KUNGL. LANTBRUKSSTYRELSEN

Meddelanden från Statens undersöknings- och försöksanstalt för sötvattensfisket. N:r 25.
(Reports from the Swedish State Institute of Fresh-Water Fishery Research, Drottningholm.)

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WITH SPECIAL REGARD TO THE PERCH

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GUNNAR ALM

(With 23 figures and 32 tables)

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Contents.

Introduction.

In the majority of fish species, the individual size of the populations varies considerably in different lakes, which also applies to individuals of one and the same year class. This is a matter of great economic significance. A rational policy as regards fishery must, therefore, aim at fish populations of sufficiently big individual size for profitable catches. Populations consisting only of small individuals are most often of but slight value. Thus, an analysis of the reasons for these differences, as well as of the possibilities of obviating them, is undoubtedly called for. This will be important also with regard to an elucidation of the problem of suitable planting material.

Populations with a greatly varying individual size are particularly common among the perch, the bream, the gwyniad, the trout, and the char. The explanation has been assumed to lie in the supply of food and in hereditary attributes. However, the material at our disposal is too restricted for a critical analysis of these particular problems. The same applies to the differences in growth in one and the same year-class. It has been established, it is true, from the rearing of fish in ponds that a dense population (NORDQVIST 1932, WALTER 1934), with subsequent reduction in the supply of food for the individual fishes, causes a deterioration in growth. Further, a certain connection is traceable in natural waters between an overcrowding of fish and deteriorated growth. Also experiments with the transplantation of forms of stunted trout (ALM 1939, LEHMANN 1942) and gwyniad (OLOFSSON 1934, RUNNSTRÖM 1944) have shown that, at any rate, some of the transplanted samples attain greatly improved growth. Detailed experiments with trout (ALM 1939) have proved the great significance of environment with regard to growth.

Still, full light has as yet not been thrown on these problems, the lack of direct experiments being particularly noteworthy. This subject has, therefore, for several years been included in the working program of the State Institute of Fresh-Water-Fishery Research at Drottningholm (Stockholm), Sweden. The results arrived at by a detailed investigation of one of the forementioned fish species should be applicable also to other species and, consequently, of a wider significance.

The perch (*Perca fluviatilis* L.) has been chosen as an experimental object, principally owing to the fact that it is extremely common in Sweden, is caught in large amounts, and is of great economic significance. Further, stunted populations are very usual and, because of its low price, a comprehensive investigation material could be easily obtained.

From a practical point of view, the most important problem was to inquire into the reasons for the occurrence of stunted perch populations, which are very common in several small lakes, above all in northern Sweden. Is the explanation ultimately to be found in the fishing, overcrowding resulting in deficiency of food, environmental conditions, small-sized races, or in an interplay of these factors? Are the possible differences in growth between the sexes of significance in this respect? Can anything be done — and, if so, what? — in order to improve the growth of the forementioned stunted populations, or in some other way to render waters with such populations more productive, or to utilize these populations for some other purpose? In connection with these principal questions, a great many others naturally offer themselves, as shown below.

The work has been based on partly the material obtained from the commercial catches in various lakes and, partly, and above all, on direct experiments. The latter have chiefly been carried out at the Station of Fishery Research at Kälarne, situated in the forest region of eastern Jämtland. In the lakes of this region, perch populations of different types were found which could be subjected to investigation with regard to the composition and growth of the particular populations. Further, the ponds at the station presented good facilities for controllable experiments of various kinds.

My sincere thanks for all kind assistance in connection with the present work are due to the staff of the research station, to the fishermen and others who have given their services.

I. Perch populations in different lakes.

1. The individual size of the populations.

The great variation in size of the perch in different lakes has been pointed out by the majority of fish biologists who have studied this particular species. However, in most cases the material collected has been fairly small. For the purpose of a closer analysis of this problem, samples caught during intensive perch fishing, under or in connection with the spawning run, have been measured in a number of lakes of various types and, sometimes, for periods of several years. Measurements have also been carried out, in many cases, in the event of particularly large collections on occasions other than the spawning run. Consequently, some of the more important fishing spots in the largest lakes in Sweden have been selected, as well as some medium-sized lakes yielding good perch fishing and, finally, also a number of smaller lakes of different types frequented by the perch. In many lakes a number of different fishing gear have come to use, such as, above all, fyke-nets, gill nets and traps. The mesh size has also varied considerably. In the larger lakes, only the gear employed in usual fishing has been used and, in particular, certain types of pound-nets. In this case the mesh size may be presumed to have been adapted to the most suitable size for the perch as far as experience goes. In view of this, a more one-sided catching method of this type will probably not change the picture to any marked extent. Table 1 shows the results of the more important experiments.

The first thirteen lakes recorded in the table are situated in the region of Kälarne. They, nevertheless, represent different types, as may be seen from Table 2. Thus, the first eight are fairly small, partly surrounded by peat-mosses and quagmires, sometimes quite without solid shores. The Big Holm Tarn (Stora Holmtjärn) and The Church Tarn (Kyrktjärn) are also comparatively small lakes, but with partly solid shores of stone and rock. Hällesjön, Balsjön and Gransjön represent the usual, small lakes occurring in northern Sweden with varying types of scenery, some being surrounded by forest and moraine territory, others by cultivated ground. As regards the rest of the lakes recorded in Table 1, the Sultentjärn in Nerike (1.5 hectares, 2—3 m deep, pH = 5.7) resembles the perch

Table 1. Size of the perch in different

Lake *Sjöns namn*	Year *År*	Operating units *Redskap*	Sex *Kön*	Number *Antal*	% ♂ ♀	Mean l.[2] in cm *Ml i cm*
Aborrtjärn I	1934—45	M. N. Lr[1]	♂	4 619	86,6	9,9
Perch Tarn			♀	714	13,4	11,6
			?	4 283	—	11,8
Abborrtjärn II	1934—45	»	♂	8 252	73,8	11,4
Perch Tarn			♀	2 933	26,2	13,0
			?	8 412	—	12,6
Abborrtjärn III........	1934—45	»	♂	2 425	81,4	14,2
Perch Tarn			♀	554	18,6	16,4
			?	3 676	—	14,0
Skarpabborrtjärn	1939, 42	M. N.	?	278	100,0	12,0
Ulvsjötjärn	1939	»	♂	253	88,8	13,3
	1939		♀	32	11,2	15,5
	1939—41		?	388	—	14,8
Bodflotjärn	1939	»	♂	263	84,0	12,7
	1939		♀	50	16,0	16,2
Sjulsontjärn	1938	»	?	350	—	15,4
Flasktjärn	1938	»	?	643	—	13,1
St. Holmtjärn	1937, 39	»	♂	272	82,9	15,3
	1937, 39		♀	56	17,1	17,4
	1937—45		?	4 737	—	19,3
Kyrktjärn	1938, 41	»	?	356	—	18,4
Hällesjön	1937, 39—40	»	♂	1 142	81,1	13,2
	1937, 39—40		♀	266	18,9	14,1
	1938—40		?	319	—	13,4
Balsjön	1936—38	»	♂	293	73,1	14,7
			♀	108	26,9	15,9
	1935—36, 39		?	688	—	15,1
Gransjön	1937, 39—40	»	♂	576	84,0	14,9
	1937, 39—40		♀	110	16,0	19,4
	1938—40		?	391	—	16,2

[1] M = Traps — *mjärdar*. N = Gill nets — *nät*. Lr = Fyke nets — *småryssjor*. Sr = Pound nets — *storryssjor*.
[2] In all tables the total length. — *I alla tabeller totallängden.*

lakes. — *Abborrens storlek i olika sjöar.*

Length[2] in cm. Number. — *Längd i cm. Antal*								
5—9	10—14	15—19	20—24	25—29	30—34	35—39	40—44	45—49
2 051	2 518	49	1					
76	578	54	6					
609	3 080	541	52	1				
1 332	6 408	503	9					
15	2 473	401	42	2				
1 095	5 400	1 828	83	6				
15	1 085	1 288	33	4				
—	118	389	46	1				
198	1 572	1 861	43	2				
7	269	2						
—	184	69						
—	9	23						
—	158	229	1					
17	202	42	2					
—	10	35	5					
—	83	266	1					
—	599	44	—					
—	74	195	3					
—	1	45	10					
—	357	2 106	2 055	213	6			
—	—	262	93	1				
1	1 010	131						
—	190	76						
7	230	82						
—	157	129	7					
—	19	87	2					
—	272	403	13					
—	261	301	14					
—	7	48	47	8				
2	213	129	22	15	4	6		

Lake *Sjöns namn*	Year *År*	Operating units *Redskap*	Sex *Kön*	Number *Antal*	% ♂ ♀	Mean l. in cm *Ml i cm*
Sultentjärn	1938—39	M. N.	♂	111	40,6	16,0
	1938—39		♀	161	59,4	16,3
L. Skärsjön	1936	»	♂	269	66,4	9,8
	1936		♀	136	33,6	10,5
Sängsjön	1943	M. N. Lr.	♂	318	75,9	19,6
	1943	»	♀	101	24,1	26,6
Stråken	1937, 39	M. N.	?	1 263	—	12,4
Råbelövssjön	1937, 40	Lr. N.	♂	535	93,0	13,1
	1937, 40		♀	44	7,0	19,3
Oppmannasjön	1939, 41—45	Sr. Lr.	♂	3 806	60,2	18,3
			♀	2 518	39,8	26,7
Öljaren	1939, 42—45	»	♂	1 465	71,4	22,1
	1939, 42—45		♀	587	28,6	26,8
Toften	1939	N.	?	156	—	35,8
Hjälmaren	1939—45	Sr.	♂	1 433	30,1	24,2
(Hemfjärden)	1939—45		♀	3 332	69,9	25,0
	1938—39	M.[3]	♂	253	64,9	14,9
	1938—39		♀	137	35,1	15,1
Mälaren	1935—37, 39	N	♂	661	61,4	13,6
(Fiskerianstalten)	1942, 44		♀	415	38,6	13,9
D:o, Stallarholmen	1942	Sr. N.	♂	55	9,1	24,6
	1942		♀	551	90,9	25,7
D:o, Kungsör	1942	»	♂	32	19,4	20,0
	1942		♀	133	80,6	22,0
Vänern, Höljebol	1943	Sr. M.	♂	268	64,3	16,1
	1943		♀	149	35,7	25,9
D:o, Kolstrandsvik	1943	Sr. Lr.	♂	221	32,4	22,5
	1943		♀	461	67,6	22,3
D:o, Leksberg	1943, 45	Sr. Lr. N.	♂	4 015	52,1	25,8
	1943, 45		♀	3 686	47,9	30,9
Kalmar l., Alsterån	1945	M. N. Lr.	♂	21 611	91,1	18,8
	1945		♀	2 119	8,9	24,4

[3] Only small indiv. taken. — *Endast små ex. tillvaratagna.*

Length in cm. Number. — *Längd i cm. Antal*								
5—9	10—14	15—19	20—24	25—29	30—34	35—39	40—44	45—49
—	1	108	2					
—	1	156	4					
107	161	1						
26	108	2						
—	—	176	17	24	1			
—	—	1	24	61	12	1	2	
60	1 129	74						
2	428	102	—	2	—	1		
—	6	29	2	1	3	2		
4	951	1 342	1 070	380	57	2		
—	38	349	471	807	624	191	38	
—	—	375	767	321	2			
—	—	45	146	213	175	5	3	
—	—	—	4	24	63	43	18	4
—	—	3	854	569	7			
—	—	8	1 514	1 627	153	27	3	
—	68	185						
—	31	106						
48	392	219	2					
59	136	216	2	2				
—	—	5	23	22	5			
—	1	9	166	304	63	7	1	
—	—	15	16	1				
—	—	22	93	17	1			
—	105	114	43	6				
—	—	—	54	72	22	1		
—	—	35	133	44	9			
—	—	103	257	89	12			
—	34	213	1 117	2 024	506	113	8	
—	—	10	372	1 295	1 049	754	197	9
3 218	3 586	3 007	6 464	4 806	483	47		
—	8	88	1 140	750	91	41	1	

Table 2.

The experimental lakes at Kälarne. — *Försökssjöarna vid Kälarne.*

Lake *Sjö*	Date *Tid*	Area *Areal*	Deep *Djup*	Temp. °C		Oxygen *Syrgas mg/l*		pH		Transparancy *Siktdjup*	Colour of water *Vattenfärg*
				y[1]	b[2]	y	b	y	b		
Abborrtjärn I	$^{16}/_{8}$ 34	2,0	8,8	22,9	4,8	7,6	0,0	6,8	6,2	1,5	Brown — *Brun*
Abborrtjärn II	$^{15}/_{8}$ 34	4,0	10,4	18,8	4,6	7,5	0,0	6,6	6,3	3,0	» — »
Abborrtjärn III	$^{17}/_{8}$ 34	1,5	6,2	23,6	5,2	7,4	0,0	6,8	6,4	1,3	» — »
Skarpabborrtjärn ...	$^{21}/_{6}$ 39	1,0	6,8	22,3	4,8	8,9	0,0	6,9	6,0	1,9	Yellow-brown — *Gulbrun*
Ulvsjötjärn	$^{17}/_{6}$ 39	1,5	4,5	17,4	6,3	10,2	1,5	7,4	6,6	3,0	Light-yellow — *Ljusgul*
Bodflotjärn	$^{18}/_{8}$ 36	2,0	8,0	17,9	4,8	8,2	0,0	6,3	6,0	1,6	Yellow-brown — *Gulbrun*
Sjulsontjärn	$^{9}/_{8}$ 38	7,0	9,0	22,2	7,5	7,9	3,5	6,7	6,1	1,9	» — »
Flasktjärn		5,0	4,4	22,6	12,1	6,9	0,0	6,6	—	1,9	Brown — *Brun*
St. Holmtjärn	$^{6}/_{8}$ 38	16,0	11,5	18,8	5,8	9,3	0,0	7,1	6,6	4,2	Yellow-green — *Gulgrön*
Kyrktjärn	$^{4}/_{8}$ 38	1,8	7,6	19,8	5,6	8,3	0,0	7,0	6,7	2,4	Yellow-brown — *Gulbrun*
Hällesjön	$^{8}/_{7}$ 37	180,0	16,5	22,0	9,2	8,2	4,0	7,8	6,0	3,8	Yellow-green — *Gulgrön*
Balsjön	$^{8}/_{7}$ 37	90,5	6,8	22,7	16,3	8,0	6,0	7,5	7,3	3,6	» — »
Gransjön	$^{6}/_{7}$ 37	100,0	9,3	22,0	16,4	8,2	5,8	7,5	7,2	3,3	» — »

[1] y = surface water — *vattenytan.* [2] b = bottom water — *vid botten.*

tarns. Sängsjön (500 hectares) in Västerbotten, Stråken (800 hectares) in Småland and Toften (1.740 hectares) in Nerike are of the same type as Gransjön, which also applies to L. Skärsjön (5 hectares) in south-eastern Småland. Öljaren (1.850 hectares) in Södermanland, as well as Råbelövssjön (1.000 hectares) and Oppmannasjön (1.400 hectares) in north-eastern Skåne, are medium-sized lowland lakes with good food resources. The same applies to Lake Hjälmaren (480 km²), Lake Mälaren (1.162 km²) and Lake Vänern (5.568 km²). Finally, Alsterån in eastern Småland represents the coast inasmuch as this river is the chief spawning run of part of the perch populations in the Kalmar straits.

The number of measured perch has, as evident from the table, been extremely large in several instances, and the results obtained may undoubtedly — with certain exceptions — be considered as typical of the varying size of the perch in different lakes. It will then be seen that the perch is throughout bigger in the large lakes and smaller in the small ones. In the majority of tarns near Kälarne and in other similar, small lakes the most common size of the perch lies between 10 and 18 cm. Naturally, there must also sometimes be a good many smaller perch which have escaped being caught in larger quantities owing to the fishing gears employed. On the other hand, larger perch are more scarce in these waters, in spite of the use of diverse gears and methods of catching at different seasons and in different parts of the lakes. Large perch are very rare in Hällesjön. The same applies, though less pronouncedly, to Balsjön and Stråken, while considerably larger perch may be collected in other parts of Råbelövssjön. Thus, the size of the perch in the collections in the latter case is not typical of the perch populations of this particular lake.

In Gransjön near Kälarne the perch has a normal length of 15—19 cm. Numerous larger samples may also be seen, several even exceeding 30 cm in length. This lake forms, as regards the size of the perch, a transitional type to that of Öljaren, Oppmannasjön, Toften, the largest lakes, and the coast. Even though conditions vary to a great extent, it is clear that the perch in these lakes is considerably larger, having a normal size of between 20 and 30 cm. Most often there is even a comparatively frequent occurrence of perch exceeding 30 cm in length. At the measurements in Lake Vänern the size has varied fairly greatly. This can also be said of the two samples of larger perch from Lake Mälaren. However, the perch was of a large size in all the cases.

Fig. 2, regarding the perch collections during different years in one and the same spot in Lake Hjälmaren, illustrates the similarity in the

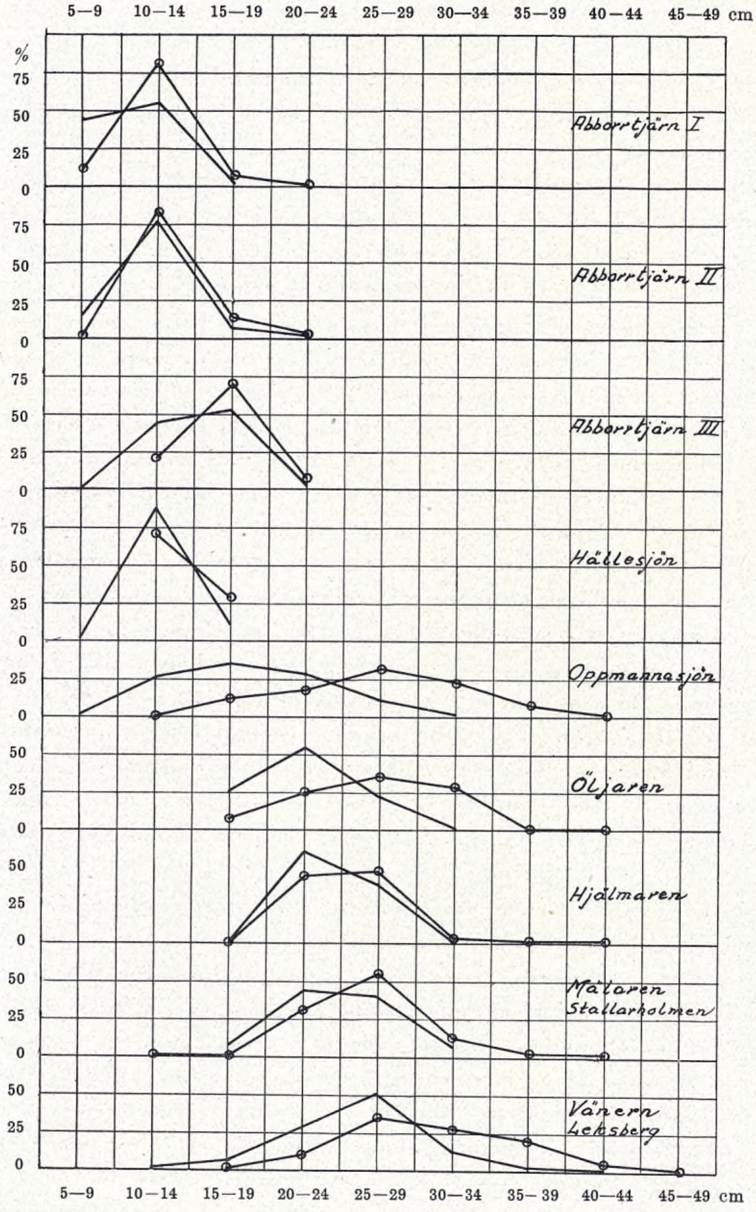

Fig. 1. Size of spawning perch in different lakes. — *Storleksfördelningen hos lekande abborre i olika sjöar.* (——— = ♂, o—o—o = ♀).

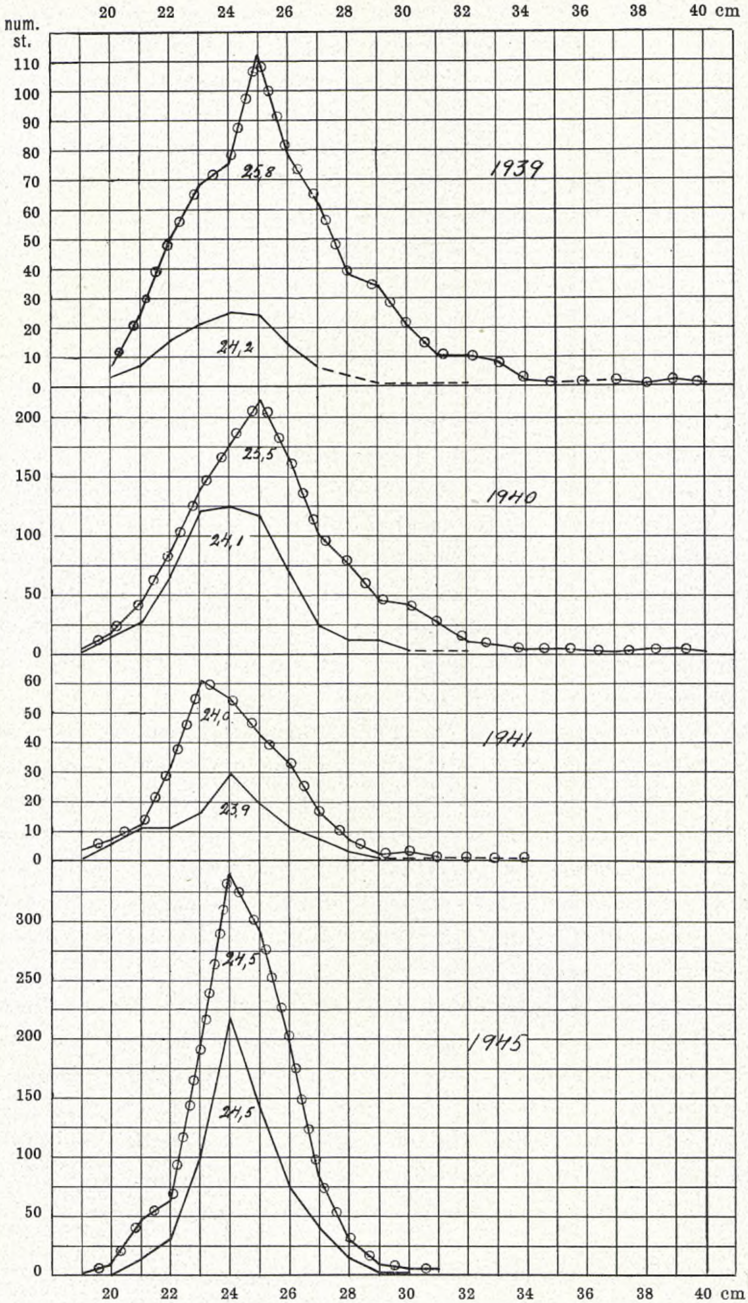

Fig. 2. Size of spawning perch in different years in a certain fishing spot in Lake Hjälmaren.
Storleksfördelningen under olika år hos lekande abborre på viss fiskeplats i Hjälmaren.

distribution of size which may occur. This is, nevertheless, not always the case, as is evident from Fig. 3 regarding the size of the perch in Oppmannasjön during different years. Notwithstanding the fact that the same nets, coarse as well as fine-meshed ones, have been used in the catches all the time, the size of the perch will be seen to be very variable. During the years 1939—1942, the perch was of a large size and the fishing has then, evidently, been based on some rich year-classes with large perch. Smaller perch belonging to new, growing year-classes have, on the other hand, been comparatively scarce. During the year 1943, hovewer, perch of this type appeared in large quantities. The same happened in 1944 except that the medium-size was then greater, and in 1945 still increased even rather considerably. This apparently concerns a new, rich year-class. The great number of males during these years is remarkable, resembling somewhat the conditions in The Perch Tarns. This is due to the earlier sexual maturity of the males. A new, rich year-class will therefore first announce its appearance by the large numbers of small males participating in the spawning. In connection with the appearance of this new, rich year-class, the old rich year-classes, on which the fishing has been based for several years, will have disappeared completely. However, the facts related above will show that, in a lake with generally large perch, sometimes a preponderance of small perch may be found.

