	0.0467	0.0000	-	-	-	-
	Σ		6	415	0.9540	0.0290	0.0170	0.8351	0.0808	0.0929	4.2932
3	Georges Bank north-west area	6.06-17.07.1970	5	500	0.9760	0.0140	0.0100	0.8717	0.0536	0.0743	2.3314
			3	300	0.9934	0.0066	0.0000	-	-	-	-
	Σ		8	800	0.9827	0.0111	0.0062	0.8941	0.0515	0.0538	4.0947
4	USA shelf Nuntacket area a)	21.11-8.12.1969	6	600	0.9467	0.0316	0.0217	0.8092	0.0798	0.1102	5.1563
	b)	28.11.4.12.1969	2	200	0.9000	0.0350	0.0650	0.7119	0.0599	0.2292	0.7674
5	USAshelf Norfolk area	13.03-17.04.70	4	400	0.9150	0.0225	0.0625	0.7275	0.0409	0.23313	1.1254
	Georges Bank southern area	4.04-2.06.1970	4	400	0.9275	0.0200	0.0525	0.7494	0.0396	0.2009	1.6160
	Σ		8	800	0.9200	0.0212	0.0588	0.7355	0.0397	0.2245	1.2899
6.	Gulf of Maine	20.06.1970	1	100	0.9700	0.0200	0.0100	0.8619	0.0709	0.0654	0.9988

Table 2 Pattern of differences by herring blood phenotypes between sampling units from different areas of the North-West Atlantic

S. unit No.	Sampling units compared*	χ^2 A_1	A_2	A_o	$\sum \chi^2$
1.	North-west slopes of the Georges Bank (1.X.1969) and American shelf (Nantucket area, XI-XII, 69)	2.9976	0.0445	0.2925	3.3346
2.	American shelf a) and b) Nantucket area, XI-XII, 1969)	5.3750	0.0530	8.9578	14.3858
3.	American shelf b), (Nantucket area, XI, 1969) and American shelf (Norfolk area III-IV, 1970)	0.2309	0.8026	0.0000	1.0335
4.	American shelf (Norfolk area) and Georges Bank (south and south-east slopes, V-VI, 1970)	0.6114	0.0600	0.5655	1.2369
5.	American shelf (Norfolk area) and Georges Bank (north and north-west slopes, VI-VII, 1970, balanced).	18.1039	0.9195	20.2123	39.2357
6.	Georges Bank, 1969-1970 (north-west slopes, balanced)	2.5814	0.2658	0.8821	3.7293
7.	Georges Bank, north-west slopes, VI-VII, 1970) and Gulf of Maine (VI, 1970), balanced	0.1231	0.2030	0.0000	0.3261
8.	Georges Bank (north-west slopes, VI-VII.1970, not balanced) and Gulf of Maine (VI. 1970, balanced).	0.6662	0.5637	0.1887	1.4186

* Differences between sampling units are statistically authentic ($P < 0.001$) if $\chi^2 > 10.8$.

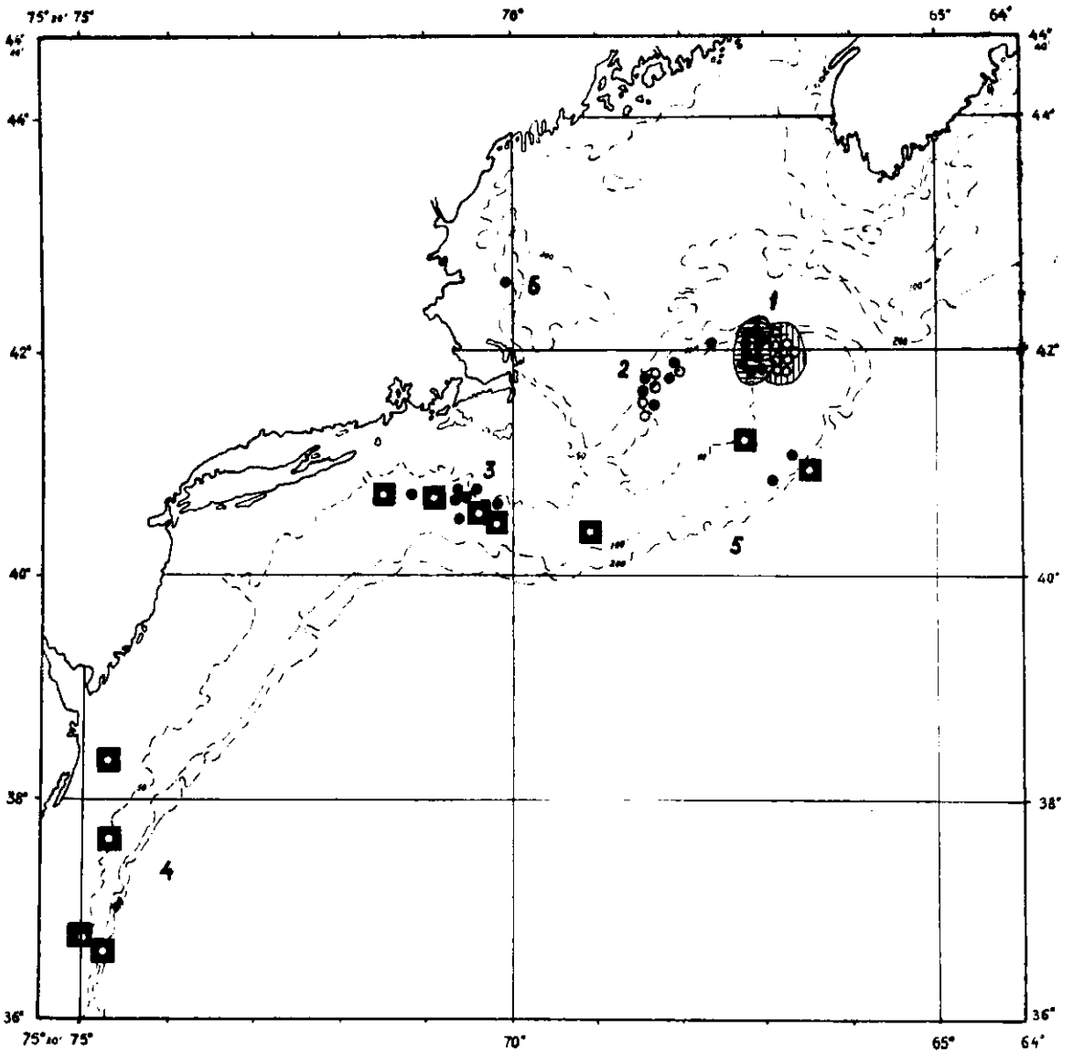

Fig. 1. Areas of collection of herring samples for immunogenetic analysis and designations of the observed groups:

1 - northern slopes of Georges Bank

2 - northwest slopes of Georges Bank

3 - American Shelf (Nantucket area)

4 - American Shelf (Norfolk area)

5 - south and southeast slopes of Georges Bank

6 - Gulf of Maine

● - a group of Georges Bank herring with A_1, A_2, A_o - phenotypes

○ - a group of Georges Bank herring with A_1 and A_2 phenotypes

■ - a group from the American Shelf