Similar conditions occur in the Perch tarns and will be discussed in greater detail in connection with the experiments made there. Also in these tarns, distinctly different, rich year-classes appear, causing the medium-size to vary during the different years (Fig. 8 and 11 and pages 53 and 61). Simultaneously, a certain connection exists at times between the disappearance of an older year-class and the appearance of a younger one. The occurrence of different year-classes has also been stressed by JOBES (1933) in America.

However, it may be established that, on the whole, a direct correlation exists between the size of the perch and the area of the lakes. Still, it should be borne in mind that the perch may be extremely common also in the largest lakes, although it is there, of course, more restricted to certain definite regions. The annual catches in these parts may be considerable. The individual number in the populations per area of water surface is, however, without doubt considerably bigger in the small lakes (see page 75).

Further, it will be noticed from Fig. 1 that almost invariably a certain difference in size occurs between the sexes and that the females are larger. This will be discussed more closely in connection with the subject of growth.

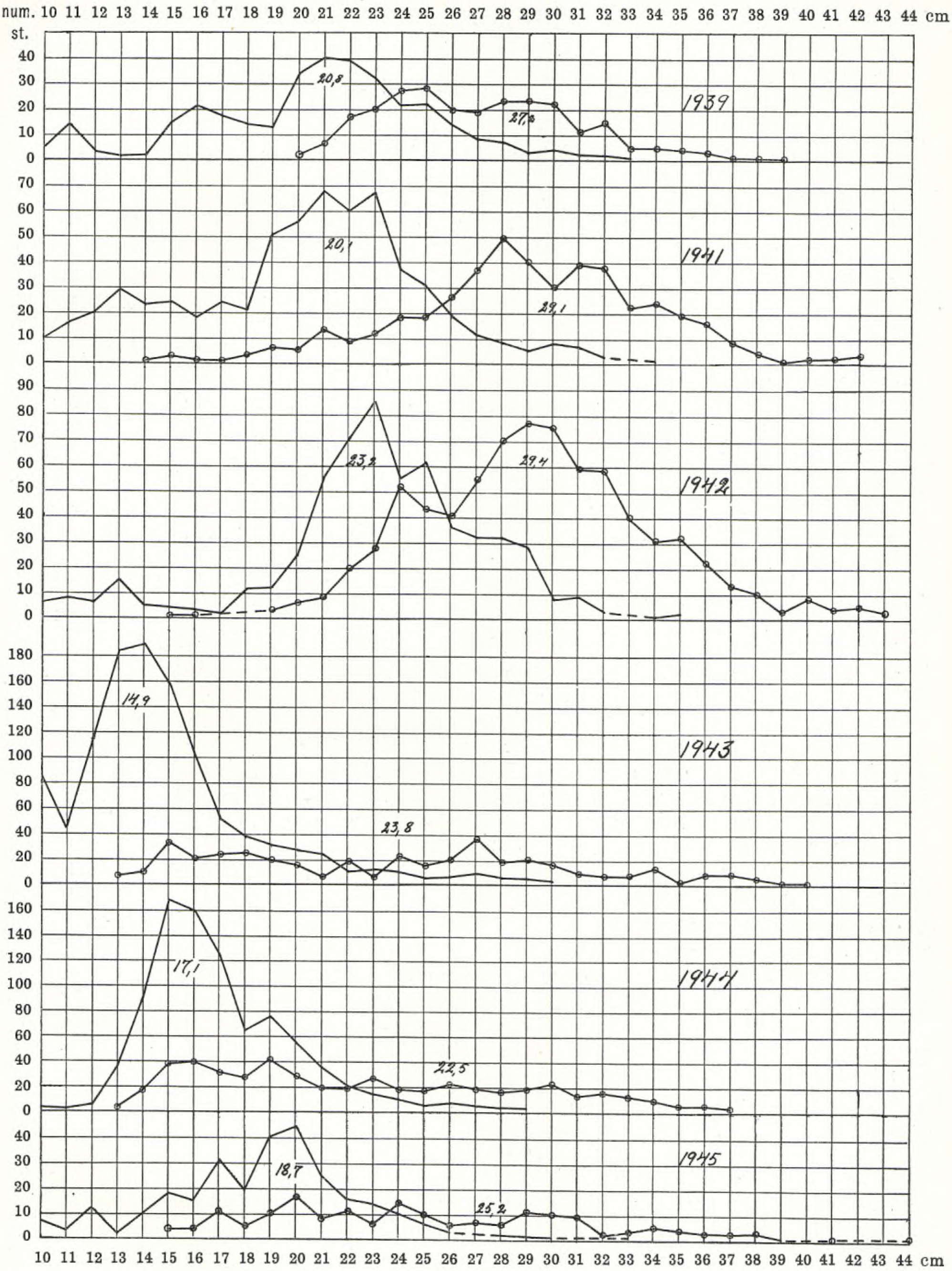

Fig. 3. Size of spawning perch in different years in lake Oppmannasjön. — *Storleksfördelningen under olika år hos lekande abborre i Oppmannasjön.*

2. Sex ratio.

Broadly speaking, the literature regarding the sex ratio of the perch indicates a predominating number of males in the spawning run. ESCHMEIJER (1937, 1938) states that the primary sex ratio is disturbed by the fact that males and females often frequent different places in the lakes, the males going deeper down, the females keeping to the surface and close to the shores. In poisoning experiments in different lakes, he found the sex ratio to be 2—3 males to every female. HILE and JOBES (1942), on the other hand, came across a very large number of female perch in Michigan, i. e. 688 females to 100 males, and this only concerned perch aged from 3—5 years. RÖPER (1936) points out that regard must be paid to the size and age of the fishes. He arrives at the result that the ratio is 115 males to 100 females among 1-summer old perch, being 100 among 2- and 3-summer old perch, 63 among 4—10-summer old, 33 among 11—15-summer old, and maximum 25 males among perch older than 15-summers. Similar figures are presented by OLSTAD (1919). Further, the sex ratio has been examined by DYK (1918) and KRIZENECKY (1940) with regard to 1-summer old perch. In both cases, comprehensive materials were used, DYK finding 100 females to 91,6 males and KRIZENECKY 125,4 males to the same number of females. LE CREN (1944) reported, from Lake Windermere in England, that the males form the great majority, but that during the years with very large catches the males have, apparently, been collected to a greater extent than the females, causing the percentage of females to rise in the following years.

The above-mentioned Table 1 illustrates the sex distribution in the *spawning collections*. It varies considerably in different lakes. In the smaller lakes the males are always far more frequent, conditions varying in the larger lakes. In Perch-tarn I, with the most extreme surplus of males, only 714, or 13,4 per cent, of females were obtained among over 5.000 spawning perch. In Oppmannasjön, on the other hand, from which a material of 6.000 samples has been obtained, the number of females was 2.518, or 39,8 per cent. During the spawning run in two particularly yielding spots in Lake Mälaren the percentage figures of females equalled 80,6 and 90,9, while in another spot in the same lake, where a great quantity of smaller perch were spawning, the number of males exceeded that of the females. In Lake Hjälmaren the female percentage was high, and in Lake Vänern the corresponding figure varied between 35,7 and 67,6 per cent. The spawning perch from Alsterån shows en overwhelming surplus of males. However, in this case it is quite probable that numerous, small males, which have escaped, have reappeared in the nets or traps and, accordingly, have been counted several times over. Still, the male figure in Alsterån will be found to be very large among also the bigger perch, exceeding 20 cm in length.

The seemingly high sex ratio of the males in especially the stunted perch populations may, sometimes, be due to the localization of the fishing gear and the different spots in which the sexes make their appearance. In 1941, in Perch-tarn II a certain trap contained 39 females and 13 males, while another trap had 133 males and only 2 females. On the whole, the males seem to be caught more often in the traps than do the female perch. Finally, in certain experiments where the fish has been let loose, the same sample has again been caught several times over, as mentioned above with regard to Alsterån.

Simultaneously, it should be borne in mind that the catching in, for instance The Perch Tarns has been carried out with different gears, set out in different places, and that they have been so effective as hardly to let any spawning females, whenever they have occurred in greater numbers, pass uncaught. Since the perch in these tarns does not grow any larger than shown in the collections, also the spawning females must occur in these sizes. However, the number of males has varied during different years and it is noteworthy that, during the very last years, the percentage of females has considerably exceeded that of former years. This may, possibly, indicate that the females in the year-classes occurring at the beginning of the experiments have died, while the sexes are as yet fairly normally manifested in the new year-classes.

It will be seen from Table 1 that the number of males may be great even in lakes with large-sized perch (Öljaren), in spite of the fact that the opposite is more common. It is therefore obvious that the type of gear, and above all the mesh size, often is the decisive factor. However, also the different sizes of the perch, in different lakes and under different years, play a part in this connection. This is clearly shown in Figs. 1—3 when compared with the sex ratios in Table 1. Nevertheless, it all serves to demonstrate the uncertain sex ratios obtained in an examination of the material from the spawning run.

In order to examine more closely the actual sex ratio, a large material has been collected with different gears at seasons other than the spawning time (Table 3). An analysis of the activity of the stunted perch populations in this respect was of particular interest. It is, of course, quite possible that the sex distribution may be influenced by factors, acting in these lakes in favour of the occurrence of males, of which we are as yet ignorant.

Table 3.

Sex ratio in other seasons than in springtime. — *Könsfördelningen vid andra årstider än vid leken.*

Lakes and ponds *Sjöar och dammar*	Number — *Antal*	
	♂	♀
Abborrtjärn I	202	243
Abborrtjärn II	168	242
Abborrtjärn III	181	179
Skarpabborrtjärn	94	105
Sultentjärn	110	161
L. Skärsjön	269	136
Balsjön	20	66
Gransjön	18	63
Hjälmaren	253	137
Mälaren	286	369
Total lakes — *Summa sjöar*	**1 601** (48,5 %)	**1 701** (51,5 %)
Dammar Kälarne 1 somr.	99	89
» » 2 »	241	196
» » 3 »	133	146
» » 4 »	23	21
» Älvkarleby 1 »	290	306
» Harvik 1 »	173	266
» Aneboda 1 »	118	108
» Drottningholm 1 »	73	73
» » 2 »	27	20
Total ponds — *Summa dammar*	**1 177** (49,0 %)	**1 225** (51,0 %)
Total lakes and ponds — *Summa samtliga*	**2 778** (48,7 %)	**2 926** (51,3 %)

Accordingly, the question arises: Is the number of males really as large as it would seem from the spawning results, or does it only appear so?

The table 3 now shows that the large male surplus at the spawning run is not typical of the sex distribution at other seasons, but that in the majority of cases the females are approximately equally common. In the lakes with large-sized perch the material has comprised fishes of the same size groups as in the forementioned lakes. Thus, the sex ratio was normal in Lake Mälaren, while the number of males was greater in Lake Hjälmaren. When the total material from the lakes is amalgamated, 1.601 males and 1.701 females are obtained, or 48,5 and 51,5 per cent, respectively.

It is evident from the results obtained also in pond experiments that such a sex distribution is typical of the perch. Even though the number of males may sometimes be greater, sometimes smaller. The percentage figures 49 and 51 per cent are arrived at in an amalgamation of all the samples. The majority of these perch derive from stunted populations in The Perch Tarns. The forementioned sex distribution is typical from the very start, and the large male surplus, reported by RÖPER with regard to the youngest ages, does not agree with the results obtained by the present author.

In this connection, the result from an experiment with 1-summer old perch deserves to be mentioned, where all the 132 examined samples were males. The experiment formed part of a series of experiments with the offsprings of certain selected females and males. Thus, fertilization had taken place by means of the spawn from only one female and with only one male. Apparently, certain changes have then occurred in the gene complex, causing an altogether one-sided sexual determination.

In what manner is the large male number in the spawning run of the stunted populations to be explained? Owing to the difference in size between the sexes, the majority of spawning males have a length of 8—14 cm, while the females begin to spawn only at a length of 9—10 cm, and the maximum number occurs at lengths of 12—17 cm. Among the larger samples, even the females are just as common as the males, in spite of their great absolute scarcity.

As will be shown further on, growth decreases rapidly in these lakes when the perch have attained a length of 12—15 cm and, as far as has been possible to judge, then sometimes ceases almost altogether, the fishes in several cases dying. It is therefore easily assumed that some females never have time to attain the necessary size for spawning, or only take part in the spawning but once or, more rarely, a few times during their lives. Accordingly, in a certain year-class with from the start approximately equal quantities of males and females, the number of times of spawning on the part of the males will be many times greater than that of the females, while the corresponding figure with regard to the females will, perhaps, not even correspond to the number of females. Probably, the females which do not join in the spawning, keep more still and are, therefore, not caught to any particularly great amount. Thus, the actual sex distribution in these lakes does not deviate from conditions in large-sized perch populations.

T a b l e 4. Mean weight in grammes for different length-groups. (Number

Lake *Sjö*	Date *Tid*	L e n g t h			
		7,8–8,2	8,3–8,7	8,8–9,2	9,3–9,7
Abborrtjärn I. .	S[1] 37, H 37, V 38, H 38, S 39, H 39, H 41, V 42, V 43, V 44, H 44		6,0 (10)	7,7 (20) 1,06[2]	8,8 (37)
» II. .	S 35, H 35, V 36, S 36, H 36, V 37, S 37, H 37, V 38, H 38, V 39, S 39, H 39, H 40, H 41	5,0 (23) 0,98	6,1 (35)	6,9 (39) 0,90	8,4 (49)
» III. .	V 37, S 37, H 37, V 38, H 38, S 39, H 40, V 42				
Skarpabborrtjärn	S 39, V 42			8,2 (5) 1,12	
Flasktjärn	S 38				
St. Holmtjärn . .	V 37, S 38				
Hällesjön	S 37, S 38				
Balsjön	S 35, H 35, V 36, S 36, H 36, V 37, V 38, S 39				
Gransjön	V 37, S 38, V 39, S 39				
L. Skärsjön . . .	S 36			9,6 (32) 1,32	10,5 (97)
Sultentjärn . . .	S 38, S 39				
Hjälmaren	S 38, S 39				
Mälaren	V 35, S 36, H 36, H 39, V 42, H 42, V 44, H 44	4,5 (38) 0,88	5,5 (5)	7,8 (3) 1,07	

[1] S = summer, *sommar;* H = autumn, *höst;* V = spring, *vår*. Same in all tables.
[2] Coefficient of condition (Fulton), konditionskoefficient.

in brackets.) — *Medelvikt för olika längdgrupper. (Antal inom parentes.)*

in cm — *Längd i cm*							
9,8–10,2	10,3–10,7	10,8–11,2	11,3–11,7	11,8–12,2	12,3–12,7	12,8–13,2	13,3–13,7
10,2 (62) 1,02	11,6 (83)	13,3 (74) 1,00	15,0 (49)	17,4 (45) 0,93	20,7 (19)	22,5 (13) 0,95	25,9 (15)
9,9 (54) 0,99	11,5 (56)	13,6 (67) 1,02	15,3 (56)	17,3 (80) 0,92	19,2 (82)	21,1 (82) 0,89	23,8 (105)
10,3 (8) 1,03	12,6 (12)	13,5 (27) 1,01	16,1 (24)	17,0 (57) 0,91	19,9 (43)	23,1 (22) 0,98	26,8 (29)
10,2 (8) 1,02	10,8 (5)	13,5 (22) 1,01	14,7 (44)	16,7 (52) 0,89	17,7 (22)	19 1 (15) 0,81	
		13 2 (5) 0,99	16,5 (4)	19,6 (11) 1,05	19,3 (14)	22,4 (53) 0,95	23,5 (41)
							22,6 (10)
				14,6 (29) 0,78	15,8 (24)	18,7 (63) 0,79	21,6 (47)
				16,9 (68) 0,90	18,9 (35)	21,9 (53) 0,93	24,6 (65)
				15,6 (44) 0,83	17,7 (22)	20,4 (45) 0,86	22,8 (60)
11,8 (109) 1,18	13,5 (71)	15,0 (41) 1,13	17,3 (18)	21,7 (6) 1,16		28,4 (10) 1,20	33,0 (5)
							32,6 (16)
11,7 (5) 1,17	12,5 (15)	14,9 (24) 1,12	16,1 (15)	20,5 (37) 1,10	23,3 (63)	24,4 (70) 1,03	27,5 (68)

Lake *Sjö*	Date *Tid*	Length		
		13,8–14,2	14,3–14,7	14,8–15,2
Abborrtjärn I . .	S[1] 37, H 37, V 38, H 38, S 39, H 39, H 41, V 42, V 43, V 44, H 44	29,6 (15) 1,08	33,9 (11)	36,1 (6) 1,07
» II . .	S 35, H 35, V 36, S 36, H 36, V 37, S 37, H 37, V 38, H 38, V 39, S 39, H 39, H 40, H 41	26,0 (171) 0,95	29,1 (169)	33,3 (132) 0,99
» III . .	V 37, S 37, H 37, V 38, H 38, S 39, H 40, V 42	29,7 (34) 1,08	32,5 (43)	35,5 (42) 1,05
Skarpabborrtjärn	S 39, V 42			
Flasktjärn	S 38	25,1 (42) 0,91	27,6 (14)	30,1 (14) 0,89
St. Holmtjärn . .	V 37, S 38	25,4 (25) 0,93	25,7 (37)	30,0 (66) 0,89
Hällesjön	S 37, S 38	22,3 (25) 0,81	23,7 (20)	26,3 (37) 0,78
Balsjön	S 35, H 35, V 36, S 36, H 36, V 37, V 38, S 39	27,9 (99) 1,02	30,5 (134)	34,6 (132) 1,03
Gransjön	V 37, S 38, V 39, S 39	26,0 (73) 0,95	28,3 (51)	32,3 (42) 0,96
L. Skärsjön . . .	S 36			
Sultentjärn . . .	S 38, S 39		35,9 (7)	37,7 (37) 1,12
Hjälmaren	S 38, S 39	35,3 (35) 1,29	38,6 (77)	40,7 (67) 1,21
Mälaren	V 35, S 36, H 36, H 39, V 42, H 42, V 44, H 44	30,1 (112) 1,10	35,9 (107)	38,9 (154) 1,15

[1] S = summer, *sommar;* H = autumn, *höst; V* = spring, *vår*. Same in all tables.

i n c m — *L ä n g d i c m*

15,3–15,7	15,8–16,2	16,3–16,7	16,8–17,2	17,3–17 7	17,8–18,2	18,3–18,7	18,8–19,2
42,0 (6)							
36,9 (108)	40,9 (106) 1,00	45,0 (89)	51,7 (64) 1,05	55,4 (43)	66,0 (21) 1,13		
39,8 (50)	41,7 (49) 1,02	47,6 (22)	51,5 (24) 1,05	55,2 (22)	59,1 (12) 1,01		
32,0 (2)	42,4 (5) 1,04						
33,1 (58)	38,5 (41) 0,94	43,4 (28)	49,4 (30) 1,01	51,6 (16)	60,2 (12) 1,03	69,2 (6)	71,1 (9)
29,4 (21)	32,0 (30) 0,78	39,0 (21)	45,3 (19) 0,92	47,7 (14)			
37,4 (94)	41,5 (100) 1,01	45,2 (97)	50,7 (84) 1,03	54,7 (32)	58,2 (47) 1,00		
37,3 (33)	40,0 (32) 0,98	45,3 (27)	50,3 (15) 1,02	55,0 (20)	61,5 (11) 1,05	65,0 (8)	
38,9 (70)	40,6 (62) 0,99	43,2 (41)	47,3 (21) 0,96	53,0 (10)	51,1 (5) 0,88		
44,3 (48)	47,8 (28) 1,17	52,0 (18)					
42,7 (121)	44,6 (74) 1,09	52,2 (41)	59,1 (27) 1,20	65,7 (7)	73,4 (5) 1,26		

3. Length-weight relationship.

Table 4 gives the results of weight measurements in some of the lakes mentioned previously. In the majority of cases, the primary material is based on collections made in different seasons and in different years, only mean figures being noted in this particular survey. The material includes only the sizes from principally 10 to 16 cm which were to be compared in this connection.

In Fig. 4 the curves offer a graphical illustration of the differences between the weight of perch in some of the lakes. The condition coefficient has also been calculated with regard to certain length groups, according to Fulton's formula $\left(K = \frac{100\ W}{l^3}\right)$.

The relative weight is, apparently, greatest in the large lakes, such as Lake Mälaren and Lake Hjälmaren, with their abundant, large-sized perch populations. An unusually heavy relative weight is manifested by the perch in Skärsjön where, however, the population is typically stunted. An intermediary position is taken by the perch in the three Perch tarns. In these tarns the differences are slight as regards the smallest groups, and the weight figures lie very close also in other groups. However, the Perch Tarn II discloses throughout somewhat lower weight. Flasktjärn, Skarpabborrtjärn and Sultentjärn, with stunted populations, and Balsjön and Gransjön, with larger-sized populations, have mutually rather equal weight figures, but otherwise mostly slightly lower figures than in the tarns. The lowest relative weight throughout is to be found in the perch population in Hällesjön, i. e. a relatively big lake but with a numerous, very stunted population of perch.

Undoubtedly, the weight at a certain length is principally connected with the supply of food. Therefore, it is quite natural that the weight is best in Lake Mälaren and in Lake Hjälmaren where the supply of food is rich. The uncommonly light weight in Hällesjön must, no doubt, be attributed to the exceedingly dense population and the subsequent deficiency in nourishment in the various size groups. The same may be inferred with regard to Holmtjärn where the population of perch was exceedingly large during the years 1937—38 (cp. page 77). However, during the last years a noticeable increase in size has taken place. The low weight in certain cases does not, however, seem to prevent the perch from growing fairly large, as observed in Gransjön and Balsjön, while, on the contrary, a relatively heavy weight may be seen in certain lakes with stunted populations. This is, probably, due to the fact that zooplancton is fre-

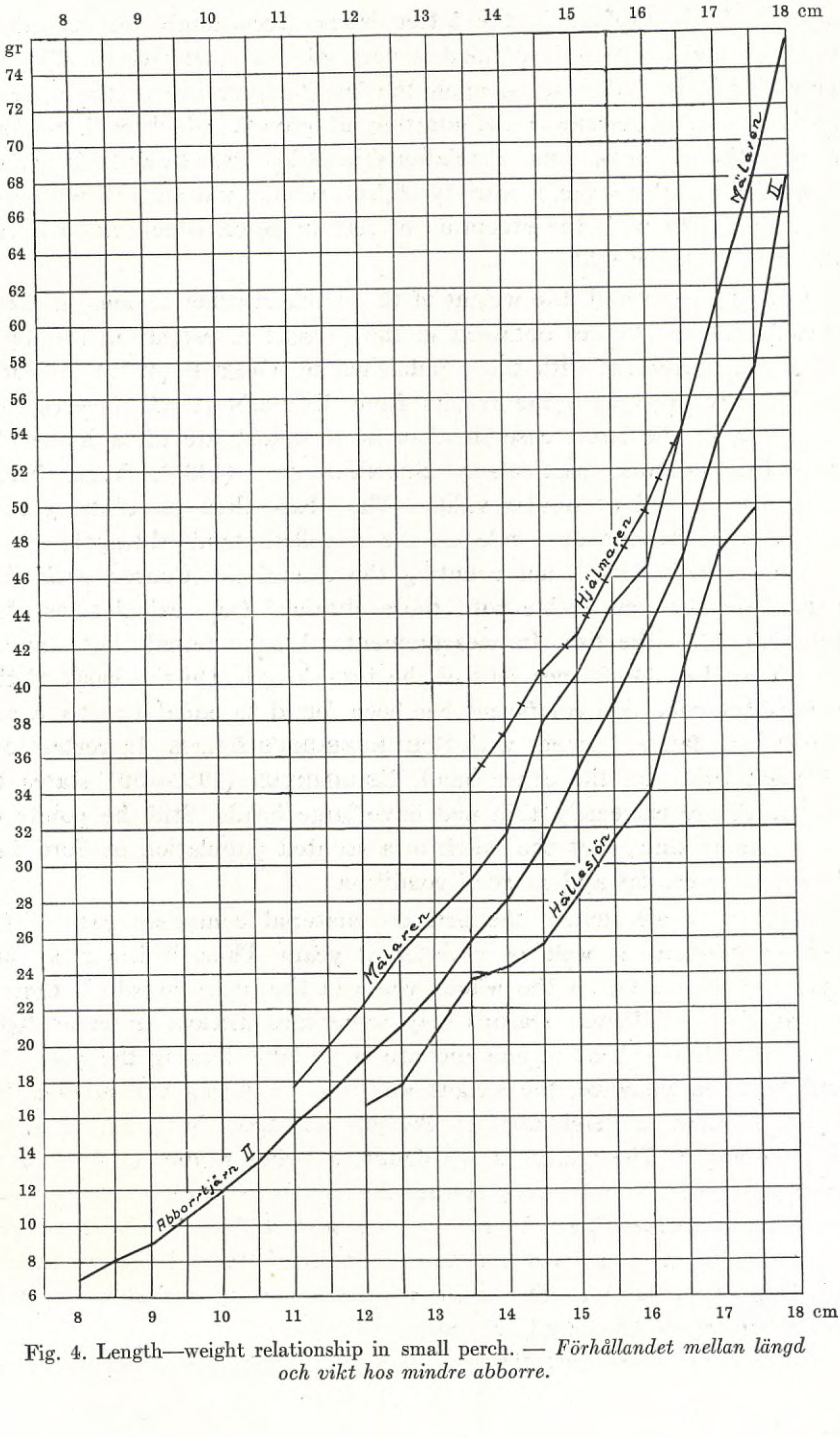

Fig. 4. Length—weight relationship in small perch. — *Förhållandet mellan längd och vikt hos mindre abborre.*

quently fairly profuse in the latter lakes. Accordingly, as regards the younger ages the supply of food is very good in many cases. The short period of growth depending upon the low temperature of the water, on the other hand, causes a delimitation of growth which will, probably, explain the otherwise unusual relationship of bad growth and high relative weight. At a later stage, a scarcity of food sets in and with it deteriorated relative weight with the exception of certain perch which reach a larger size and better weight.

In comparison with the weight of the perch in other regions, it may be stated that the figures obtained in the present investigation are, on the whole, in agreement with those published by OLSTAD (1919) in Norway and, partly, also with the results from RÖPER'S (1936) investigations. However, in the latter case the figures of weight are often higher. The American authors, particularly SÇHNEBERGER (1935), have, broadly speaking, arrived at similar values. They base their calculations of the condition coefficient, as a rule, on the so-called standard-length, i. e. the maximum body length not counting the caudal fin. Consequently, their values are not comparable with those obtained from calculations of the total-length of the fish. In measurements, I have found that standard-length reaches 83—85 per cent of the total-length. On the basis of these values, the condition coefficient has been found to equal $1_{,7}$—$1_{,8}$, a value which is in fair agreement with SÇHNEBERGER'S figures. In certain over-crowded lakes, on the other hand, ESCHMEYER (1937—39) states that the perch are extremely thin and have large heads. Still, he points out, at the same time, that the perch in a stunted population in Ford Lake, Michigan, were fat and in good condition.

As already mentioned, the primary material comprises catches from different seasons as well as in different years. Thus, it has been found that the lakes still, on the whole, come in the order in which they are stated above. Different seasons may sometimes disclose different figures of weight throughhout in one and the same lake. During the years 1935 and 1936, for instance, the weight was heavier during the summer than in the autumn in Perch tarn II, Balsjön and Lake Mälaren, as may be seen in Fig. 5. The reason is, no doubt, a richer supply of food, in the form of plancton and insect larvae, during these summers for perch of the sizes concerned here. In other years such differences have not been ascertainable. At times also a difference in weight may be found throughout from one year to another. Such a phenomenon is, probably, dependent on differences in the supply of food.

However, it is evident that, in spite of discrepancies during different

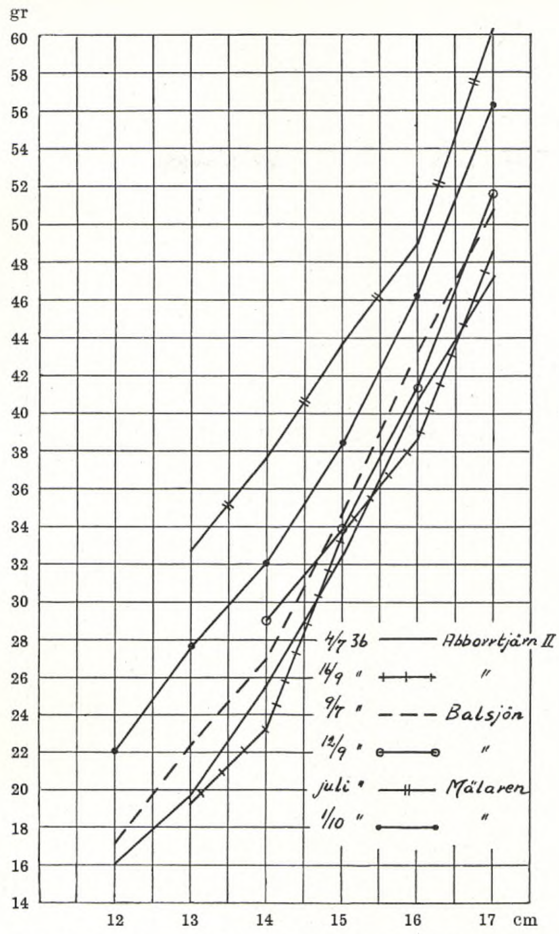

Fig. 5. Length—weight relationship in different seasons.
— *Längd och vikt under olika årstider.*

years, the mean weight of a certain length group varies greatly in different lakes. In the majority of cases a correlation with size exists. Thus, large size and high mean weight, as well as small size and low mean weight in the populations mostly accompany one another.

4. Growth and age.

Since we have now established that a certain correlation exists between the individual size of the perch and the size of the lakes, and that the females grow bigger than the males, the possibility of a connection with size, growth and age will be examined.

Table 5. Mean (actual) length in cm for different age-groups (Number
(Antal inom

Lake *Sjö*	Date *Tid*	Sex *Kön*	Mean	
			2	3
Abborrtjärn I	V 33, V 35, S 36, H 39, V 41, H 41	♂	7,8 (19)	9,6 (17)
		♀		10,7 (3)
		♂ + ♀	7,8 (19)	9,8 (20)
Abborrtjärn II	V 34, H 35, S 36, H 36, H 41, V 42, H 42	♂		
		♀		
		♂ + ♀		
Abborrtjärn III	V 36, H 36, V 41, H 41, V 42	♂		
		♀		
		♂ + ♀		
Skarpabborrtjärn	S 42	♂		10,5 (5)
		♀		10,8 (1)
		♂ + ♀		10,6 (6)
Sultentjärn	S 39	♂		
		♀		
		♂ + ♀		
Kyrktjärn	H 43	♂		
		♀		
		♂ + ♀		
Stråken	V 38	♂		10,8 (7)
Oppmannasjön	V 43, H 43	♂ + ♀		
Mälaren, stunted perch (småabborre)	V 36, H 36, V 42, H 42, H 44	♂		13,5 (34)
		♀	11,3 (8)	13,4 (22)
		♂ + ♀		13,5 (56)

in brackets).—*Medellängd i cm för olika åldersgrupper (empiriska värden).*
parentes.)

length by age of — *Medellängd vid en ålder i år av*							
4	5	6	7	8	9	10	11
11,2 (20)	11,9 (31)	11,7 (13)	12,0 (3)	18,4 (3)	19,3 (2)		
10,5 (4)	11,9 (15)	12,9 (18)	13,8 (8)	13,8 (4)	16,3 (4)	18,2 (3)	
11,1 (24)	11,9 (46)	12,4 (31)	13,3 (11)	15,8 (7)	17,3 (6)	18,2 (3)	
11,0 (19)	12,1 (27)	12,8 (20)	13,8 (16)	14,2 (9)	15,2 (12)	15,6 (14)	15,6 (8)
11,3 (6)	12,1)12)	13,1 (12)	13,8 (6)	14,9 (10)	16,5 (6)		
11,0 (25)	12,1 (39)	12,9 (32)	13,8 (22)	14,6 (19)	15,6 (18)	15,6 (14)	15,6 (8)
10,5 (8)	11,1 (18)	12,5 (16)	13,5 (8)	15,3)15)	17,7 (7)	17,6 (3)	
		13,3 (3)	13,5 (9)	14,1 (3)			
10,5 (8)	11,1 (18)	12,6 (19)	13,5 (17)	15,1 (18)	17,7 (7)	17,6 (3)	
11,2 (14)	11,7 (19)	12,2 (11)	12,3 (3)				
11,2 (8)	11,8 (11)	12,5 (20)	12,9 (7)				
11,2 (22)	11,7 (30)	12,4 (31)	12,8 (10)				
	15,6 (9)	15,6 (11)	16,0 (9)	17,0 (1)			
	15,6 (5)	15,5 (13)	16,2 (10)	16,5 (6)			
	15,6 (14)	15,6 (24)	16,1 (19)	16,3 (7)			
	20,3 (2)	20,5 (2)					
	21,0 (13)	20,9 (6)					
	20,9 (15)	20,8 (8)					
11,9 (12)	13,4 (4)	14,9 (3)					
14,2 (13)	16,3 (22)	19,9 (15)	23,8 (5)	25,5 (8)	29,0 (8)		
13,7 (45)	13,9 (69)	14,3 (63)	15,3 (49)	15,7 (26)	17,4 (6)		
14,2 (20)	13,7 (10)	15,1 (31)	15,5 (27)	16,0 (24)	16,6 (6)		
13,8 (65)	13,8 (79)	14,6 (94)	15,3 (76)	15,9 (50)	17,0 (12)		

T a b l e 6. Calculated mean length in cm for different age-groups. Results

grupper i vissa tidigare under-

Lake *Sjö*	Auctor	Date *Tid*	Sex *Kön*	Mean	
				1	2
Mälaren, Västeråsfjärden	Nilsson	Maj 1914	♂	3,7	6,9
Mälaren, Västeråsfjärden	»	» 1914	♀	4,1	7,5
Hjälmaren, St. Sundby	Alm	» 1916	♂ + ♀	3,9	7,9
Toften, Örebro län	»	1917—1918	»	4,1	7,9
Yxtasjön, Södermanlands län ..	»	1918—1920	»	3,0	5,7
Östersjön, Kallrigafjärden, Uppsala län	Nilsson	Juni 1914	♂	3,9	7,0
Östersjön, Kallrigafjärden, Uppsala län	»	» 1914	♀	3,9	7,3
Bottenhavet, Sandön (Luleå skärgård)	»	» 1914	♂	4,5	7,8
Bottenhavet, Sandön (Luleå skärgård)	»	» 1914	♀	4,7	8,0
St. Öivann, Norge	Olstad	1917—1918	♂	3,9	7,0
St. Öivann, Norge	»	1917—1918	♀	4,0	7,2
Helgeren, Norge	»	Juli 1917	♂	4,0	6,9
Helgeren, Norge	»	» 1917	♀	4,2	7,2
Mårsjön, Norge	»	Aug. 1918	♂	3,8	7,5
Mårsjön, Norge	»	» 1918	♀	3,8	7,3
Mjösen, Norge	»	—	♀	4,0	7,3
Storsjöen, Norge	»	—	♀	4,5	7,2
Thusby träsk, Finland	Brofeldt	1915	♂ + ♀	3,2	6,1
Längelmäväsi, Finland	»	1917	»	2,9	5,0
Ladoga, Finland	Jääskeläinen	1917	»	5,9	9,3
Müggelsee, Berlin[1]	Röper	—	♂ ♀		
Flera sjöar i Preussen	»	—	♂ + ♀	7,2	9,0
Michigan Lake	Hile and Jobes	—	♂ ♀	6,2 6,1	9,9 9,9
Weber Lake, U. S. A.[2]	Schneberger	1932	♂ ♀		

[1] Actual lengths — *Empiriska värden.* [2] Growth not ended — *Tillväxten för året ej av-*

from earlier investigations. — *Beräknad medellängd i cm för olika åldersökta sjöar i olika länder.*

length by age — *Medellängd vid en ålder av*										
3	4	5	6	7	8	9	10	11	12	13
10,7	14,6	17,9	20,1	22,2	24,2					
10,0	13,1	16,7	20,0	22,5	24,9	26,2	27,7	29,6		
11,6	15,6	19,5	22,6	25,8	27,4	31,6	32,5			
11,8	15,0	17,6	20,2	23,6						
11,9	13,0	13,9	14,7	15,8						
10,4	13,4	16,0	18,3	20,2	21,9	21,4	25,4			
10,9	14,0	17,1	19,6	21,9	23,9	26,3	28,2	30,3	32,3	33,7
11,3	14,2	15,8	17,0	18,6	19,8					
11,2	14,1	17,0	19,0	21,8	24,1	26,3				
9,7	12,2	14,6	15,9	17,6						
10,3	13,0	15,3	17,2	19,2	22,0	25,0	28,1			
9,3	11,5	14,2	15,8	18,4						
10,0	12,8	15,1	17,1	19,2	22,2	25,0				
11,0	13,9	15,2	17,7							
11,0	14,1	16,0	18,4	20,6						
11,0	14,5	18,5	22,0	25,3	28,2	30,5	32,2	34,0		
11,0	14,8	18,7	21,8	24,7	27,0					
7,7	11,3	13,9	17,1	17,7	19,3	24,3				
7,5	10,0	12,5	15,0	17,5	20,6	23,0	25,0	27,5	29,5	32,0
12,8	14,9	17,2								
		12,7	13,4	13,7	—	—	17,8	18,6	—	20,6
		13,2	13,8	14,5	16,6	17,4	—	18,6	20,2	21,4
10,2	11,2	12,6	13,4	14,8	16,2	17,7	—	19,0	—	22,0
13,0	15,9	18,5	21,1	22,7						
13,2	17 3	19,7	22,8	25,1	26,8					
10,7	12,5	12,7	16,6	17,1	18,1					
11,0	15,8	16,7	18,9	20,2	21,0					

slutad.

It is important, then, from the start to make a clear distinction between certain definitions. In the preceding pages, the individual size of the perch has been mentioned and, in connection with it, reference has been made to whether the populations were small-sized or large-sized. This has only served to express the most usual size in the population but not whether the growth has been bad or good. Most often, as shown below, small size and slow growth are connected, but this need not always be the case. A population of small-sized perch may also be due to the fact that the fishing is carried on so intensively as to prevent the fish from having time to grow to a greater length. In such cases, though fairly rarely, the growth itself may be good.

In the present work, the age has been determined in several of the experimental lakes. The scales have been used in this process, in certain cases the opercular bones. Attempts have been made with polished otolites, though with very unsatisfactory results. Also the scales and opercular bones have generally been difficult or even impossible to use. Accordingly, no back calculation of length at earlier ages has been performed, in view also of the fact that the material in the majority of cases comprises the younger age groups. It has therefore been considered more correct to use only the empirical values. However, these latter values must also be regarded as fairly uncertain, as must the results of all investigations of the age of particularly the slowly growing perch be accepted with great caution. Still, some guidance with regard to the value of the determinations has been obtained in certain lakes by the measurements of length performed during different years, in the course of which different year-classes and their increase in length have been ascertainable. In Table 5 the figures of growth in the experimental lakes have been put together. Table 6 shows the figures of growth in certain other lakes examined earlier.

In determinations of the growth of the perch in Sweden and other countries, growth has been found to vary rather considerably and, above all, the age is very different in different quarters. Thus, the figures of growth in certain Finnish and German lakes are generally lower than those of the lakes in Norway and Sweden, although there are exceptions as, for instance, in lake Lohilämpi in Finland (Jääskeläinen 1917) and in the lower Elbe (Mohr 1922). Information from the North-American lakes, as a rule, indicates very good growth, considerably better than in the large-sized perch populations in the European lakes. At the same time, the age of catching in America is much lower, being often only 3 or 4 years. In fact, an age higher than 10 years is seldom reached there

(HILE 1942, JOBES 1933, SCHNEBERGER 1935). LINDHÉ (1942) has propounded the opinion that in the lakes of Sweden a large amount of the perch die at the early age of 4 or 5 years. SCHNEBERGER contends, on the basis of his own and other American investigations (particularly HARKNESS 1922), that in lakes where the perch grows slowly it becomes older (8—9 years), while in lakes with good growth it does not attain this age (only 5—6 years), although it is even then larger than the forementioned individuals of 8—9 years of age. SCHNEBERGER as well as WAGNER (1910) have, furthermore, pointed out that reversed conditions occur between growth and the density of the populations. OLSTAD (1919) states that the greater length of the perch in large lakes than in small ones is due to the fact that the perch attains a higher age in the former, while the growth is fairly equal in both cases.

As regards the annual growth, scientists in America generally state it to be extremely good during the first two years of life. After this it decreases in connection with sexual maturity, only to increase again after a couple of years. On the other hand, in the populations where a high age is not attained, the growth is exceedingly slow after the very first years. RÖPER (1936) reports the growth to be good during the first year, but after this it becomes slow for several years and then gradually increases. Otherwise, data vary considerably on this point. In Lake Windermere in England, with from the start of the investigations a very dense perch population, LE CREN (1944) found the growth to be good during the first two years with a mean length of 10 cm, but after that it decreased. The main part of the spawning perch had an age of 2 years for most of the males and 3 years for some of them, being 3 and 4 years for the females.

My investigation results, as compared with earlier results from Swedish and foreign lakes, show the possibility of distinguishing between two types of growth among the perch, corresponding to the large-sized and stunted populations, although, of course, all transitional types do occur. In large and medium-sized lakes and at the coast, where the populations are generally large-sized, the growth is fairly even and continues to a high age of over 10 years and more. However, the growth must be regarded as relatively slow in comparison with, for instance, that of the salmonoids and the pike. In small lakes with stunted populations, the growth during the first 1 or 2 years, sometimes for longer, agrees comparatively well with the growth of the perch in the large lakes, but after this period it decreases rapidly and sometimes ceases almost entirely. In the former case a length of 10 cm is attained at about the age of 3 years, 20 cm at about

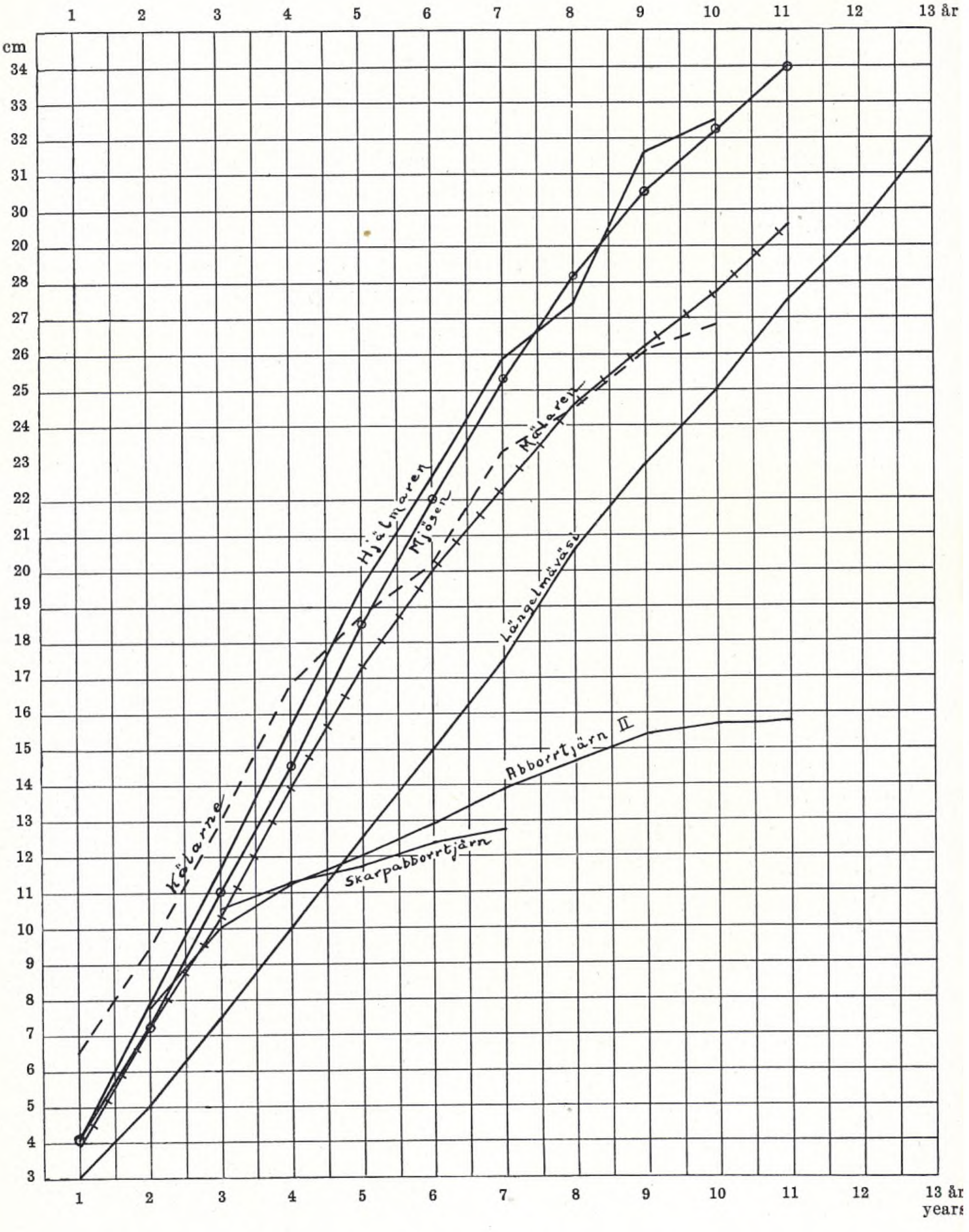

Fig. 6. Average rate of growth of perch in some lakes and in ponds at Kälarne. — *Tillväxtkurvor för abborre i några olika sjöar samt i dammar vid Kälarne.*

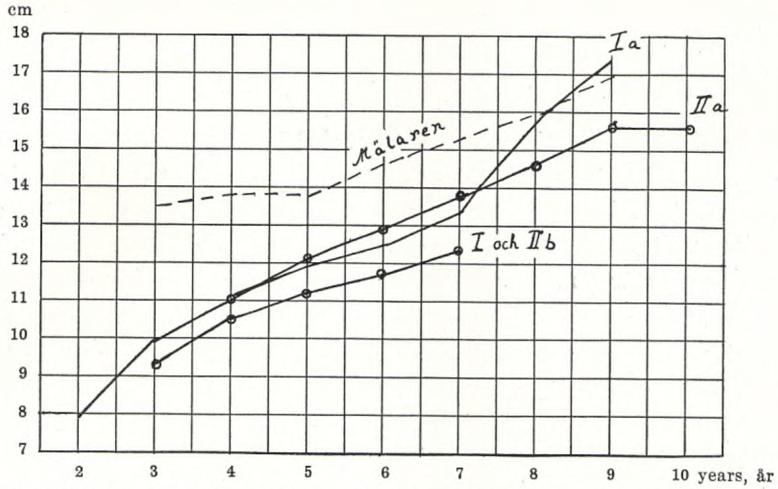

Fig. 7. Actual (a) and calculated (b) growth curves from annual collection analysis in the Perch Tarns nos. I and II, as well as the actual growth curve of small-sized perch in Lake Mälaren. — *Empiriska (a) och efter årliga fångstanalyser beräknade (b) tillväxtkurvor för Abborrtjärn I och II samt empirisk tillväxtkurva för småväxt abborre i Mälaren.*

6 or 7 years, and 30 cm at 10 or 11 years. The most common age of catching is 6—10 years. On the other hand, in the stunted populations the age at a length of 15 cm is most often 8—10 years, and a length of 20 cm is reached only by some individuals, while a length of 30 cm never occurs or but in exceptional instances. Particularly in the smaller tarns, the growth stops in the majority of individuals even at a length of 12—14 cm, without therefore resulting in the death of these perch. Markings of these fishes have shown that they are often alive year after year, without increasing particularly in growth. However, sometimes a greater mortality occurs. In fact, on the whole, the age of the individuals in these stunted populations does not seem so high as in the large-sized populations. Accordingly, OLSTAD'S contention, that the perch with a rapid growth usually become older and, consequently, also larger, finds some support in these observations. However, the determining factor as regards size is, in the first place, the difference in rapidity of growth which sets in after a few years.

Returning to the subject of the growth of the stunted populations, the curves in Fig. 6 do not give the actual state of affairs. The explanation is as follows: The perch whose age has been determinable with some degree of accuracy, without doubt, concern individuals with fairly good growth. In the case of individuals with particularly slow growth, the annuli become so thin and close together as to render a determination of age quite impossible. The curves will therefore reflect a better growth than is typical of the population in question. This is proved in Fig. 7 where the size curves of the perch from two of the Perch Tarns have been presented, being based partly on the above-mentioned examinations of age, and partly on the measurements of length dealt with in a later chapter. In the latter case, I have taken for granted that the perch with a length of 7 cm have been 2 years of age, and have described the curve accordingly. It will be noticed that this curve runs considerably below those based on the age analysis, which reveal an increase in growth at a somewhat higher age. This is due to the fact that, in this particular case, individuals are concerned which in the lakes with stunted populations have, already at an early stage, changed over to a fish diet, owing to better capacity of fending for themselves, greater competitive power, definite taste, etc., and have in this way grown more rapidly and become larger in size than the great majority of the others. This applies especially to the females. In Perch Tarn II, one female perch attained a length of over 30 cm. This circumstance has been established earlier with regard to other species of fish, and recurs regularly at all sorts of breeding of fish in ponds.

It is far more remarkable sometimes to find smaller populations occurring in lakes simultaneously with large-sized perch populations. While examinations of growth performed on large samples from, for instance, Lake Mälaren show throughout good growth, an examination of small samples disclose frequently during the last years a growth more resembling that of the stunted populations. Thus, apart from the collections made at the Institute of Fishery Research during the years 1936, 1942 and 1944, great quantities of perch have been captured, including males as well as females, which have revealed bad growth (cp. Tables 5 and 6, as well as Fig. 7, where a curve has been drawn in illustration of this), and at the age of 5—8 years have only attained a length of 13—17 cm. It seems fairly improbable that these perch should later on have a so much better growth as to become as large as the large-sized perch occurring in the same lake. Probably, this concerns individuals which have belonged to rich year-classes and very large shoals, with subsequent less favourable feeding conditions and deterioration in growth. Since these small perch seldom become caught, the number of them must easily become rather large. Among the youngest perch, included in the age analysis, according to which the curve has been drawn, the mean length will be seen to be approximately equal in 3-, 4- and 5-year-olds. This is probably due to the inclusion of quite a number of individuals with good, continuous growth also afterwards. During the Autumn of 1945, perch of the forementioned sizes were not particularly common while, on the other hand, there was an abundance of perch in the sizes 5—7 and 11—13 cm. These sizes corresponded to the 2 and 3 age groups, thus revealing normal growth. Simultaneously, captured 1-summer old perch had a length of only about 3 cm. Corresponding empirical figures of length of 1-, 2- and 3-summer old perch have been found earlier in the Swedish Yxtasjön (ALM 1922).

RÖPER (1936) has also drawn attention to the fact that the growth may vary in small perch. However, he is, apparently, of the opinion that the assumed better growth of the large perch does not correspond to actual conditions, but is due to neglect of differentiation between the growth of the first years of life and that occurring later on. Accordingly, these large perch should be older and should have had a less good growth than assumed in their youth. However, as we will soon find, the large-sized perch undoubtedly had a good growth capacity even at an early stage and, for this very reason, have attained a greater length.

Further, RÖPER, as well as WALTER (1934), SCHIEMENZ (1905), and others, distinguish between three different forms, viz., »Krautbarsche» which frequent the vegetation close to the shores, have a high shape of the body, vivid colouring, and feed on the various lithoral forms, »Tiefenbarsche» which collect in the deep waters, are longer, have a dull colouring, and eat mainly fish, and »Jagebarsche» which live in the upper layers of the water, also have a duller colouring, and eat fish and plancton. The latter are, as a rule, smaller than the »Tiefenbarsche» and, according to RÖPER, even the »Krautbarsche» grow less well than the »Tiefenbarsche». The difference in appearance is, mainly according to RÖPER'S examinations, dependent on the whereabouts of the fish and the nature of the food. It is not a question of different races, from a genetic point of view, but the various forms will freely intermix. Such different forms of perch occur also in several of the larger Swedish lakes. They have been described in greater detail by LINDHÉ (1942) who has called them pond-weed perch, smelt- or deep-sea perch, alburn or hunting-perch.

The occurrence of perch populations with discrepancies in growth and individual size in one and the same lake has also been mentioned by VARGA and MIKA (1937) from the Neusiedlersee (Ungarn). Thus, this lake earlier contained quite a stunted, extremely common form of perch which lived along the shores, while a large-sized but rather sparse form kept out in open water. However, no information has been given regarding age in this particular case. SUJETOW (1934) in Russia has reported the occurrence of a large-sized and a small (stunted) form of perch in one and the same lake, the former disclosing good growth, with a length of 17—19 cm as soon as after 3 years.

As already mentioned, there is in the majority of cases a discrepancy as between the size of the two sexes of the perch, the males being more common among the smaller individuals, the females more often forming the majority among the larger fishes. Even OLSTAD (1919) and HUITFELDT-KAAS (1927) ascertained this discrepancy among the sexes and explained it as due to a generally better growth on the part of the females, the growth of the males decreasing more rapidly. This difference in growth between the sexes has also been proved in American investigations, where the females have been found to be larger as early as in the third or fourth year of life. In Lake Mälaren, according to NILSSON'S (1921) examinations, the growth is approximately equal between the sexes. However, NILSSON'S material was rather too restricted, i. e. comprised 21 males and 16 females, for a definite conclusion. OLSTAD states that this discrepancy in the size of the sexes and their growth is more conspicuous in the stunted populations than in the large-sized populations. LASKAR (1940) is of the same opinion. Still, in both these latter cases, the materials were too small for a definite analysis of this problem.

This different growth of the sexes also applies to the populations in the present investigations. In the cases where the sexes have been kept apart, the females reveal throughout a somewhat better growth. However, this is not manifested during the first years of life, but the older the perch the more distinct is the discrepancy. Table 1 illustrates the fact that in populations with a very slight individual size as well as in the opposite case, small differences in length [Perch Tarns I and II, Hällesjön, Hjälmaren, Mälaren, Vänern (Kolstrandsviken)], as well as great differences in length [Perch Tarn III, Bodsjötjärn, Gransjön, Oppmannasjön, Öljaren, Vänern (Höljebol, Leksberg)] are to be found between the sexes, even though the differences are fairly insignificant among the stunted populations. However, also in the cases where the growth is more similar, do the females grow bigger than the males. It is impossible to decide whether this is due to the fact that the growth of the males at a higher age becomes so slight as to be unnoticeable and unascertainable from the scales, or to the fact that the males die earlier than the females. In all probability both these factors cooperate. Nevertheless, the capacity of the males to live long without showing any marked growth is evident from the experiments discussed later which were performed in the tarns, as well as from the above-mentioned great male surplus in the Perch Tarns during the first experimental years. The smaller size and earlier decrease of growth on the part of the males is, however, characteristic of the large-sized as well as the stunted populations.

II. Experiments in lakes and ponds.

The results of measurements of length and determinations of growth have shown that the perch generally becomes larger in the big lakes than in the small ones. This has been found mainly due to a fairly good growth which usually continues for several years. On the other hand, the stunted perch populations are soon subjected to a decrease in growth which is accentuated until the increase in length becomes, in several cases, almost unnoticeable. Further, a distinct difference in size between the sexes has been observed, owing to the better growth of the females during later years.

The question may be asked: What is the reason for this discrepancy in growth among the various perch populations? The answer is, in the first place, to be found in the nature and supply of the food in relation to the individual amount in the populations, as well as in the environmental conditions. The discrepancies in size and growth may, conceivably, be due to the occurrence of races with genetically different capacities of growth, or to intensive fishing, preventing the perch from growing up to a bigger size.

A number of experiments have been performed for the purpose of a closer analysis of these problems. These experiments have consisted, partly, of a reduction of the stunted populations by intensive fishing, or by the planting of predatory fish, thus improving the feeding conditions for the individual fishes, partly of producing the same results by transfering perch from stunted populations to waters with more favourable external conditions, and partly, finally, of breeding the spawn from such populations under varying environmental conditions in order to study the effect of the environment on growth. Before describing these experiments, a brief survey will be given of the nature and supply of the food of the perch.

1. Nature and supply of the food.

The most detailed investigations of the food of the perch have been presented by ALLEN (1935), RÖPER (1936), PEARSE and ACHTENBERG (1917—18), and the present author (1922). Broadly speaking, the results show that the perch principally feed on plancton during the first year of life. In the following years, they eat, apart from plancton (the *Leptodora* in particular), also diverse small animals, such as especially the *Chironomus*-larvae, as well as dragon-fly larvae (e. g., the *Ephemeridae*), the *Gammarus* and the *Asellus,* and sometimes small fish. When a greater length has ben attained, i. e. up to 15—20 cm, the perch changes over to a diet of fish and cray-fish whenever these are obtainable. However, the food varies considerably in different lakes and in accordance with the whereabouts and the season of the year. At times a shoal of perch has almost exclusively fed on small animals, at other times only on plancton. This may, as mentioned earlier, influence the appearance, as well as the growth and size of the perch. According to RÖPER, more plancton are consumed during the winter than during the summer. PEARSE and ACHTENBERG have studied this seasonal variation, mainly with regard to small perch. They have, in the course of these examinations, ascertained marked variations in the food. This has also been observed by CONEY (1935) and REIGHARD (1914). PEARSE and ACHTENBERG mention that the perch consumes daily 7 per cent of its own weight. Further, they found the smelt to be the most in demand, next followed by the roach, the alburn, the ruffe and the small perch. When the smelt, the roach and the alburn are unavailable, OLSTAD reports that even perch of a length of 20—25 cm often keep to a diet of small animals, less frequently going for small perch and minnows, and still more seldom for trout and the char. On the other hand, ALLEN found that small perch play an important part in the food of the perch, in spite of the fact that the tables presented are not quite in agreement on this point. Also ESCHMEYER is of the opinion that the perch, at the age of 3 and 4 years, to a large extent feeds on the youngest year-classes of its own species. According to RÖPER, the usual length of the small fish, which form the food of the perch, equals 6—8 cm. Cray-fish are included in the food to a great extent in certain lakes, and small cray-fish are consumed even by perch of a length of 10—12 cm.

Examinations of the food of the perch have been performed in the Perch Tarns, as well as in some of the other experimental lakes. The results have ben presented in Table 7. In this connection, perch of different lengths have not been kept apart, owing to the fact that the examined size groups comprise, above all, the medium-sizes of 10—15 cm. In the Perch tarns, the *Chironomus*-larvae most frequently form part of the food of the perch. Thus, in a total of 437 examined perch, these larvae have occurred in 163 cases. However, in tarn no. III other insect larvae are still more common. They also often occur in tarn no. II, i. e. the *Ephemeridae,* in particular, while the *Copepoda* come second in tarn

Table 7.

Nature of food. — *Födans beskaffenhet.*

Lake *Sjö*	Date *Tid*	Length *Längd*	Number investig. *Antal ex. undersökta*	Number with food *Därav antal ex. med maginnehåll*	Number with — *Antal med*: Cladocera	Copepoda	Corethra	Chironomidoe	Insektlarver (andra)	Insekt-imagines	Fish Fiskrester	Plants Växtrester	Diverse
Abborrtjärn I	S 36—H 44	9—17	279	126	19	35	5	46	19	7	1	48	—
Abborrtjärn II	S 36—H 44	8—20	314	154	16	22	15	58	30	25	15	28	—
Abborrtjärn III	S 36—H 44	9—22	311	157	32	21	23	59	69	27	3	13	—
Sultantjärn	S 38	15—18	137	97	38	3	—	9	7	24	1	5	63[1]
Hjälmaren	S 38	13—17	91	81	40	12	—	—	—	6	17	9	42[2]
Mälaren	V 36—H 36 V 44	12—17	160	77	13	8	—	19	8	26	4	1	14[1 2]
Kälarne, ponds, dammar 1—4	H 38	8—13	166	156	141	36	—	111	101	33	—	24	—
Kälarne, dammar 8—9	H 42	7—14	77	50	10	—	—	17	44	1	1	1	—
Kälarne, dammar 20, 21, 29	V 43	7—16	60	52	—	—	—	10	35	1	—	—	9[3]

[1] Asellus. [2] Leptodora. [3] Iglar.

no. I, although even in this tarn the insect larvae are of more importance as a food, owing to their size, than are the small *Entomostraca.* The *Cladocera* are fairly common. This shows that plancton still play an important part in the diet of perch of these sizes. The *Corethra* larvae have been distinguished from the other insect larvae, being rather frequent in particularly tarn no. III. The *Imagines* are, apparently, also of significance in this respect. However, it is evident from Table 8 that perch of suitable sizes, at least in tarns nos. I and II, must have been abundant in the year 1938 when the principal examinations of food were carried out. Finally, it is noteworthy that the remains of plants are contained in the food of a large number of samples. They may, perhaps, have formed part of the tubes of the *Trichoptera*-larvae. No palpable differences in the food during the various seasons have been ascertainable. Still, in 1938, the *Chironomus*-larvae were found to be most frequent in the Spring in all the tarns, while the *Imagines* were more common in the Autumn.

In Sultentjärn, the food of the perch shows to some extent other characteristics. Here, the *Asellus* predominates entirely, being followed next by the *Cladocera,* and thirdly, by the *Imagines,* while the *Chironomus* and other insect larvae are more scarce. Only 1 sample out of 97 at the size of 15—18 cm had eaten fish. Among 81 equally large perch from Lake Hjälmaren, on the other hand, as many as 17 samples had eaten this type of food, and a large quantity of plancton, above all the *Leptodora* and the *Cladocera.* No insect larvae were noted in this case. In Lake Mälaren, fish had not been contained in the food to the same extent as in Lake Hjälmaren. Finally, a number of perch of the size of 8—13 cm have been examined, having been kept in ponds without special feeding. In this particular instance, insect larvae predominated (the *Chironomus,* as well as, still more, the *Ephemeridae*), and in the Autumn of 1938 the *Cladocera.* The *Copepoda* and the *Imagines* come far behind in demand. The remains of plants have also been observed in this case. It should be pointed out, in this connection, that in the ponds where large perch have been kept and spawning has taken place, in certain autumns a good number of 1-summer old perch have occurred. They have, apparently, not been eaten up by the larger specimens.

These results confirm what has been said above regarding other examinations of the food of the perch. In addition, they show that, in the lakes where only perch occur, the small perch do not constitute a particularly tempting food for the medium-sized perch. Otherwise, the small perch should undoubtedly have been consumed to a far greater extent.

This is apparent from a comparison between Sultentjärn and Lake Hjälmaren, where perch of about the same size have been examined in either case. In Sultentjärn, approximately 1 per cent of the perch have eaten fish, while the corresponding figure in Lake Hjälmaren is 21 per cent. The results from the ponds point in the same direction. This is, of course, also due to the fact that the perch have not attained the size at which they more generally change over to a fish diet. It is, moreover, possible that the young perch were rare in Sultentjärn. Further, the occurrence of the remains of plants is noteworthy, as well as of the *Corethra* in the tarns. Some of the experimental results obtained by ESCHMEYER (1938) further confirm these data. In a lake like Ford Lake, with only perch from the start, large quantities of minnows had been planted for the purpose of increasing the food supply. An examination of the food a year or two afterwards disclosed that 25 perch out of 100 had eaten minnows, while only one perch had taken a young one of its own species.

From the above, it will be seen that one of the reasons for the varying growth and size of the perch in different lakes is, undoubtedly, to be found in the nature and supply of the food, the fish diet being the decisive factor with regard to the attainment of a larger size. In the several small lakes, where the perch does not become large in size, fish but seldom plays any particular part as a food. This is, no doubt, due to the fact that the fish species which are the most appetizing, i. e. above all the smelt, the roach and the alburn, are lacking in these lakes. The occurrence of smaller perch does not seem to stimulate a change over to a fish diet to the same extent. Furthermore, as will be shown below, during certain years small perch of a size suitable for food are very sparse in these lakes. It is also conceivable that the more unfavourable environmental conditions in these lakes, which will be touched upon later, have a diminishing influence on the appetite and directly serve to reduce the consumption of food.

In the literature on this subject, it has been reported that the laying out of bundles of shrubs is a good means of increasing the food and improving the growth of stunted perch populations (ECKERBOM 1937, LINDHÉ 1942). A gathering of the smallest young perch in and outside of these bundles of shrubs in order to get at the richer supply of food there, would cause the large perch to be more easily tempted to begin eating these small perch than if they were more scattered. This seems rather plausible from a theoritical point of view. However, many experiments with bundles of shrubs in typical tarns with small perch (Sjulsontjärn, Flasktjärn and Abborrtjärn III) have as yet not confirmed this.

The conditions in the large lakes with their abundance of small fish of all kinds must be far better than in the tarns. Naturally, the growth in these large lakes should be capable of continuing even at a higher age, resulting in the large-sized perch populations which are common there. OLSTAD (1919), it is true, is of the opinion that no particular difference exists between the rapidity of growth in different lakes, in spite of the great variation in feeding conditions. However, his figures of growth are not in very good agreement with this statement, rather confirming what has been said above. RÖPER (1936) contends that there is no close connection between the growth and the nature of food. Instead, he states that growth is determined by the density of the populations. However, from the above it will be seen that the abundance and nature of the food form decisive factors. The density of the populations is of very great indirect significance in this respect. This has been suggested above as an explanation to the occurrence of populations of small-sized perch with fairly slow growth observed in lakes with large-sized populations. The occurrence of typically stunted populations, which can often be accounted for in this way, is illustrated by the experiments described further on in this work and has, moreover, as already mentioned, been pointed out by American investigators.

However, not only does the supply of small fish vary in different lakes. Also plancton and various lower animal species belonging to the lithoral and bottom fauna, principally insect larvae, disclose a markedly varying occurrence both as regards species and individuals. In the case of the plancton, this does not, as first pointed out by NAUMAN (1921), apply so much to the zooplancton, since even in apparently very unproductive lakes, of especially a dystrophic type, the humus substances collected in the water are consumed by the *Cladocera* and, accordingly, render a fairly profuse supply of such organisms possible. On the other hand, the phytoplancton is more sparse in the less abundant forest and moss lakes than in the eutrophic lowland lakes. Several authors (ALM 1922, 1943, BRUNDIN 1942, JÄRNEFELT 1917, LUNDBECK 1926) have proved that this also concerns the lithoral and bottom fauna, even though the bottom fauna, in many lakes of an apparently unproductive type, has been found to be a good deal more abundant than could at first be presumed.

Finally, it should be borne in mind that the shore region in many small forest lakes often consists of quagmires, the sides of which are either steep or hollowed out underneath. Accordingly, the region accessible to the lithoral fauna becomes extremely restricted and the fauna, to a corresponding degree, becomes poor (ALM 1943).

2. Experiments regarding stunted populations.

a. Experiments in the Perch Tarns (Abborrtjärnarna).

(Year-classes, reduction by fishing, etc.)

Reports have been issued from many quarters stating that a reduction of stunted perch populations by intensive fishing or through the planting of predatory fish has involved an increase in the individual size. However, no direct figures, based on the measurements of a more comprehensive material, demonstrating this phenomenon exist in the literature at our disposal.

At Kälarne, systematic experiments of this type have been made in different lakes with stunted perch. Firstly, the experiments in the Perch Tarns I—III will be accounted for. As regards the nature of these lakes, reference may be had to Table 2. Apart from the possibility of decimating the populations and thereby increasing their growth and value, the purpose of these experiments was to study the individual number in the populations and the usual size of the perch, their growth and food, as well as the occurrence of different year-classes.

Principally, traps have been employed as catching gear with different mesh-sizes (¼ and ½ inch mesh-size), fyke nets with a mesh-size equalling 2,7 cm, gill nets with a mesh-size of 2, 2,5 and 3 cm, a herring-net with a mesh-size of 2 cm, a seine with a mesh-size of 1 cm, long-lines and hook-and-line fishing. Thus, a direct selection of only certain sizes has not been possible.

During the first years, the experiments took place in the spring, the summer, and the autumn, in later years only in the spring and in the autumn, or in one of these seasons. During most of these years, a number of the perch were marked in the spring by the cutting away of a certain fin. This is a method of marking which has proved excellent with regard to the perch, owing to the fact that its fins seldom grow out provided the cutting is done carefully. These marked perch were recaptured in the summer and autumn of the same year, as well as in later years. The cutting away of different fins for each year has made it possible to identify the various annual markings. Principally males have been marked in this way, but in certain years also several females.

The experiments were commenced in the years 1933 and 1934, according to slightly different principles in each of the three lakes. Thus, in tarn no. I the main purpose was to determine the effect of intensive fishing on the population. Accordingly, in the first seven years all the captured perch

Table 8. Mean length in cm of spawning perch in the
i Abborrtjärnarna

Lake *Sjö*	Year År	Sex *Kön*	Number *Antal*	% ♂ + ♀	Mean l. *Ml.*	Length		
						6	7	8
Abborrtjärn I	1935	♂	100	100,0	11,5			
	1936	♂	100	1000,	11,7			
	1937	♂	50	100,0	11,6		1	
	1938	♂	665	96,0	10,4		2	31
		♀	28	4,0	10,9			
	1939	♂	402	90,3	12,1	1	1	5
		♀	43	9,7	12,9			
	1940	♂	32	53,3	11,4	4		
		♀	28	46,7	16,4			
	1941	♂	729	96,8	8,4	4	150	310
		♀	24	3,2	17,0			
	1942	♂	1 683	91,4	9,3		14	425
		♀	159	8,6	10,8			9
	1943	♂	205	74,3	10,3			7
		♀	71	25,7	10,5			
	1944	♂	429	75,5	10,6			
		♀	139	24,5	11,3			
	1945	♂	224	50,2	10,8			2
		♀	222	49,8	11,6			
Abborrtjärn II	1934	♂	505	95,3	13,5			
		♀	25	4,7	14,3			
	1935	♂	191	95,5	14,0			
		♀	9	4,5	15,4			
	1936	♂	173	86,5	13,7			
		♀	27	13,5	16,2			
	1937	♂	309	97,8	13,2			
		♀	7	2,2	16,3			
	1938	♂	461	97,1	11,4			3
		♀	14	2,9	16,1			
	1939	♂	880	91,4	10,0		5	214
		♀	83	8,6	13,3			
	1940	♂	1 574	90,7	10,2		2	112
		♀	161	9,3	13,1			

Perch tarns I—III. Number. — *Abborrens längd vid lekfisket I—III. Antal.*

in cm — *Längd i cm*													
9	10	11	12	13	14	15	16	17	18	19	20	21	22
9	8	31	40	8			2	1	1				
1	5	41	38	4	9	2							
7	16	3	4	6	3	9	1						
46	313	206	49	4	3	4	3	2	1	1			
1	8	12	7										
	13	72	198	86	18		3	3	1		1		
		2	14	17	8	2							
3	3	10	2	1	2	3	4						
					2	6	7	7	3	3			
180	58	10	6	2	2	3	2			2			
			2	1	1	2	2	6		8	1		1
770	376	91	4		2			1					
55	42	27	12	1	1		1	3	2	2	2	2	
56	65	44	20	13									
10	30	20	9	2									
9	212	162	43	3									
1	27	58	40	12	1								
13	78	73	50	8									
	17	86	97	19	3								
		15	44	203	203	29	7	3	1				
				9	8	2	4	2					
		1	1	38	110	33	7		1				
				1	2	3	1		1	1			
	20	9	16	12	51	44	14	4	2	1			
					1	9	7	6	2	2			
5	29	66	36	25	52	42	27	8	15	4			
					2	1	1	2				1	
83	122	80	74	22	9	20	24	15	5	2	2		
			1			5	3	3		1	1		
226	122	139	106	34	16	4	4	4	2	1	3		
	1	9	21	25	8	7	1	1	2	4	3		
512	458	217	134	58	32	17	9	11	5	4	2		1
6	28	18	31	26	11	9	9	8	2	6	4	3	

Lake *Sjö*	Year År	Sex *Kön*	Number *Antal*	% ♂ + ♀	Mean l. *Ml.*	Length		
						6	7	8
Abborrtjärn II	1941	♂	801	75,4	11,1			3
		♀	261	24,6	12,4			
	1942	♂	964	80,9	11,1			4
		♀	228	19,1	12,3			
	1943	♂	182	33,6	12,2			
		♀	359	66,4	12,2			
	1944	♂	1 209	54,0	12,2			
		♀	1 030	46,0	13,8			
	1945	♂	1 003	57,9	11,9			
		♀	730	42,1	12,6			
Abborrtjärn III	1935	♂	193	96,0	14,6			
		♀	8	4,0	14,1			
	1936	♂	174	86,1	15,1			
		♀	28	13,9	16,4			
	1937	♂	191	94,6	14,7			
		♀	11	5,4	16,1			
	1938	♂	248	69,3	15,1			
		♀	110	30,7	16,6			
	1839	♂	435	83,7	16,5			
		♀	85	16,3	17,1			
	1940	♂	205	82,3	16,0			
		♀	44	17,7	17,7			
	1941	♂	*small-large* 460 104 564	94,2	11,7			
		♀	35	5,8	19,2			
	1942	♂	176	70,1	14,5			
		♀	75	29,9	14,9			
	1943	♂	152	51,8	15,2			
		♀	141	48,1	15,2			
	1944	♂	49	96,1	13,1			
		♀	2	3,9	18,5			

[1] 3 samples of 26, 28 and 35 cm respectively. — [2] 2 samples of 24 and 24 cm respectively.

in cm — *Längd i cm*

9	10	11	12	13	14	15	16	17	18	19	20	21	22
87	295	229	90	59	19	14	2	2			1		
2	22	94	69	32	20	7	3	5		1	1	1	1[1]
27	224	440	173	57	25	7	4		2	1			
	4	60	85	46	17	11	5						
1	6	69	44	34	16	4	4	1	2	1			
7	19	86	120	75	37	8	3	1	1	2			
48	62	177	512	251	71	45	30	13					
		35	190	262	292	146	40	21	10	10	11	7	6
	30	273	486	201	11	2							
		51	306	323	26	11	7		3	1	2		
		11	11	15	35	64	46	9	1	1			
			1	1	3	2	1						
	1	10	22	10	16	28	36	31	12	6	1	1	
					1	4	9	10	4				
		8	18	20	29	43	54	12	5	2			
				1	2	1	1	4	1	1			
		1	37	28	20	47	54	42	15	2			2
				1	5	13	29	39	20	2	1		
				12	14	47	126	189	30	9	2	5	1
					5	12	10	20	21	13	4		
		6	7	7	1	28	78	52	17	6	3		
							11	9	13	4	7		
5	226	207	22			6	26	38	25	7	1	1	
							1	2	5	12	10	5	
2	14	27	16	24	11	2	10	25	36	6	1	2	
				13	35	15	1	1	1	1	5	1	2
	3	14	29	6	14	6	14	30	18	9	3	6	
		7	38	4	5	13	14	34	13	7	2	1	1[2]
	3	7	10	9	6	11	3						
								1			1		

were taken away, i. e. even the marked ones. During the following years, all the captured perch were set free again, with the exception of the marked ones. In tarn no. II, the intention was to improve the conditions for the remaining fish by moderate reduction of, above all, the large samples. In addition, the population was decimated by the planting of fish calculated to consume perch spawn (gwyniad) and bigger perch (pike). During the first years, therefore, only about half of the captured perch, including marked samples, were removed. During the later years and up to 1943, replanting took place. In 1944 and 1945, on the other hand, a maximum amount of perch was removed. Finally, in tarn no. III, the size and rejuvenation of the perch population was to be studied, without any particular interventions of any kind. Thus, during the first four years all the captured perch were restored. In order to study the effect of reduction, however, the majority of the collected samples were removed in 1938 and, in 1939, a large number of small samples, in particular. All the marked samples were replaced. During the years 1940—1942, a distinction was made between large perch (15 cm and more), which were returned, and small perch (under 15 cm) which were removed. Finally, during the years 1943—1945, no perch at all were taken away.

For reasons of space, only one table (Table 8) has been presented, viz., regarding the number of captured perch in the spawning run during different years, distributed according to size and sex. Table I summarizes the data regarding perch caught at other seasons. Further, Tables 9—11 give a survey of the results of reduction by fishing and of marking. These figures of captured perch differ from those in the forementioned Table 8 owing to the inclusion of all the perch caught during the different years. Figs. 8, 9 and 11—13 give a graphical illustration of the percentage occurrence of the various length groups.

The experiments in Perch Tarn I. The number of collected perch in this tarn has during certain years (1933, 1936, 1938 and 1942) been great, while it has been small in other years (1935, 1940 and 1943). It is evident that, at the commencement of the experiment in 1933, a fairly large population occurred in the tarn which was strongly decimated by fishing during this and the two following years. The most common length was 14—16 cm in the year 1934 (1933 was unfortunately not measured), but several samples attained a length of 20 cm, as well as above this. In 1935, large samples of this kind were even more usual. Simultaneously, an abundance of perch at lengths ranging from 10 to 11 cm were found, while the intermediary groups were more sparse. The larger samples caught in 1934—1935, apparently, belonged to several rich year-classes

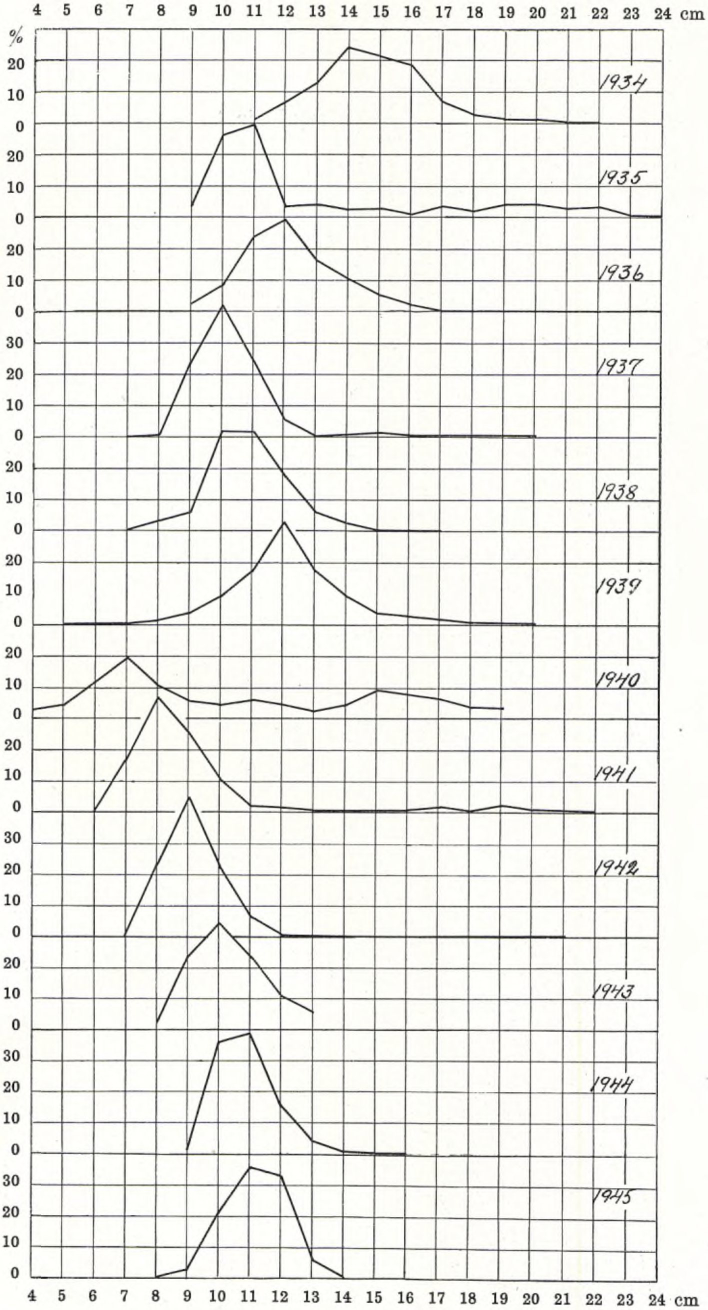

Fig. 8. Size in different years in Perch tarn I. — *Storleksfördelningen under olika år i Aborrtjärn I (% av antalet).*

Table 9. Survey of the experiments in Perch Tarn I.

Year *År*	Total catch (num. of removed samples denoted in brackets) *Totala antalet fångade (inom parentes antal borttagna)*	Num. caught in the *Fångade under*				Num. marked and replanted in the spring *På våren märkta och återutsatta*
		Spring *våren*		Summer—Autumn *sommar—höst*		
		Removed *borttagna*	Replanted *åter-utsatta*	Removed *borttagna*	Replanted *åter-utsatta*	
1933	1 770 (1 570)	—	200	1 570	—	200 anf[1]
1934	726 (526)	—	200	526	—	200 v buf
1935	384 (284)	—	100	284	—	100 v brf
1936	1 180 (1 080)	—	100	1 080	—	100 b rf
1937	818 (768)	—	50	768	—	50 h buf
1938	1 649 (878)	50	771	828	—	50 f rf
1939	696 (596)	349	100	247	—	104 h brf
1940	327 (100)	50	103	50	124	0
1941	946 (50)	25	818	25	78	0
1942	2 087 (50)	50	1 973[2]	—	64	100 anf
1943	276 (50)	50	226	—	—	100 h buf
1944	726 (50)	50	560	—	116	100 v brf
1945	562 —	—	562	—	—	—

Marked — *märkta*

Recaptured — *återfångade*

%

[1] anf = anal fin; v buf = l abd f; v brf = l pectoral f; b rf = post dorsal f; h buf = r abd f; f rf = ant dorsal f; h brf = r pectoral f.

[2] 1.470 later in the spring. — *Därav 1.470 senare på våren.*

— *Sammandrag av försöken i Abborrtjärn I.*

Num. of recaptured marked perch in different years, distributed according to the year of marking and in percentages (in brackets) of the total number of marked samples (after the exclusion of earlier removed, marked samples) *Antal under olika år återfångade märkta abborrar, fördelade på märkningsåret samt i % (inom parentes) av hela antalet märkta exemplar (efter frångrag av tidigare borttagna märkta ex.)*										Calculated size of the populations *Beståndets beräknade storlek*	Year *År*
1933	1934	1935	1936	1937	1938	1939	1942	1943	1944		
61 (30,5)										5 148	1933
10 (7,2)	87 (43,5)									1 209	1934
3 (2,3)	26 (23,0)	16 (16,0)								1 775	1935
0	9 (10,3)	41 (48,8)	88 (88,0)							1 227	1936
0	0	0	1 (8,3)	9 (18,0)						4 267	1937
0	0	1 (2,3)	0	16 (39,0)	27 (54,0)					1 553	1938
0	0	1 (2,3)	3 (27,3)	0	6 (26,1)	64 (61,5)				400	1939
0	0	0	0	1 (4,0)	0	10 (25,0)				—	1940
0	0	0	0	0	0	3 (10,0)				—	1941
0	0	0	0	0	0	0	62 (62,0)			2 474	1942
0	0	0	0	0	0	0	4 (10,3)	0		—	1943
0	0	0	0	0	0	1 (3,7)	21 (61,8)	3 (3,0)	4 (4,0)	2 900	1944
0	0	0	0	0	0	0	9 (69,2)	6 (6,2)	2 (2,1)	—	1945
200	200	100	100	50	50	104	100	100	100		
74	122	59	92	26	33	78	96	9	6		
32,0	61,0	59,0	92,0	52,0	66,0	75,0	96,0	9,0	6,0		

from the start, representing the population at the commencement of the experiment in 1933.

The small samples in 1935 disclosed the fact that one or, probably, two year-classes — according to growth and age hatched in 1932 and 1933, possibly, even one year earlier — were in the process of growth. This is also apparent from collection results in 1936, when the individual quantity was comparatively large and the usual length equalled 11—12 cm, i. e. approximately 1 cm more than during 1935. Only isolated samples remained of the larger perch from earlier years and during the following years perch from these earlier generations were almost completely lacking. The fishing in 1936, however, had severely taxed the forementioned year-classes with small perch of the years 1935—1936, for in 1937 the number of captured perch again decreased and samples of greater length than 12 cm were unusual. On the other hand, small perch of 9—11 cm and, principally, 10 cm were again frequent, particularly during the latter part of the year, probably being 4 summers old, and in such case due to a new, rich year-class from the year 1934, and possibly from 1935. The following years yielded good catches, with the most common length of 10—12 cm in 1938, and 11—13 cm in 1939. In these two years, this year-class apparently formed the main part of the catch. The population was, in 1940, strongly decimated. However, it was characterized by the occurrence of somewhat larger samples which still remained, though at increasing size and age, during the years 1941—1942. In spite of replanting during these latter years, the samples of these greater lengths became gradually more sparse. This indicates that the forementioned reduction had been rather effective.

In the Autumn of 1940, an increase of the samples belonging in the shorter groups was again observed, i. e. chiefly those of 7 cm, deriving from a new, rich year-class probably from the year 1939. The advance of such a year-class was clearly evident from the catching results of the following years, 1941 showing a very marked accumulation of samples ranging from 7 to 9 cm in length, the most common length in 1942 being 8—10 cm, in 1943 9—11 cm, in 1944 10—11 cm, and in 1945 11—12 cm. Fig. 9 illustrates the differentiation between the size of the sexes, showing distinctly the discrepancy in length. This will be seen to have increased from one year to the other, when the larger females included in 1942 are omitted. No other new year-class has appeared during these years.

The marking results confirm the observations made above with regard to the size of the population, and the great decimation of various year-classes by fishing. The number of samples marked in the spring, and re-

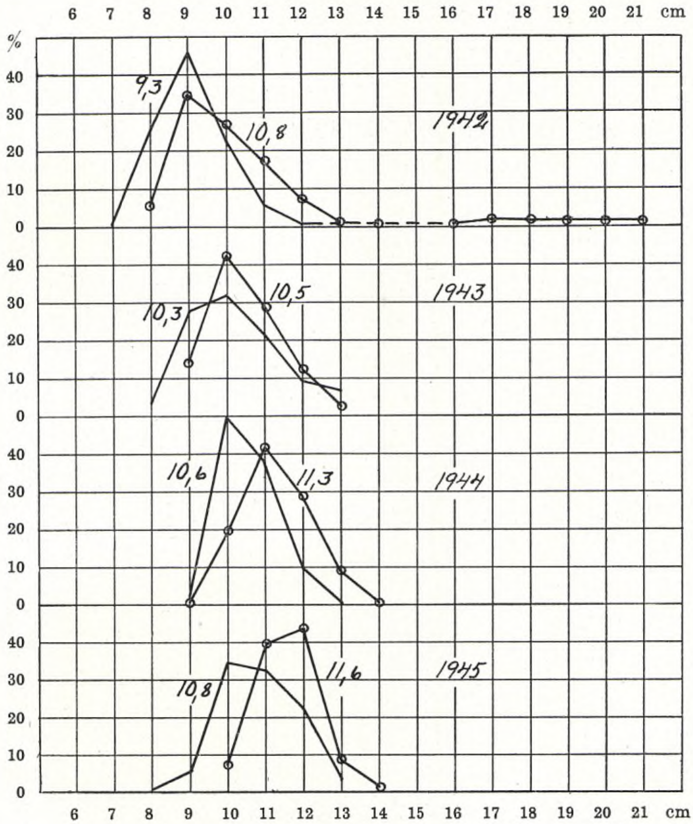

Fig. 9. Size of males and females in different years in Perch tarn I. — *Storleksfördelningen under olika år i Abborrtjärn I hos hanar och honor (% av antalet).*

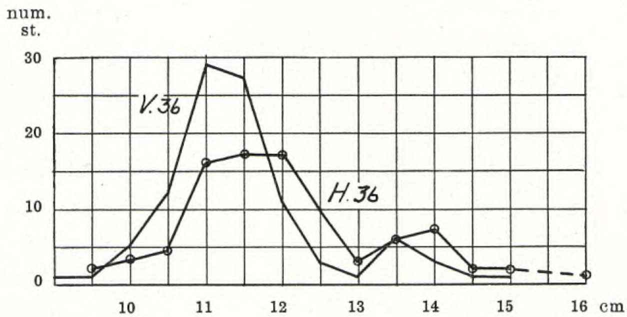

Fig. 10. Size of perch marked in the spring and recaptured in the autumn of 1936 in Perch tarn I. — *Storleksfördelningen hos våren 1936 märkta och hösten samma år återfångade abborrar i Abborrtjärn I.*

Table 10. Survey of the experiments in Perch

Year *År*	Total catch (num. of removed samples denoted in brackets) *Totala antalet fångade (inom parentes antal borttagna)*	Num. caught in the *Fångade under*				Num. marked and replanted in the spring *På våren märkta och återutsatta*
		Spring *våren*		Summer—Autumn *sommar—höst*		
		Removed *borttagna*	Replanted *åter-utsatta*	Removed *borttagna*	Replanted *åter-utsatta*	
1934	1 394 (864)	50	530	814[1]	—	530 anf[4]
1935	1 006 (550)	100	200	450[1]	256	200 h buf
1936	1 299 (600)	—	200	600[2]	499	200 b rf
1937	1 263 (150)	50	325	100[1]	788	316 v brf
1938	1 326 (150)	50	462	100	714	50 f rf
1939	2 007 (200)	50	1 119	150	688	50 h brf
1940	2 203 (100)	50	1 858	50	245	—
1941	1 880 (50)	25	1 545[3]	25	285	—
1942	2 340 (85)	35	2 223	50	32	100 v buf
1943	541 (50)	50	491	—	—	100 anf
1944	4 003 (3 362)	3 362	100	—	541	100 h brf
1945	1 733 (1 733)	1 733	—	—	—	—

Marked — *märkta*

Recaptured — *återfångade*

%

[1] 500 caught by anglers. — *Härjämte ytterligare c:a 500 fångade av ortsbor*
[2] 400 caught by anglers. — *Härjämte ytterligare c:a 400 fångade av ortsbor.*
[3] 1.824 later in the spring. — *Därav 1.824 senare på våren.*
[4] Abbreviations, see Table 9. — *Förkortningar, se tabell 9.*

Tarn II. — *Sammandrag av försöken i Abborrtjärn II.*

Num. of recaptured marked perch in different years, distributed according to the year of marking and in percentages (in brackets) of the total number of marked samples (after the exclusion of earlier removed, marked samples) *Antal under olika år återfångade märkta abborrar, fördelade på märkningsåret samt i % (inom parentes) av hela antalet märkta exemplar (efter fråndrag av tidigare borttagna märkta ex.)*									Calculated size of the populations *Beståndets beräknade storlek*	Year *År*
1934	1935	1936	1937	1938	1939	1942	1943	1944		
28 (5,3)									15 417	1934
32 (6,4)	21 (10,5)								6 724	1935
35 (7,5)	18 (10,1)	22 (11,0)							9 991	1936
10 (2,3)	8 (5,1)	10 (5,6)	11 (3,5)						25 517	1937
5 (1,2)	0	10 (6.0)	11 (3,5)	3 (6,0)					13 567	1938
2 (0,5)	0	0	1 (0,4)	1 (2,0)					—	1939
8 (1,9)	0	2 (1,2)	5 (1,6)	2 (4,0)	1 (2,0)				—	1940
1 (0,2)	0	1 (0,6)	1 (0,4)	0	0				—	1941
0	0	0	0	0	0	2 (2,0)			95 300	1942
0	0	1 (0,6)	0	0	0	2 (2,0)			—	1943
0	0	0	0	0	1 (2,0)	1 (1,0)	3 (3,0)		—	1944
0	0	0	0	0	0	1 (1,0)	1 (1,0)		—	1945
530	200	200	316	50	50	100	100	100		
121	47	46	29	6	2	6	4	0		
22,7	23,5	23,0	9,2	12,0	4,0	6,0	4,0	—		

captured during the summer and the autumn of the same year, has often been considerable, equalling up to 88 per cent (1936). The recapture has comprised over 50 per cent of the number of marked samples, which applies to all markings except three, the main part occurring during the first or the first two years (including the year of the marking). Later, isolated marked samples have only been recaptured in certain cases. When a year, during which the catches have not been particularly intensive and the recapture of marked samples consequently less frequent, has been followed by a year with strongly intensifed fishing, the recapture of samples marked in the previous year will also have increased. This is clearly demonstrated by the years 1935—36 and 1937—38. It has already been pointed out above that the cutting of the fins is ascertainable even after many years.

A certain conception has been obtained of the growth of these samples by measurements of length, performed generally both at the marking process and at the recapture. In some cases, a palpable growth has been noticeable. Thus, Fig. 10 discloses an increase in length of about 0,5 cm among the perch marked in the Spring of 1936 and recaptured in the Autumn of the same year. However, the marking results from other years do not show any particular increase in length.

An approximative calculation of the size of the whole population may be obtained on the basis of the percentage figures of recaptured and marked perch of the first summer. The individual quantity in the population should be related to the number of captured samples, as the total number of marked samples is related to the number of recaptured marked samples. The individual amount in the population has been calculated on the basis of these percentage figures. Naturally, only the collections made in the summer and in the autumn have been included in the equation. It is also obvious that the figures obtained in this way refer to the particular classes of sizes comprised in the marking process. These figures may be seen furthest to the right in the tables, and serve to confirm the above statements concerning the quantity of perch during different years.

The experiments in Perch Tarn II. The experimental catches in this tarn have yielded a large number of perch each year. Apart from the samples set down in the tables, annually a few hundred, some years even about 500, samples have been caught with ordinary hook-and-line fishing by persons living on a farm in this district. The most frequent size at the commencement of the experiment equalled 13—14 cm, i. e. slightly less than in tarn no. I. Perch under 11 cm in length were very sparse.

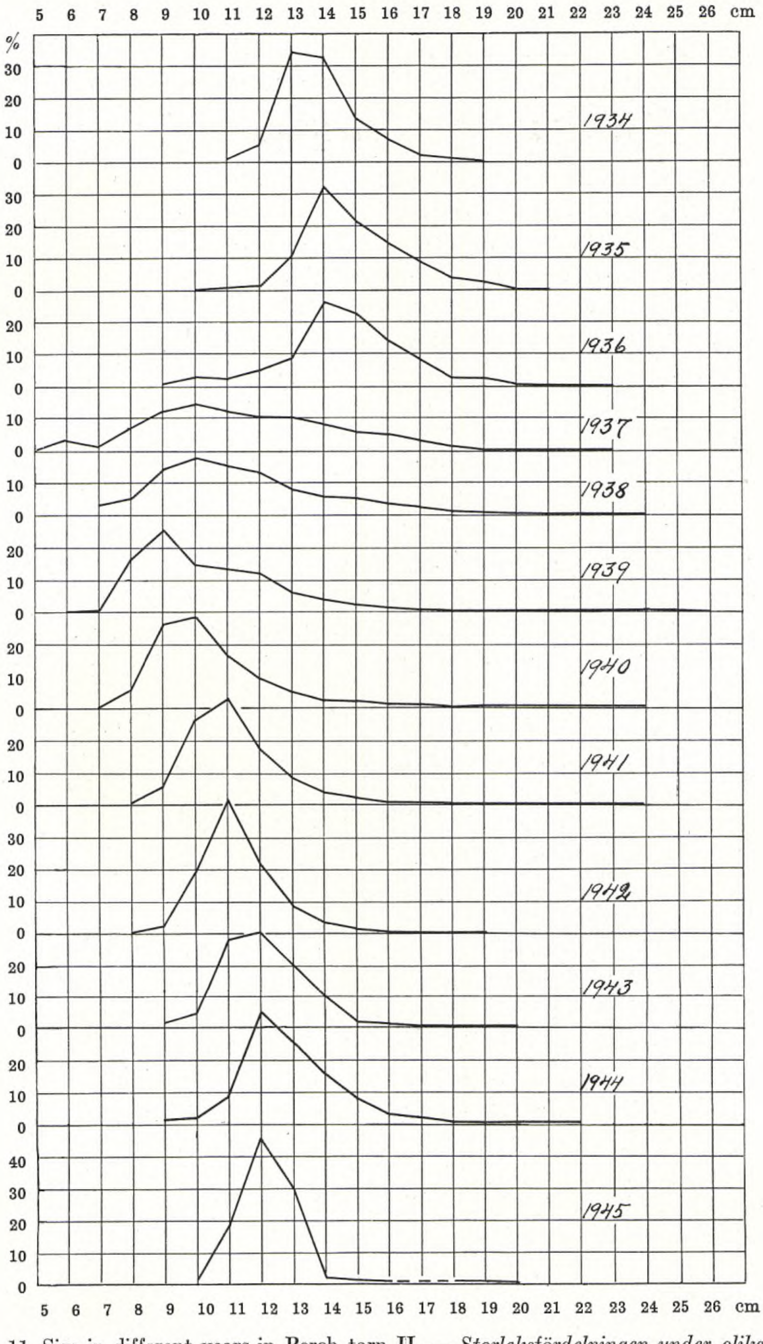

Fig. 11. Size in different years in Perch tarn II. — *Storleksfördelningen under olika år i Abborrtjärn II (% av antalet).*

During the years 1935 and 1936, the length was approximately the same, with but a small increase. No decimation of the population was noticeable as the result of the removal of 550—850 samples under each of these first three years. It is evident that also in this tarn several year-classes occurred, being however so rich in individuals as not to involve any particular reduction by the relatively insignificant fishing which took place. A fairly large number of perch of greater lengths, i. e. 20 cm and more, were therefore caught during several of the following years. It is quite probable that a record perch of 35 cm in length, caught in 1941, belonged to one of these year-classes.

Apparently, these year-classes began to decrease in number during 1937, since the size groups of 14—15 cm which were so common earlier had by then become very sparse. In all probability a decimation had occurred in 1936 through the death of a number of the perch. Instead, perch of a length of 9—11 cm were very common in 1937 and 1938, the length being somewhat greater in the latter year, indicating the existence of one or possibly two new year-classes, deriving quite probably from the year 1933 and, above all, from 1934.

In the Spring of 1939, a very great number of the perch had a length of 9 cm and thereabouts, having by now, in all probability, reached the age of 3 years and deriving from a new, rich year-class of the year 1936. This year-class can be distinctly followed during the next years, with the most common length of 9—10 cm in 1940, 10—11 cm in 1941, 11 cm in 1942, 11—13 in 1943, and 12—13 cm in 1944 and 1945. Apparently, the growth was fairly insignificant, being less good than in the case of the large perch of earlier year-classes. This is, no doubt, due to the abundance of individuals in this year-class. The smaller size of 1945 can be explained by the large number removed in 1944. Fig. 12 illustrates the difference in length and the increase in growth of males and females belonging chiefly to this year-class. Evidently also quite a number of larger and, without doubt, older females are included from the earlier year-classes. Also other irregularities have been observed.

In this tarn, as in tarn no. I, a very large population apparently occurred from the very beginning. However, the length groups were somewhat shorter and, no doubt, considerably more numerous than in tarn no. I. Also in this case, the majority of the perch stopped growing at a length of 14—15 cm. In spite of the enormously abundant supply of food in the form of small perch, at least during certain years, only a small amount seem to have changed over to a fish diet, revealing a subsequent increase in growth. The number of large perch is, from an absolute point

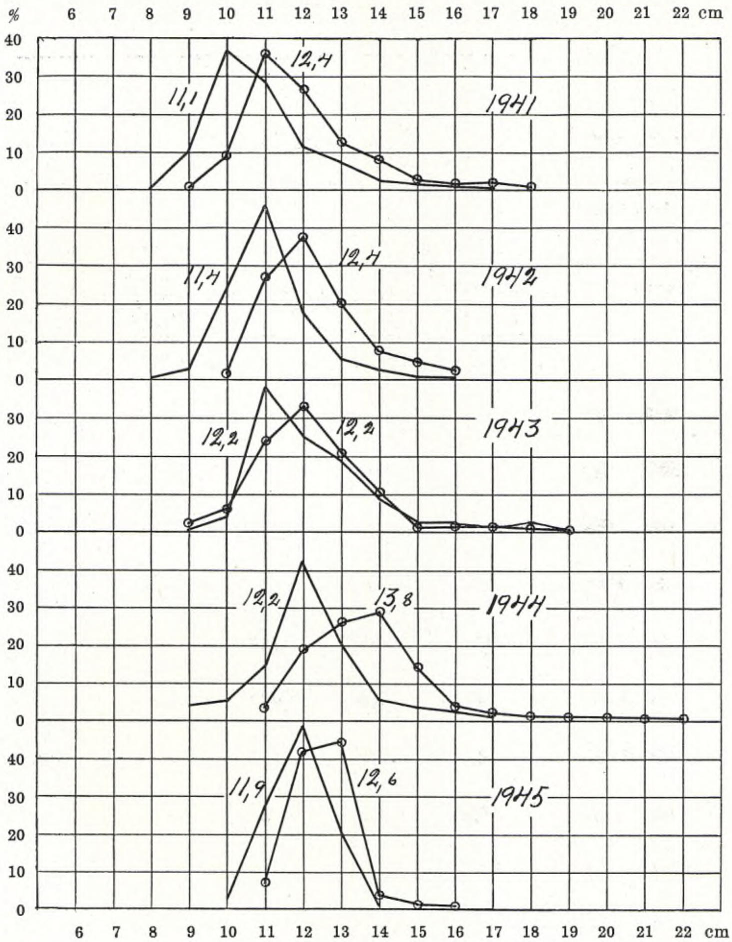

Fig. 12. Size of males and females in different years in Perch tarn II. — *Storleksfördelningen under olika år i Abborrtjärn II hos hanar och honor (% av antalet).*

of view, greater here than in tarn no. I, but they are considerably fewer in relation to the great number of individuals in the population.

Furthermore, support is found for the above-mentioned conclusions in the results of the marking process. In 1934, not less than 530 samples were marked. Only 28 were recaptured in the latter part of the same year, and 32 and 35 samples, respectively, during the two following years, which were all removed. During the next two years, another 26 samples were recaptured, not less than 8 in 1940, and 1 in 1941. This equals in all 121 samples, or only 22,7 per cent of the total number of

Table 11. Survey of the experiments in Perch

Year *År*	Total catch (num. of removed samples denoted in brackets) *Totala antalet fångade (inom parentes antal borttagna)*	Num. caught in the *Fångade under*				Num. marked and replanted in the spring *På våren märkta och återutsatta*
		Spring *våren*		Summer—Autumn sommar—höst		
		Removed *borttagna*	Replanted *åter-utsatta*	Removed *borttagna*	Replanted *åter-utsatta*	
1934	514 (0	—	250	—	264	250 anf[3]
1935	357 (0)	—	201	—	156	201 h buf
1936	843 (60)	60	202	—	581	202 b rf
1937	1 062 (150)	50	202	100	710	202 v brf
1938	1 103 (936)	200	167	736	—	50 f rf
1939	995 (348)	81	515[1]	267	132	317 h brf
1940	500 (211)	34	270[2]	177	19	128 v buf
1941	754 (605)	552	145	53	4	—
1942	387 (205)	205	144	—	38	—
1943	293 (25)	25	268	—	—	—
1944	161 (50)	50	53	—	58	49 anf
1945	82 —	—	82	—	—	—

[1] 198 later in the spring. — *Därav 198 senare på våren.*
[2] 142 later in the spring. — *Därav 142 senare på våren.*
[3] Abbreviations, see Table 9. — *Förkortningar, se tabell 9.*

marked perch. This is a very small figure as compared to tarn nr. 1, where sometimes more than 50 per cent were recaptured in the very year of marking and the total recapture of each marking amounted to considerably more than 50 per cent. The results of the markings during the

Tarn III. — *Sammandrag av försöken i Abborrtjärn III.*

Num. of recaptured marked perch in different years, distributed according to the year of marking and in percentages (in brackets) of the total number of marked samples (after the exclusion of earlier removed, marked samples) *Antal under olika år återfångade märkta abborrar, fördelade på märkningsåret samt i % (inom parentes) av hela antalet märkta exemplar (efter fråndrag av tidigare borttagna märkta ex.)*								Calculated size of the populations *Beståndets beräknade storlek*	Year *År*
1934	1935	1936	1937	1938	1939	1940	1944		
27 (10,8)								2 444	1934
17 (6,8)	6 (3,0)							5 200	1935
64 (25,6)	88 (43,8)	52 (25,7)						2 260	1936
78 (31,2)	99 (49,3)	80 (39,6)	80 (39,6)					2 045	1937
75 (30,0)	73 (36,3)	46 (22,8)	67 (33,2)	22 (44,0)				1 672	1938
73 (29,2)	61 (30,3)	37 (18,3)	91 (45,0)	21 (42,0)	173 (54,4)			1 097	1939
33 (13,2)	70 (34,8)	5 (2,5)	57 (28,2)	4 (8,0)	136 (42,8)	94 (73,4)		460	1940
12 (4,8)	20 (10,0)	2 (1,0)	30 (14,9)	1 (2,0)	70 (22,0)	105 (82,0)		—	1941
25 (10,0)	20 (10,0)	10 (5,0)	29 (14,4)	6 (12,0)	65 (20,4)	99 (77,3)		—	1942
10 (4,0)	4 (2,0)	3 (1,5)	20 (10,0)	0	32 (10,2)	36 (28,1)		—	1943
3 (1,2)	3 (1,5)	0	7 (3,5)	0	5 (1,6)	12 (9,4)	1 (0,5)	2 842	1944
0	0	0	0	0	0	2 (1,6)	2 (1,0)	—	1945

year 1935 and the following years are in agreement with those of 1934. The recapture under the same year, as well as later, was invariably insignificant, and after a few years only isolated samples were caught. The increase in length of the marked and recaptured perch was very slight, which is in good conformity with what has been said above regarding the slow growth. The comparatively low percentage of recaptured and marked perch shows that the population must have been very large. This is also proved by a calculation similar to the one performed in tarn no. I. This applies especially to the latest, rich year-class.

The experiments in Perch Tarn III. The experimental catches (Table 11) in this tarn during the years 1934—1935 gave rather weak results and comprised each year only a few hundred perch, mainly of the size of 14—16 cm. This length was somewhat greater than in the two other experimental tarns. The scarcity of small samples is noteworthy in this tarn. Thus, the population must also in this case have consisted chiefly of large samples belonging to several earlier good year-classes. However, these classes must have been far more scarce in individuals than were tarns nos. I and II. Not until in 1936 did the number of small perch increase, although the medium-sized samples of 14—16 cm in length continued to be the most common. In 1937, the latter still holds good, with the exception that now also the 12 cm group was fairly rich in individuals. In the following year these two length groups of 11—13 and 15—17 cm, respectively, predominated. The more abundant occurence of small samples during the last years is due to an addition from the new year-classes of 1933—1935. This is also confirmed by the increased amount in the catches from one year to another. In 1938 a strong reduction of particularly the small samples was performed. This was reflected in the next year by a scarcity of perch in the sizes 11—14 cm. Larger samples were, however, still common and now for the first time, in addition, a considerable amount of small samples of 7—8 cm in length were noted. This concerns the Autumn fishing of 1939. The perch were at that time probably 2 summers old, and belonged to a rich year-class deriving from the year 1938. In the Spring of 1940, principally the earlier, larger length groups were caught, while they were very scarce in the Autumn. On the other hand, an abundance of perch of 10—11 cm in length were caught at the latter part of the year, probably belonging to the forementioned year-class of 1938 in spite of their unusually good growth. The abundance in this year-class is evident from the fact that, notwithstanding the removal in 1939 of a large quantity of smaller samples and, in 1940, of all captured samples under 14 cm in length, there still remained in 1941 a profuse amount of these small perch. Not less than 605 samples were removed in this year, and the reduction during these three years had, apparently, now become so effective as to render sparse the samples in the year-class of 1942. However, they also occur in the collections from

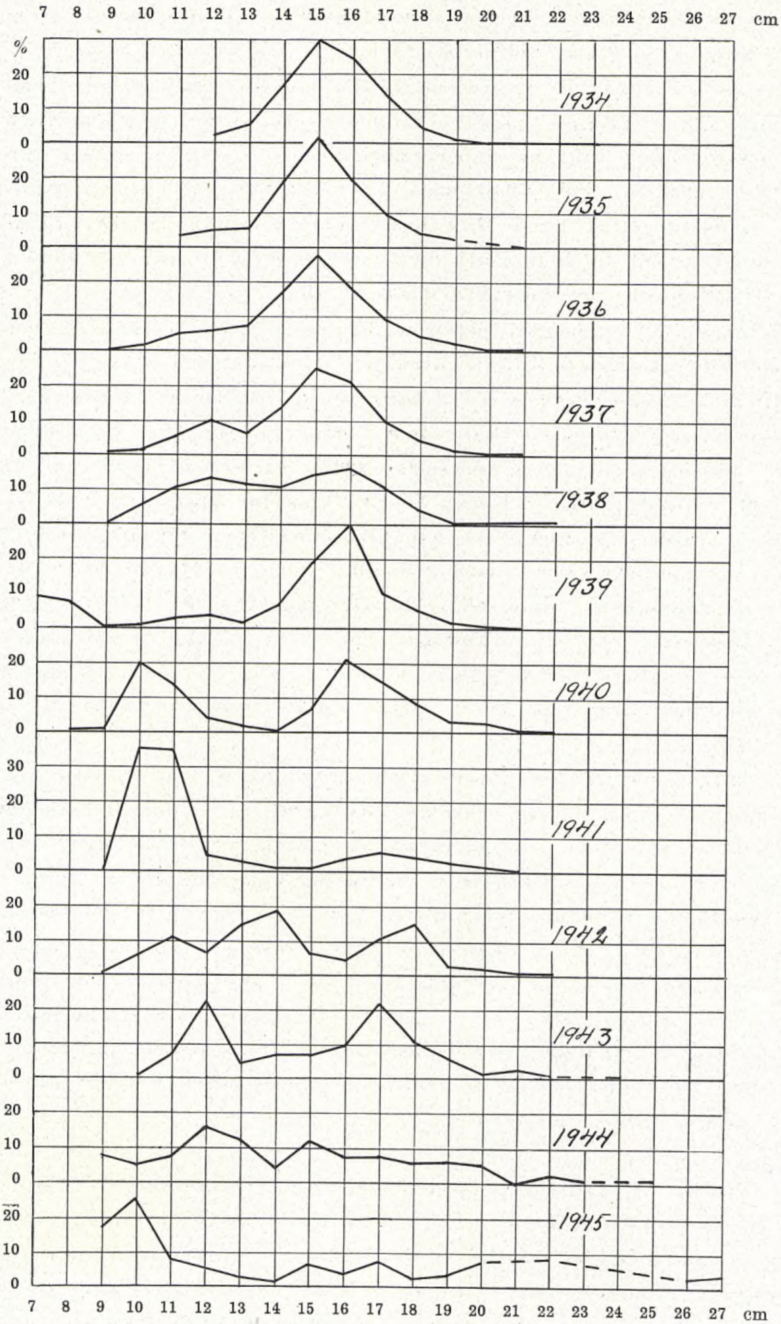

Fig. 13. Size in different years in Perch tarn III. — *Storleksfördelningen under olika år i Abborrtjärn III (% av antalet).*

later years. They have then a chance of growing up and presenting several large samples of 20 cm and more in length.

Further, in 1941 the reduction in the larger length groups was conspicuous. These groups, which belonged to the year-classes occurring at the commencement of these experiments, had been very abundant throughout the period of 1934—1940, while they seem to have disappeared to a large extent in 1940. Since they have not been removed, this disappearance must be due to their death owing to, possibly, a competition for food from the vigorous, growing year-class of 1938.

The marked, recaptured perch in this tarn have invariably been returned. Since it has not been possible to obtain for a primary marking a sufficient number each year of samples not previously marked, a comparatively large quantity have been subjected to this process several times over, even for three successive years. However, it has not proved difficult to distinguish between the various markings. As will be seen from the table, the recapture has almost without exception been considerable, the large recaptures from one year to the other being particularly noteworthy. This concerns the marking of each year. In the years 1940 and 1941, a pronounced reduction in the percentage of recapture of earlier markings was observed, which is in fair agreement with what has been said above regarding the probable mortality in the year 1940.

Fig. 14 shows the annual increase in length in one of the marking experiments, similar results having been arrived at in all these experiments. The growth is extremely slight, which serves to prove that the large perch in the collections of 1934—42 belonged to the same year-classes. When, in 1934 or perhaps even earlier, they attained the normal size for the tarns, the growth rapidly decreased or almost stopped, but the perch are still living. At any rate, the high recapture percentage of marked perch in certain years in tarn no. III indicates that the population has not been particularly rich in individuals. This applies particularly, as seen from the calculations, to the latter years when a great number of small samples were removed.

The following data may be derived from a summary of the experimental results of examinations in the three Perch Tarns. In all the tarns at the commencement of the experiments, the populations of perch had principally a length of 12—16 cm and an age of from 5 to 6 years or more. Smaller samples were rather uncommon. Even bigger perch were sparse, although several perch were found of a length of up to 20 cm.

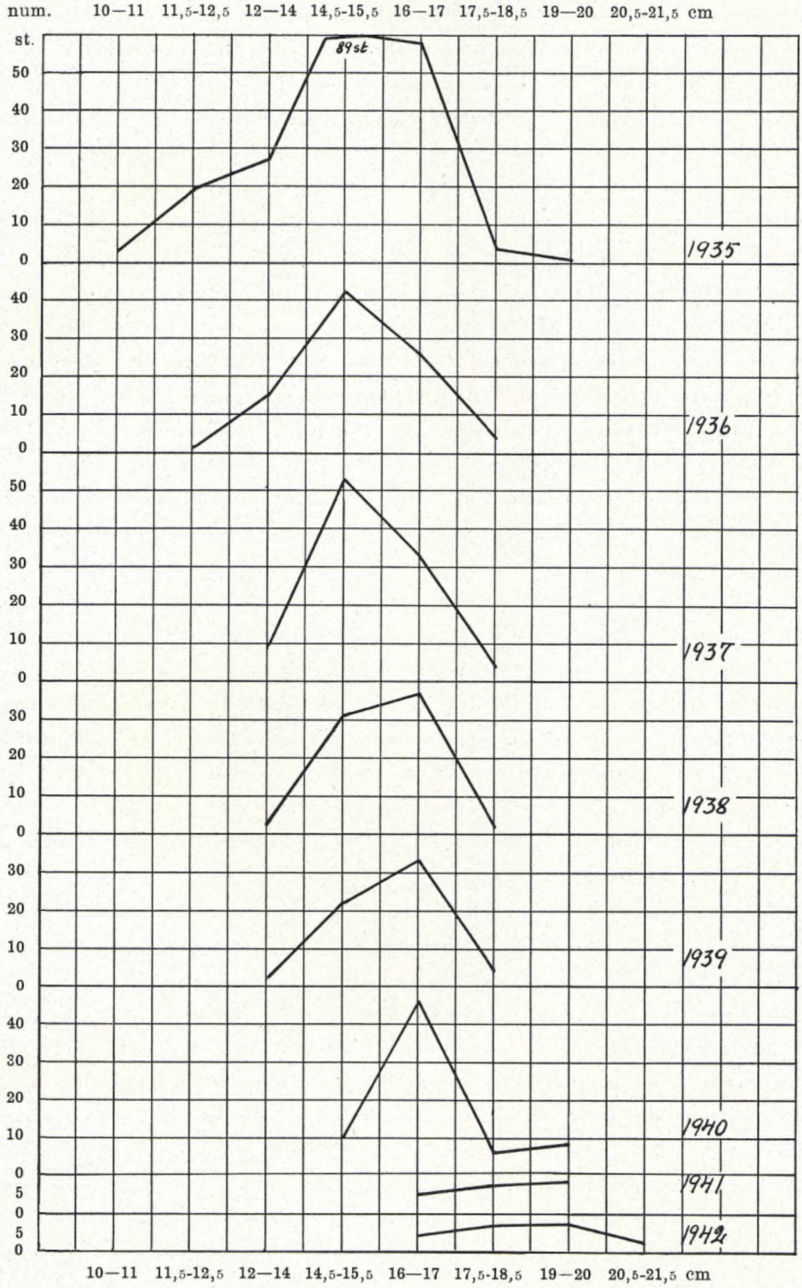

Fig. 14. Size of perch marked in the spring 1935 and recaptured in the following years. — *Storleksfördelningen hos våren 1935 märkta och under följande år återfångade abborrar i Abborrtjärn III (antal ex.).*

The marking experiments, as compared to the earlier investigations of age, have shown that this is due to the fact that the majority of perch stop growing at the forementioned size of 12—16 cm, even though they may live on for several years afterwards. However, at a higher age a greater mortality sets in. Occasional samples differ from the rest by continuing to grow and consequently attaining a greater length than the others. These perch with a more rapid growth, nevertheless, form exceptions from the general rule in the lakes concerned.

Owing to the fact that every rich year-class stops growing, so to speak, at the forementioned size although the individuals may all the same live on for long, an accumulation of these relatively small perch, of approximately the same size but of different ages, takes place. Since in reality new year-classes of any significance only appear in certain years, the result is that the individual quantity in the younger growing year-classes becomes smaller, and the number of older and more equal-sized individuals in several older age groups proportionately bigger. The population will then chiefly consist of perch of a fairly even size, while the larger as well as the smaller perch are more or less unusual. When a new, more abundant year-class comes to and grows up, frequently an intense competition for food will probably occur between them and the older individuals, with subsequently increased decimation among the latter. Accordingly, for a few years perch of a variety of sizes will be met with. A tarn, intact from the point of view of fishing, will however, as a rule, disclose a greater or smaller number of perch of a certain length, which may, of course, vary in different quarters and under different years, but mostly ranges from 12 to 16 cm.

Further, it has been found that rich year-classes have only appeared in certain years, the multiplication in the between years having been very poor. However, this does not seem to be in any way connected with the number of spawning perch. The year-class of 1934 in tarn no. I derived from a year with a numerous population, while the year-class of 1939 came from a year with probably rather a weak population. On the other hand, the rich population in 1937 has not given rise to a more abundant year-class.

There are, apparently, other reasons for the lack of certain new year-classes. Thus, as demonstrated by investigations in the U. S. A. by Eschmeyer (1937—38) and pointed out by Tägström (1940, 1943), a decimation by the larger perch is quite conceivable. Eschmeyer contends, on the basis of direct observations, that even perch in their third year of life feed to a great extent on the two younger year-classes, decimating the latter so severely that they themselves later die of starvation. In this way, only the year-class deriving from the few remaining samples of spawning, three-year-old perch have a chance of growing up. For this reason, principally one single year-class should predominate each year, and perch exceeding an age of 3 years should be rare.

It is possible that the numerous bigger perch in the tarns, during the years preceding the commencement of the experiments, consumed the smallest young ones. It seems strange, otherwise, that no samples of the length groups of 10 cm and below it from younger year-classes were noticed, which occurred during the later years, though only in small numbers in certain years. As mentioned above, perch of the size of 12—16 cm but rarely appear to eat fish. Thus, only the sparse, larger samples can be regarded as fish-eaters. It is, moreover, quite conceivable that, during the course of the experiments, and in spite of the presence of an abundance of bigger perch, new rich year-classes have been capable of growing up.

No doubt, the quantity in the various year-classes is also dependent on other factors, such as the question of the supply of food for the weak spawn, the wind and wave movements which may to a great extent decimate the extremely delicate perch spawn. Furthermore, it must be remembered that the conditions for good spawning results are, probably, rather unfavourable in these tarns with their precipitous, tufty shores and loose bottom. Therefore, in all likelihood an interplay of favourable factors is necessary for the appearence of a rich year-class.

The experiments have, furthermore, shown that a large catch may immediately affect the size of the population. The collections in tarn no. I were so intensive as to decimate rather rapidly the original population, as well as to hinder in the future the growing up of new year-classes to higher age and greater size. At least two such rich year-classes from the years 1934 and 1939 have clearly demonstrated this, the former having quickly decreased in number, although sparse, growing samples occurred for several years. The year-class from 1939, on the other hand, has been allowed to grow up owing to the fact that it has not been decimated by fishing and is therefore still numerous. In tarn no. II, the small reduction by fishing has had no noticeable effect in this particular respect. In tarn nr. III, as in nr. I, the occurrence of a new year-class has been prevented by intensive fishing during the latter years. In this way a small-sized population may appear owing to the fishing which has hindered the individuals from growing up. However, the reasons for a small-sized population of this particular kind differ from those typical of these tarns.

Finally, it has been established that the reduction-experiments performed in tarn no. I, and partly also in tarns nos. II and III, have not given any marked results as regards increase in growth. The results from the marking of 1934 in Perch Tarn I indicate, it is true, that the thinning out of the individual quantity in the population has involved that large perch were more frequent than before. However, the catching has later been carried on so intensively as to prevent a fairly great number of these perch from growing up. The later markings in this tarn, as also in tarn no. III, disclose but an insignificant increase in growth. Nor have similar decimation experiments in America revealed any palpable increase in growth. However, this was in fact observed by ESCHMEYER in Ford Lake, Michigan. But in this case large quantities of minnows had been planted, and Ford Lake is of a type quite different from that of the tarns concerned here (i. e. of an oligotrophic type with fairly high pH value).

From what has been inferred above, it will be seen that in lakes of the type dealt with in the present work, the abundance of small perch, frequently of rather an even size, is due to the rapid decrease in growth, the fairly long life, and, consequently, an accumulation of individuals of a certain size, as well as to the absence of new year-classes for, at times, several years in succession. The stunted appearance of these fish has therefore nothing to do with the intensive fishing, nor with the gradual reduction in growth by net fishing, as assumed by TÄGSTRÖM (1938), owing to the fact that only individuals with particularly bad growth would be left to have the opportunity of propagating a perhaps bad capacity of growth. Furthermore, this is contradicted by the extremely rare occurrence of fishing in these tarns.

The question is then, what is the reason for the rapid decrease in growth among the individuals in these perch populations. It may be due to hereditary factors, as will be discussed later. However, a more likely answer is to be found in the matter of environment. Thus, it is quite sure that these tarns and similar lakes are highly unfavourable for the fishes. The hypolimnion is always either entirely or almost free from oxygen-gas and has a very low temperature (BRUNDIN 1942, ALM 1943). The greater part of the lower water regions of a lake of this type will, accordingly, be more or less unsuitable for the fish and only an upper layer of water, of but a few metres in depth, may be counted on as appropriate during the greater part of the year. Experiments with deeper-going nets have, in fact, shown that either no perch have been captured in the deeper parts of these nets, or else the few individuals caught have been dead. They have not been capable of enduring the strong decrease in oxygen-gas for a longer period of time, although they have been able to make short excursions into these layers of the water. In direct experiments, PEARSE and ACHTENBERG (1917—18) were in a position to prove that the perch can stay for a fairly short time without injury in water that is almost free from oxygen-gas. Even though the sparse bottom fauna in these tarns can to a certain extent be made use of, principally the plancton in the upper water layers, the lithoral fauna, and the bottom fauna nearest the shores will be at the disposal of the fish as a source of food. Since these faunal elements are comparatively scarse, as already mentioned, the supply of food for the fish becomes rather small in the majority of these tarns.

It has frequently been suggested in the literature (ECKERBOM 1937) that the deficiency in food consisting of small animals should be compensated for by the rich supply of small perch. Thus, the greater the amount of perch of the first age-groups, the greater the extent to which these individuals would be consumed by the somewhat older perch. The latter would, accordingly, be stimulated to better growth, i. e. this would be an example of ESCHMEYER'S phenomenon, referred to above. However, this does not, as previously mentioned, apply to the tarns concerned here, since the perch does not, apparently, change over to a fish diet to any very marked extent and, further, owing to the fact that in many cases small young perch only occur in slight quantities. The inconsistency between this and the forementioned result from ESCHMEYER'S experiment may, possibly, be explained by the use of a different type of lake than the tarns. The surroundings consist of highlands and wooded country, the shores and bottom of sand, the water is clear (transparency = = 7—8 m) and, above all, alkaline (pH mostly 8—9). Since, as mentioned above, the growth is apparently better in the American waters, it is perhaps quite natural that the perch there have changed over to a fish diet even at a relatively low age.

However, conditions are different in the tarns. The supply of food is more scarce than in lakes of another type, and the forementioned temperature and oxygen-gas conditions, without doubt, cause an abbreviation of the period of growth. Nor is it altogether out of the question that these factors, as well as the degree of acidity of the water, may reduce the appetite and, perhaps, also cause the change to a fish diet to become less common than supposed.

This can be illustrated as follows. The consumption of a sufficient amount of nourishment should not provide any particular difficulty as regards the first age-groups, where plancton form the main food and the fish are, as yet, of a small size. Whith an increase in the individual size and the demand for bigger organisms as food, on the other hand, a great difference is noted. There is, inevitably, a very strong competition for food, as well as direct difficulties of finding adequate quantities and, possibly, a lack of the required stimulant (i. e. suitable temperature and degree of acidity) to cause a change to a fish diet.

The occurence sometimes of a population which is exceedingly rich in individuals will offer an added complication. A comparison between the area of the three tarns and the calculated individual number at the commencement of the experiments will show that there are approximately 4,—2,6 and 6,—m^2 of water area to every individual. In this connection, it should be borne in mind that this only applies to samples of a somewhat greater length, while those belonging to the first age-groups have not been included. Thus, the populations must have been a good deal larger. In certain recent years, the individual number became so large in the case of tarn no. II as to leave less than 1 m^2 to each individual. Moreover, owing to the deficiency in oxygen-gas in the hypolimnion, as mentioned before, only a comparatively thin upper layer of the water will be at the disposal of the fish, except at very short periods. Accordingly, the volume of water for each individual will be extremely small. The experiments in Lake Windermere in England (WORTHINGTON 1941, 1943, LE CREN 1944) also show that the fairly stunted perch population there was very numerous. Thus, in this lake of approximately 900 hectares, not less than 25.500 Kg (i. e. over 1 million) and 30.500 Kg respectively, of small perch were caught during the years 1941 and 1942.

For the sake of comparison, it may be mentioned that, in the poisoning experiments performed by ESCHMEYER (1938, 1939) in different American lakes, the populations were far from being so large (one perch out of 9 to 40—50 m^2) and, in addition, consisted mainly of the youngest age-groups. Thus, in a lake of 13,5 hectares, apart from bass and some other fishes, 2.826 perch were obtained. Among these, not less than 2.678 were only 1 year old, 131 2 years old, and only 17 3 years old or more. In another case, in a lake of 17 hectares, 3.615 perch were caught, the majority being not more than 2 years old. The densest population equalled almost 5.000 samples (approximately 170 Kg) in a lake of 4,7 hectares, and approximately 1.700 samples (approx. 38 Kg) in a lake of 1,5 hectares, corresponding to approximately 35 and 23 Kg per hectare, respectively.

Furthermore, the attempts at decimation by fishing in the tarns reveal that rather considerable weight quantities of perch may be collected annually from these lakes. In Table 12, regarding Perch Tarn I, a classification has been made between various length-groups, the mean weight of each group having been calculated. In this way, an approximative weight value of the collected perch has been arrived at. However, these values have been found to be comparatively definite in a comparison with the values obtained at a detailed calculation of the weight value of each length-group. During the years when more extensive fishing has taken place, 82 Kg or 13,7 Kg per annum (corresponding to 6,8 Kg/hectare) were caught. In Perch Tarn II similar calculations revealed that during the years 1934—36 a total of 69 Kg, corresponding to 23 Kg per annum and 5,8 Kg/hectares were removed, and during the years 1944 and 1945, not less than 76 and 21 Kg, respectively, or 19 and 4 Kg/hectare, respectively. Finally, in Perch Tarn III during the years 1938—41 a total of 65 Kg and 16,3 Kg were collected annually, i. e. 10,9 Kg/hectare. In certain tarns with small perch, however, they are by no means as common, sometimes even rather sparse, although stunted.

Even though it is in several cases a question of over-population, the matter must also be viewed in another aspect. It may be expressed in the following manner. The conditions of feeding for attaining a larger size among a great number of fish are lacking in these tarns, while they may offer fairly good facilities for small fish that feed on plancton. Because of this, a reduction of the population by intensive fishing becomes rather useless. The reduction has to be extremely severe if any result whatsoever is to be gained. However, such a reduction will then affect the population so heavily as to leave only a few individuals the opportunity of utilizing these more favourable conditions of feeding. Therefore, a reduction of this kind has, apparently, no practical value.

Nor is it even certain that a small number of perch would be able to find sufficient food so as to grow into large samples. The insect larvae and the several larger organisms required are so scarce that time would, no doubt, be lost merely in seeking them out. Conditions similar to those of a rather unsuitable fish pond have, to a certain extent, to be taken into account here. All experiences indicates that a pond of this type is far better utilized by spawn and small fish than by large samples. The small individuals, which do not need large organisms for food, have a fairly good supply of plancton at their disposal, while the large samples have

Table 12.

Total weight (calculated) of perch removed from Perch Tarn I. — *Beräknad vikt för i Abborrtjärn I borttagen abborre.*

Length *Längd* cm	Mean weight *Medelvikt* gr	Total weight in grammes for different length-groups (number in brackets) *Summa vikt i gr för olika längdgrupper (antal inom parentes)*					
		1934	1935	1936	1937	1938	1939
5—7	2,5	—	—	—	—	12,5 (5)	12,5 (5)
8—10	7	—	700 (100)	840 (120	3 640 (520)	2 520 (360)	595 (85)
11—13	17	2 040 (120)	1 785 (105)	12 750 (750)	3 825 (225)	8 160 (480)	6 885 (406)
14—16	37	12 432 (336)	740 (20)	7 215 (195)	740 (20)	1 295 (35)	3 330 (90)
17—19	65	3 900 (60)	1 625 (25)	650 (10)	325 (5)	—	650 (10)
20—22	105	1 050 (10)	3 675 (35)	525 (5)	—	—	—
	Summa	**19 422 (526)**	**8 525 (284)**	**21 980 (1 080)**	**8 530 (770)**	**11 987,5 (880)**	**11 472,5 (595)**

to spend too much effort seeking out the more sparse bigger organisms which form their principal diet. These conditions have been studied in detail by WALTER (1934), and in part also by H. NORDQVIST (1932), with regard to the carp and the tench. However, they can undoubtedly be applied also to natural waters.

The planting of large quantities of minnows (small roach, small alburn, etc.), would perhaps improve matters. Still, it should be observed that minows are difficult, if not impossible, to procure in several quarters. Further, these minnows will hardly produce settled populations, even though they may thrive and spawn in these lakes, on account of the lack of food and the cannibalism of the perch. Nevertheless, experiments are being continued with these fishes.

b. Experiments in the Big Holm Tarn (Stora Holmtjärn).

It may, no doubt, be taken for granted that the conditions in the perch tarns, referred to previously, and in other small lakes of a similar type have invariably been most unfavourable, resulting in the non-occurrence for long periods of time of large-sized perch populations. On the other hand, there are many lakes, where the perch has earlier been large-sized, that now contain only small-sized perch. Therefore, the finding of a lake of this particular type in the Kälarne region, viz., Stora Holmtjärn, (See Table 2) was of great value for our investigations. This lake comprising 16 hectares, is of a common type, being surrounded by wooded territory, with chiefly stony shores and sparse vegetation. Only the bottom water are either deficient in oxygen-gas or completely lacking in it for a certain period of the year.

Since this lake has a rather distant locality, the experiments have had to be committed into the hands of persons living in the neighbourhood. The experiments have, consequently, not been performable to the same extent with regard to the collection of samples and measurements as in the perch tarns. However, they have offered very interesting results. According to reports from reliable persons, the perch in this lake at the beginning of the twentieth century was large-sized and caught by net or hook-and-line. No other kind of fish has been found in this lake before. However, a few years ago, gwyniad and char were planted. A year or two after the first World War, all fishing was prohibited since it was feared that the until then intensive fishing should have damaged the perch population. This stipulation was maintained right up to the latter part of the third decade of the twentieth century, thanks to the occurrence of other good fishing waters for the villagers. When fishing was resumed, large perch were practically non-existent according to information received, while there was a profusion of small perch. The perch population in this lake was, accordingly, entirely stunted. This interesting observation resulted in the inclusion of also this lake in our experiments which had already been going on for several years in the three Perch tarns. As a matter of fact, everything favoured the assumption that the stunted appearance was in this case due purely to over-crowding, and that a strong decimation of the population would improve growth and increase the size of the fish. Thus, after having conferred with the holders of the fishing rights, an intensive decimation by fishing was started, at first principally with traps of 1/2—3/4 inch mesh size, later also with nets of varying mesh size and with hook-and-line fishing. During the year 1937 about 25.000 perch were removed, during 1938 about 7.000, during 1939 about 2.000, during 1940 about 3.000, during each of the years 1941 and 1942 about 2.000, and during 1943 about 1.500 samples. In addition, during 1938 and 1939, branches were laid out along the shores, in which the perch especially liked to spawn, and then they were taken away again.

The results of the measurements performed in connection with the decimation by fishing are illustrated in Fig. 15. The most frequent size was 14—16 cm in 1937 at the commencement of the experiments, and only a few perch exceeded this length. In the very next year, the mean length had increased and larger perch were more common. During the subsequent years, this becomes still more evident, with an increase of the mean length from year to year, and gradually more numerous samples of over 20 cm in length. During 1943 one perch was measured to equal 37 cm, and 6 were 32 cm. The increase in size throughout is conspicuous. Evidently, the lake had by now, as was the case earlier, a normal, fairly large-sized perch population. The many peaks in the curves show simultaneously the occurrence of several year-classes.

The stunted appearance in this lake is, apparently, due to an over-crowding and too small a supply of food for each individual, with subsequent deterioration in growth. The following reduction was effective enough to increase greatly the supply of food for the remaining perch, and facilitate added growth. However, the population has, on the other hand, been so large as to let quite a great number of perch in the younger year-classes grow up and benefit from the increased supply of food for each individual. Table 13 shows the marked discrepancies in this repect occurring between Holmtjärn and Perch Tarn I. The results of the reduction by fishing in these two lakes are rather different.

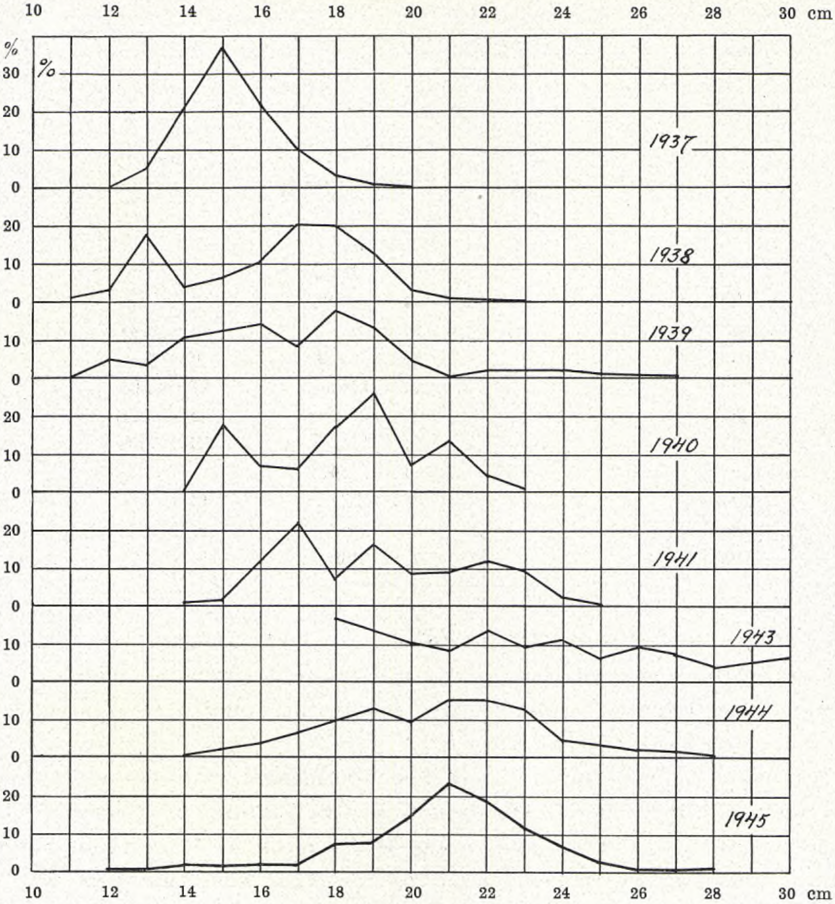

Fig. 15. Size in different years in Holmtjärn. — *Storleksfördelningen under olika år i St. Holmtjärn (% av antalet).*

Furthermore, the experiments in Holmtjärn indicate that, in a lake with good spawning facilities for the perch, a reduction of the population by direct fishing, so as to bring about a stunted appearance of the fish, owing to the fact that no perch have the opportunity of growing up and attaining high age and big size, is a very complicated matter. The earlier fishing in Stora Holmtjärn gave reversed results, i. e. the perch became large-sized at intensive fishing, and small when the fishing was discontinued. It can, therefore, no doubt be assumed that, in the cases where the lakes are favourable with regard to spawning and the appearance of new year-classes, the occurrence of stunted perch populations is due merely to over-

Table 13.

Mean length in cm in different years. (Number in brackets.)
Medellängd i cm under olika år. (Antal inom parentes.)

Year *År*	Perch Tarn I *Abborrtjärn I*	*St. Holmtjärn*
1934	12,1 (526)	—
1935	12,8 (284)	—
1936	12,2 (1 080)	—
1937	10,3 (818)	15,3 (746)
1938	10,9 (1 649)	16,3 (515)
1939	12,1 (696)	17,1 (317)
1940	10,9 (327)	18,3 (112)
1941	9,0 (946)	19,2 (205)
1942	9,2 (1 842)	—
1943	10,3 (276)	23,0 (100)
1944	10,9 (726)	20,5 (2 494)
1945	11,2 (446)	21,0 (576)

crowding, caused by insufficient fishing. In lakes of this type, which in many instances are not particularly unfavourable from the point of view of food, an intensive reduction by fishing may fairly soon involve an increase in growth and size.

A number of experiments have been performed with the intention of decimating stunted perch populations by the planting of 1-summer pike, plancton-eating gwyniad, and young trout, all however without success. Direct poisoning experiments have, on the other hand, not been resorted to, as in certain American lakes.

3. Transfer of perch from stunted populations to other waters.

It has been made clear above that the reduction experiments in the Perch Tarns have not afforded any results with regard to the increase in growth and size, apart from certain individual samples. In lakes of a different type (Holmtjärn), on the other hand, satisfactory results have been achieved in this way. Accordingly, stunted perch populations in unfavourable surroundings may easily be supposed to have gradually transformed into genotypical, stunted races in the course of the years by means of natural selection. This is a matter of great practical significance and several experiments have been made with a view to solving the problem. The experiments have comprised a direct transfer of stunted perch to other lakes and ponds, as well as the rearing of spawn deriving from the roe of stunted populations.

a. Transfer of older perch.

The transfer of grown-up samples of stunted perch populations has taken place from the Perch Tarns I and II, as well as from certain other tarns. Great care must be observed in the course of these experiments. The perch must not be injured in the fins or otherwise, since this might easily cause fungal growth with subsequent marked mortality. The experiments have involved a transfer to other lakes, as well as to ponds. In the former case, the intention was partly to examine the possible increase in growth of the transferred individual, which had therefore been marked by the cutting of the fins as well as by direct marking, and partly to find out whether the cross-breeding of a previous, newly introduced perch family would produce an improved growth in the offspring. The only positive result hitherto obtained is that of a transfer in the Spring of 1935 of 100 perch, 12—16 cm long, from Perch Tarn II to Barntjärn (Kälarne). This lake which was formerly devoid of fish, has an area of 2 hectares, and is 3,8 m deep. It has a marked thermocline and there is a deficiency of oxygen-gas in the hypolimnion. The pH value equals 6,5. The lake earlier contained planted tench which however died out, probably owing to a deficiency in oxygen-gas during a severe winter. Test fishing in the Autumn of 1937 gave 4 perch 26, 27, 28,5 and 28,5 cm long, respectively, and weighing between 250 and 350 grammes. Three of these were females and one a male. All of them were caught in a net with a 3,6 cm mesh size. None were caught in the finer and coarser nets laid out at the same time. These perch had, apparently, increased about 12 cm in length during the three summers in Barntjärn, which must be considered as an exceedingly good growth. Unfortunately, later experiments have been negative. In all likelihood, the perch has, like earlier the tench, died out as the result of suffocation. The experiment shows that, at any rate, some of the transferred samples have had a very good latent capacity for growth which has been manifested immediately in the new environment and, in view of the lack of fish, undoubtedly rather favourable conditions as regards food.

However, it is evident from the experiments with transferring of stunted perch to ponds at the Institute of Fishery Research at Kälarne, that this

Table 14.

Increasing length of perch, caught in Perch Tarn I and later reared in ponds. — *Längdökning hos från Abborrtjärn I till damm vid Kälarne överflyttade abborrar.*

Date *Tid*	Number *Antal*	Mean l. *Ml.*	Increasing mean l. *Ökning i ml.*	Length in cm — *Längd i cm*								
				12–14	15–17	18–20	21–22	24–26	27–29	30–32	33–35	36–38
V 33	50	13,0	—	50								
H 33	36	15,6	2,6	3	33							
H 34	33	18,9	3,3		3	28	2					
H 35	27	21,1	2,2			8	18	1				
H 36	27	22,9	1,8			4	13	10				
H 37	27	25,3	2,4			1	6	9	10	1		
H 38	21	26,8	1,5				2	7	7	5		
H 39	20	28,0	1,2				2	5	6	5	2	
H 40	17	30,6	2,6					4	5	3	5	
H 42	17	32,5	1,9					3	2	4	1	7
V 43	3 ♂	27,0	—				1	1		1		
V 43	9 ♀	33,9	—					1	1	1		6

good, latent capacity for growth is not characteristic only of certain individuals, but applies to all these stunted perch. Three experiments of this type have been performed, certain results being reproduced in Table 14. The first two experiments included perch from tarns nos. I and II, the third one the transfer to one and the same pond of an equally large number of approximately equal-sized perch from tarn no. II and from Gransjön, distributed at approximately the same proportion of females and males. In all the experiments, along with the perch a comparatively large number of equal-sized trout and grayling were kept in the ponds. In addition, special feeding also took place. The feeding conditions in these ponds must have been fairly good.

At each of the first two experiments, 50 perch were planted of a size normal for the tarns. At first the experiments were carried out in different ponds, later in the same pond, with marking of the perch from one of the experiments. After 10 and 9 years, respectively, in the ponds, in the Autumn of 1942, 17 and 19 samples, respectively, remained of these perch. In the following Spring, when the experiments were discontinued owing to too intensive a decimation, attaining a number of only 12 and 13 in either experiment, the perch were found to include 3 males and 9 females in experiment no. I, while there were 3 males and 10 females in experiment no. II. Considering that at the transplantation the number of males undoubtedly exceeded that of the females, the losses or natural mortality had, apparently, been greater among the males.

Growth was best during the first years with an annual increase of, on an average, 2—3 cm. During later years, growth generally decreased, but did not, however, actually stop. Unfortunately, on account of the fact that in the first years spawning had taken place before the examinations in the spring, the sexes had not been kept apart until during later years when the results disclosed continued growth also in the males. Thus, the mean length in the Spring of 1943 in experiment no. I was 27,0 cm for the males and 33,9 cm for the females, and in experiment no. II 29,0 and 27,2 cm, respectively. The distribution in size increased with the years. The perch in experiment no. I, further, showed throughout a somewhat better growth than in experiment no. II. The increase in length in the former experiment equalled, during the 10 years, close on 20 cm, being in the latter between 13 and 14 cm, during the 9 years' period. Both experiments definitely prove that these transferred perch from stunted populations in their new environment show a far better growth than in the tarns where, as already mentioned, samples exceeding 20 cm are but rarely caught. In addition, this has concerned all the transferred individuals.

This is, moreover, confirmed by the third experiment which was performed for the purpose of comparing the increase in growth of perch from a stunted and a normal-sized population, as previously mentioned Perch Tarn II and Gransjön. The mean length was, at the beginning and at the end of the experiment, as follows:

Perch Tarn II	Spring	42	Males	12,2 cm (41 s[1])	females	12,3 cm (32 s)
	»	44	»	19,7 cm (17 s)	»	20,3 cm (8 s)
Gransjön	»	42	»	12,5 cm (42 s)	»	13,0 cm (27 s)
	»	44	»	20,0 cm (28 s)	»	20,6 cm (13 s)

[1] s = samples.

The growth during the first year in the pond was particularly good with approximately 6 cm in both the perch families. During the later years, on the other hand, growth deteriorated. However, no marked difference was noted between the two families. The females showed better growth than the males, notwithstanding the fact that males and females had from the start been purposely selected with a fairly equal size.

It is conceivable that the perch concerned in these experiments had a bad start, so to speak, on account of their stay, during the first years of life, in the unfavourable tarn environment, with an early sexual maturity and subsequent deterioration in growth. They have, therefore, perhaps not been able to display their whole inherent capacity of growth, whenever such a capacity has existed. On the other hand, this would be possible if roe were taken from stunted perch of this type in the tarns and the spawn was later allowed to grow up in better surroundings from the start. Several experiments have, in fact, been performed in this direction, as will be accounted for below.

b. Transfer of perch spawn and young perch, from stunted populations.

Three small lakes of little value were selected for the planting experiments with spawn and young perch, first brought up in ponds. One of these lakes caused suffocation during certain years, while in another lake the possible occurrence of a stunted population could not cause any particular damage, and in the third lake perch occurred even before the experiments.

In the Spring of 1938, in the V. Vontjärn (2 hectares, 3,3 m deep, pH 6,2, transparency 1,4 m) which was deficient in fish, 1.000 newly hatched spawn from Perch Tarn II were planted. In the Autumn of the same year, 10 1-summer old perch were caught with the following lengths:

Length	11	11,5	12 cm
Number	4	2	4

Thus, the growth was exceedingly good. Later fishing experiments have all given negative results, without doubt due to the fact that the fish have died of suffocation in the shallow lake.

The second experiment was performed with 1-years old perch in the Spring of 1936, when 300 were planted in Bodtjärn (2,5 hectares, 3,8 m deep, pH 6, transparency 2,2 m). This planting proved of great interest. Owing to the fishing experiments made every autumn and, in the last years also in the spring, good information has been obtained with regard to the growth (Table 15). At the fishing, nets of varying mesh size have been employed and, during the years 1944 and 1945, also traps. At the planting, the length varied between 4 and 7 cm. The first fishing experiment was made in the Autumn of 1937, when 67 now 3-summer old perch were collected. The mean length equalled 19,8 cm, which must be regarded as an exceptionally good growth with, on an average, approximately

Table 15.

Results of experimental planting in Bodtjärn. — *Resultatet av försöksutplantering i Bodtjärn.*

Date *Tid*	Sex *Kön*	Captured number *Antal fångade*	Mean length in cm *Ml i cm*	Length in cm — Längd i cm																											
				8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
H 37	—	67	19,8									1		7	21	20	9	8	1												
H 38	♂	16	20,9												1	6	5	2	2												
	♀	14	23,4															4	3	5	1	1									
H 39	♂	8	23,6															1	2	4	1										
	—	5	10,0	1	2		1		1																						
	♀	5	25,2															1			1	2	1								
H 40	♀	5	26,6																	1		1	2		1						
H 41	—	16	17,5									6	5	2	1	1				1											
H 42	—	17	18,6									4	6	3	1	1							1				1				
V 44	♂	342	12,8				54	114	91	48	20	4	4	4	2	1															
	♀	73	15,2[1]				2	8	12	18	11	7	4	4	2	1	2											1			1
	—	42	12,5				12	11	11	4	2	2																			
H 44	♂	5	15,8							1	2	1			1																
	♀	7	17,1									3	2	1		1															
V 45	♂	147	12,8				8	59	51	15	8	5	1																		
	♀	108	13,8				1	20	35	28	12	4	5	1	1				1												

[1] The two large female samples not included. — *De två stora honorna ej medräknade.*

7 cm per annum. 28 males and 30 females among them had strongly developed gonads and were to spawn in the following spring. The males had undoubtedly spawned already in the spring. Unfortunately, the length of the two sexes was not noted. This was, however, done in the following years (see the table) and the growth was even then good. During 1939, 5 small perch were caught by hook-and-line fishing and in finely-meshed nets equalling 8—13 cm in length, probably being 2-summer old deriving from the first spawning run in the Spring of 1938. In the Autumn of 1940, only 5 large females, but no small samples, were obtained. During each of the two next years, on the other hand, 16 and 17 small perch were caught, respectively, now equalling 16—20 cm in length, and probably deriving from the new year-class of 1938 being, accordingly, 4-summer and 5-summer old. Only isolated large females were collected simultaneously. During the year 1943, the experiments failed to give any results, while during the following years, several hundreds of chiefly small perch, 12—13 cm in length, were caught each year. The age of some of the samples examined in 1944 was 4—6 years. They accordingly come from generations hatched in the Springs of 1939—41. Also two samples from the generations which were planted first were obtained in the Spring of 1944. Strangly enough, the generation of the year 1938, which gave samples of 16—20 cm as early as in 1941, did not manifest itself in large individuals. This would imply that a certain deterioration in growth had already occurred. The bad growth in the later generations, as compared to that of the planted perch, is at any rate noteworthy in this connection.

During the Spring of 1944, 25 males and 25 females were marked by the cutting of fins. 4 of these females were recaptured, one in the Autumn of 1944 and three in the Spring of 1945, corresponding to 8 per cent of the number of marked ones. This would, in a catch of 267 perch, correspond to a population of approximately 3.000 individuals. This would then explain the occurrence of a lack of food, causing the growth to deteriorate and giving rise to a stunted population. Thus, the experiment shows that in the case of the generation planted first, with only a few individuals in proportion to the area of the lake, very good growth had been attained, as well as the rapid appearance of new rich generations, and finally, in connection with this, a strong decrease in growth and size.

In the Spring of 1938, 143 3-year old perch, deriving from the spawn in the Perch Tarn II were taken from Kälarne and planted in Kyrktjärn (see Table 2). The mean length equalled 11,2 cm. All the perch were marked by the cutting of the anal fins in order to distinguish them from the original perch in this tarn. 145 of these samples were caught simultaneously with a mean length of 18,7 cm. They were marked in the left abdominal fin and replanted. During the years 1938—1944 a total of 607 samples were caught by nets with a mesh size of 2,5—3,7 cm, 30 being recaptured of those marked from Kälarne, and 36 of those from Kyrktjärn. This corresponds to about 20 and 25 per cent of the number of marked samples, and indicates in this case a fairly large population. The mean length in centimetres of the marked samples which were invariably removed during the various years of collection is tabulated below (the number of samples is denoted in brackets):

Year	Kälarne	Kyrktjärn	Year	Kälarne	Kyrktjärn
1938	18,0 (1)	19,8 (5)	1942	—	19,5 (2)
1939	15,0 (8)	18,0 (8)	1943	18,0 (3)	21,0 (1)
1940	16,5 (8)	18,5 (6)	1944	21,0 (1)	19,8 (10)
1941	17,3 (13)	18,2 (14)			

The lack of smaller samples in Kyrktjärn during all the 7 experimental years is conspicuous. However, it is probably partly due to the fact that nets of a finer mesh size and traps have not been made use of. This may serve to explain why such a slight number of the smaller Kälarne perch have been recaptured. Judging from the size of the recaptured and marked samples, the growth has not been particularly good in any of the cases concerned, although it is perhaps somewhat better regarding the Kälarne perch, considering their smaller original size. This bad growth is, without doubt, dependent on the lack of food, due to the great size of the population.

4. Rearing of perch in ponds from the size of spawn.

Experiments of rearing perch spawn and young perch in ponds have principally been performed at the Institute of Fishery Research at Kälarne, supplemented by experiments also in the ponds at the hatching stations at Älvkarleby (Upland), Drottningholm (Stockholm), Harvik (Dannemora, Uppland) and Aneboda (Ugglehult, Småland). As a rule, the ova has been fertilized and hatched at the various institutions.

More than 30 ponds occur at Kälarne of an area varying from 300 to 700 m^2. The size of the latter type, which have chiefly come to use in the present experiments, equals 80—90 $\times$ 8 m, the depth being 0,8—1 m.

The water volume is therefore about 500 m^3. The water supply is approximately 100 lit/min in the smaller and shallower summer ponds, and 200—250 lit/min in the bigger and deeper winter ponds. The water, which is taken from the river Ansjöån, about 500 m from its issue from Ansjön, is comparatively clear with a pH-value of about 7,0. The temperature amounts to a maximum of 22—23° C.

At Älvkarleby, newly hatched perch spawn arrive annually with the afflux water to a larger salmon spawn pond near Hyttön. This is always found, in the autumn, to have resulted in large or small quantities of 1-summer old perch in this pond. The same applies to several ponds at the Harvik hatching station.

When rearing perch spawn, it should be borne in mind that no cross-current must occur. However, the rearing often has proved a failure during the first summer. During later years of life, on the other hand, rearing has generally been successfull, although large and apparently inexplicable losses have been made at times. The number of samples received by drawing the ponds has sometimes exceeded that of the planted samples in these experiments. This is due to the fact that, at the previous examination, some samples have remained in the pond without being observed. Since the experiments have mostly continued in the same pond year after year, this is a matter of no significance. The marking by cutting of the fins has, to a great extent, been adopted in order to distinguish between different groups, sexes, etc.

The rearing of certain year-classes has in some cases been continued right up to the age of 10 years (summers). In other cases, the experiments have been discontinued before then. Measurements of length, weighing, sex determination, and the examination of spawning maturity, etc., have taken place each spring (about 1st June) and autumn (about 1st Oct.) when the ponds were drawn. Thus, it may sometimes be a question of the age in summers, at other times, the age in winters. In view of the fact that, as will be shown later, growth practically ceases during the cold season, this is a matter of little consequence.

The purpose of the present experiments has been, partly to examine the growth of the offspring of stunted populations as compared to the offspring of populations with a rapid growth, and partly to study, in connection with the problems referred to earlier, the important, fundamental questions regarding the dependence of growth on various factors (such as environment, density of population, sex, heredity, etc.), as well as the sex ratio and the relationship between sexual maturity and growth. Since direct experiments have hitherto been performed on a very small

Table 16.

Length and age of perch reared in ponds. Number of different length-groups. — *Antal exemplar av olika längd inom varje åldersgrupp vid dammförsöken.*

Length in cm – *längd i cm*	Age in summers — *ålder i somrar*									
	1	2	3	4	5	6	7	8	9	10
2	1									
3	155									
4	886									
5	606	11								
6	736	197								
7	547	107								
8	277	420	5							
9	137	605	40							
10	203	370	74							
11	119	271	142							
12	72	138	240	10						
13	28	80	288	30						
14	7	74	242	72	2					
15		25	126	97	49					
16	1	4	58	101	87	12				
17		1	29	127	88	44				
18			11	111	78	72	3			
19			11	64	78	66	20	6	1	
20			6	25	72	74	31	17	6	
21			1	17	53	57	41	22	18	16
22				11	37	36	43	24	13	13
23				6	22	46	28	21	11	10
24				4	10	26	17	26	16	13
25				1	6	15	19	11	13	9
26				1	5	12	31	10	11	8
27				1	4	6	7	22	14	8
28					2	7	7	15	14	17
29						4	8	10	17	13
30						3	4	3	6	11
31						1	5	3	3	2
32						1	3	5	2	4
33							2	5	3	3
34						1	2	4	5	4
35						1	1		5	5
36								3		2
37									2	1
38									1	2
Total – *summa*	**3 775**	**2 303**	**1 273**	**678**	**593**	**484**	**272**	**207**	**161**	**141**
Mean length – *medellängd*	6,2	9,3	13,0	16,8	18,7	20,8	23,3	24,5	26,1	26,8

Table 17.

The length of 1-summer old perch. — *Längden hos 1-somrig abborre.*

Date *Tid*	Pond *Damm*	Derivation *Härstamning*	Number — *antal* planted *insatta*	Number — *antal* obtained *utfiskade*	Mean length in cm *Ml i cm*	Mean weight in grammes *Mv i gr*
1933	1	Perch Tarn I	?	28	ca 6,5	2,0
1934	20	Perch Tarn I	800	15	ca 8,0	7,0
1935	13	Perch Tarn II	1 000	980	3,8	0,7
1935	14	Pond 15	200	154	—	0,7
1935	26	Perch Tarn II	1 000	2 050	4,5	0,9
1935	28	Perch Tarn II	2 000	1 800	4,9	1,2
1937	8	Perch Tarn II	1 000	540	4,4	0,9
1937	9	Perch Tarn II	500	350	4,9	1,1
1940	6	Gransjön	1 000	72	4,3	—
1940	7	Perch Tarn II	1 000	680	3,6	0,4
1940	10	Perch Tarn I	1 000	53	4,6	—
1941	1	Large ♀ fr. pond 16 ..	1 000	470	4,0	0,8
1941	2	Small ♀ fr. pond 16 ..	1 000	840	4,5	1,0
1941	29	Perch Tarn II	2 000	2 000	4,8	—
1941	30	Perch Tarn I	2 000	230	7,9	—
1942	11	Perch Tarn II	1 000	950	4,0	—
1942	12	Hjälmaren	1 000	43	4,7	—
1942	16	Hjälmaren	1 500	1 600	4,0	—
1943	22	Perch Tarn I	?	34	4,8	—
1944	29	Large ♀ pond 23	2 000	190	6,5	3,1
1944	30	♀ Gransjön × ♂ Perch Tarn II	1 000	212	6,4	2,8
1945	3	Large ♀ pond 26	1 000	272	6,0	2,0
1945	4	Small ♀ pond 26	1 000	224	4,5	0,9
1945	7	Large ♀ pond 17	500	325	5,1	2,0
1945	8	Small ♀ pond 17	500	84	6,5	5,0
1945	11	♀ Perch Tarn I × ♂ Perch Tarn II	500	460	5,8	0,9
1943	Drottningholm	Mälaren	500	146	4,6	—
1942	Älvkarleby	Dalälven	—	256	10,6	—
1943	Älvkarleby	Dalälven	—	190	11,6	—
1944	Älvkarleby	Dalälven	—	150	10,3	12,8
1943	Harvik	Slagmyren	—	439	7,3	—
1937	Aneboda	Stråken	—	226	6,4	—

scale, with the exception of fish species used in pond rearing, extensive experiments of this kind should throw more light on the problems referred to above.

The results of the experiments have been recorded in different tables. In Table 16, a compilation of all these experiments has been made, showing the mean growth of perch reared in ponds. The material is, as may be seen, fairly comprehensive, although it is naturally rather heterogeneous. The great distribution in size is noteworthy. This is due to the fact that the experiments have been performed under a number of different circumstances, which will be dealt with in detail further on. However, it will be noted that the distribution in the size of perch of the same year-class and in the same experiment is frequently considerable. The distribution in size increases with age. This finds its natural explanation in the discrepancy in growth between the sexes as will be referred to below. The figures of growth (recorded in Fig. 6) obtained from a compilation of the material are, broadly speaking, in agreement with those of the perch of large-sized populations (cp. Table 6). The growth during the different years of life will now be subjected to discussion.

The first year of life (Group 0). Table 17 gives the extreme variation in growth during the first year of life. In a study firstly of the results from Kälarne with regard to each year and to the summer- and winter-ponds separately, the growth will be found generally better when the population is weaker, and vice versa. Owing to the often considerable losses during the first year of life, this relationship is, however, not so apparent as at a higher age. Nor have, for this reason, any marked differences in growth been noticeable between the various years. Unfortunately, it has also been impossible, for similar reasons, to ascertain any differences in growth between the spawn from different populations (the Perch tarns, Gransjön near Kälarne and Lake Hjälmaren), as well as at the crossbreeding of stunted populations from different tarns. Several experiments with ova from a large and a small female, fertilized by one and the same medium-sized male, have also given very different results. The forementioned experiments cannot offer any answer to the problem of the effect of heredity on growth. New experiments of this kind are being planned to be performed under more controllable conditions.

In comparison with Kälarne, the growth during the first year of life in other ponds is considerably better. This applies particularly to the Hyttö pond at Älvkarleby where a record growth was obtained during the three years of experimenting. However, this pond is a large one (15 hectares) and no doubt offers favourable feeding conditions — in spite

Table 18.

Size and sexual maturity of 1-summer-old perch (1 = sexually immature, 2= sexually mature in the following spring). — *Storlek och könsmognad hos 1-somrig abborre (1 = ej könsmogen, 2 = könsmogen nästkommande vår).*

Date *Tid*	Pond *Damm*	Sex *Kön*	Number *Antal*	Mean length in cm *Ml i cm*	Length in cm — *Längd i cm* 3	4	5	6	7	8	9	10	11	12	13	14	15
H. 1935	Kälarne, 13, 26, 28	♂ 1	80	4,8	2	27	42	5	4								
		♀ 1	74	4,4	7	30	36	1									
H. 1943	Kälarne, 22	♂ 1	19	5,1	—	3	12	4									
		♀ 1	15	4,5	—	8	7										
H. 1943	Drottningholm, 6	♂ 1	67	4,4	1	47	15	3	1								
		♂ 2	6	7,7	—	—	—	1	2	1	2						
		♀ 1	73[1]	4,5	—	47	19	5	2								
H. 1943	Harvik, 1 c + 18	♂ 1	10	6,2	—	—	2	4	4								
		♀ 1	24	5,8	—	1	6	14	3								
	» , 15 N	♂ 2	7	8,1	—	—	—	—	—	7							
		♀ 1	15	7,7	—	—	—	—	8	4	3						
	» , 15 Ö	♂ 1	7	7,6	—	—	—	—	2	3							
		♂ 2	64	7,7	—	—	—	—	31	33	2						
		♀ 1	125	7,3	—	—	—	8	72	45							
	» , 16 Ö	♂ 1	12	7,5	—	—	—	3	7	2							
		♂ 2	73	7,6	—	—	—	2	28	37	6						
		♀ 1	102	7,2	—	—	1	8	64	27	2						
H. 1942	Älvkarleby	♂ 2	150	10,8	—	—	—	—	—	—	9	53	68	13	6	1	
		♀ 1	106	10,4	—	—	—	—	—	—	12	52	38	—	4		
H. 1943	»	♂ 1	3	11,6	—	—	—	—	—	—	—	2	1				
		♂ 2	92	—	—	—	—	—	—	—	—	4	43	31	10	3	1
		♀ 1	95	11,5	—	—	—	—	—	1	1	7	46	25	12	3	
H. 1944	»	♂ 2	45	10,4	—	—	—	—	—	10	26	7	2				
		♀ 1	105	10,3	—	—	—	—	3	34	51	16	1				
H. 1937	Aneboda	♂ [2]	118	6,6	—	—	—	65	43	4	4	2					
		♀	108	6,2	—	—	—	87	19	2							

[1] 4 uncertain females or hermaphrodites. — *4 osäkra, honor eller hermafroditer,*

[2] In August. The development of the gonads was not sufficient to indicate whether they would spawn in the following year. — *I augusti. Gonadernas utveckling var då inte så stark att man kunde se om de skulle leka nästa år.*

of a population of salmon-spawn — for the perch spawn arriving with the afflux water and originating from the perch populations in the large lake-like expansions of Dalälven. It is impossible to obtain any conception whatsoever of the number of in-coming spawn in the Hyttö pond or at Harvik. A fairly good growth was obtained also at Aneboda, in spite of a rather early drawing of the ponds (13/8).

Table 18 gives the results of the examination of sex and sexual maturity on material preserved in the autumn. It will be seen that in the cases which have attained good growth, all or at least the majority of the males would spawn in the following year. On the other hand, in cases where the growth was bad, no male has arrived at this stage in its development. In each experiment, as shown in this table, the big males, above all, have approached sexual maturity. No female has reached this stage. The following figures disclose the relationship between the size of the males and their sexual maturity, the perch from Aneboda not being included owing to the fact that they were examined as early as in August.

Length . . . . cm	3	4	5	6	7	8	9	10	11	12	13	14	15
Num. males spawning next spring (437 in all)	—	—	—	3	61	78	27	83	118	46	16	4	1
Num. males not spawning next spring (198 in all)	3	77	71	19	18	5	2	2	1				

Among the males 6 cm long, the majority did not become sexually mature in the following spring, while the opposite took place with regard to those 7 cm long. However, even big specimens are to be found in the former stage, which also applies to the group of perch 10 and 11 cm long.

In the Spring of 1944, 134 1-summer old perch were, in addition, examined in a pond at Drottningholm, which had been transferred in the Autumn of 1943 from Älvkarleby. 71 of these perch had a running milt, the mean length was 11,5 (10—15) cm, while the remaining 63 were sexually immature and had a mean length of 11,3 (9—14) cm. No doubt, all these latter samples were females.

In the forementioned examination material, 753 were males and 842 females, i. e. 47,2 and 52,8 per cent, respectively. Further, the table discloses the mean length in all the experiments to be somewhat greater among the males than among the females. This difference is quite significant considering the size of the material and the varying environmental conditions.

Table 19.

The length of 2-summer old perch. — *Längden hos 2-somrig abborre.*

Date *Tid*	Pond *Damm*	Number — *antal*		Mean length in cm *Ml i cm*	Mean weight in grammes *Mv i gr*
		planted *insatt*	obtained *utfiskat*		
1934	3	24	21	11,7	20,0
1935	20	14	13	13,6	30,0
1936	11	100 a[1]	99	9,0	7,0
1936	12	100 b	92	8,5	7,0
1936	13	850	625	6,4	2,4
1936	19	500	360	8,0	5,0
1936	23	100	81	10,6	14,0
1936	29	500	500	8,4	5,6
1936	30	100	17	13,0	29,0
1938	1	50	27	10,6	15,0
1938	2	200	106	9,0	8,0
1938	3	55	39	11,5	15,0
1938	4	210	195	9,3	8,0
1942	2	150	26	8,0	5,8
1942	6	250	32	9,2	7,8
1942	7	130 a	109	7,9	6,0
1942	8	125 b	60	8,0	6,7
1942	9	100 a	39	11,2	15,4
1942	10	100 b	32	9,1	9,4
1942	18	500 a	165	10,3	13,0
1942	19	500 b	109	9,5	9,0
1942	20	500	79	10,4	14,0
1942	22	150 a	39	10,4	11,8
1942	22	150 b	105	9,1	11,8
1942	29	500	320	8,8	6,0
1942	30	90 a	75	12,6	20,0
1942	30	118 b	113	11,3	14,0
1943	7	150 a	78	8,4	6,4
1943	8	150 b	35	10,8	11,0
1944	10		47	14,0	
				9,3	

[1] a = large *(stora)*, b = small *(små)*.

The second year of life (Group I). Table 19 gives the results of the pond experiments during the second year of life. A distinct relationship is evident between the density of the population and the growth (1936 — 19, 23, 29 and 30; 1938 — 1, 2, 3 and 4). In all these experiments, the mean length was greater and the growth better when the population was slight. The following figures from the various experiments shows the relationship between the mean length and the density of the population at the drawing of the ponds.

		Num. of experiments	Mean length in cm
Experiments where the collected samples equalled max.	50	12	11,1
» » » » » »	51—100	7	9,7
» » » » » »	101—200	7	9,6
» » » » » »	more than 200	4	8,8

The experiments in 1942 and 1943 were largely intended to disclose the growth of a coming year among groups of selected large and small 1-summer old perch from one and the same population. Whenever the various size groups had ben reared in different ponds, the quantity was equal in these experiments. When reared in one and the same pond, the quantity has varied but the groups have been distinguished by markings. On the whole, these experiments have proved that the difference in size in the two groups is noticeable even at the end of the second summer, although it is then mostly smaller than at the start. The increase in the mean length was, for this reason, almost invariably greater among the, from the beginning, smaller fishes than in the corresponding larger groups in each experiment. The earlier difference in growth, manifested in the 1-year old perch in the spring by a variation in size, has accordingly not been increased but rather decreased, even though it may have continued in the same direction during the second summer. The advantage in growth during the first year in a certain experiment has therefore, in all likelihood, been due less to hereditary factors and more to chance factors, and has not been the sole determining factor with regard to continued growth. However, the fact that the individuals which had, from the start, better growth continue in this way also in later years of life, and that accordingly also genetic factors are of significance in this respect, are evident from these experiments and will be entered upon more in detail below.

Table 20.

Size and sexual maturity of 2-year-old perch. — *Storlek och könsmognad hos 2-årig levande abborre.*

Date *Tid*	Pond *Damm*	Sex *Kön*	Number *Antal*	Mean length in cm *Ml i cm*	Length in cm — *Längd i cm*								
					7	8	9	10	11	12	13	14	15
V 1939	21	♂ 2	67	9,2	1	4	47	13	—	1	1		
		?	72	9,2	—	7	48	15	1	1			
V 1939	22	♂ 2	23	9,3	—	3	11	9					
		?	26	8,8	2	6	13	4	1				
V 1942	21	♂ 2	22	9,7	—	2	4	14	2				
		?	27	9,7	—	2	10	11	3	1			
V 1943	18 a[1]	♂ 2	53	10,6	—	—	6	23	14	7	2	1	
		?	84	10,2	—	2	18	36	16	10	2		
V 1943	18 b	♂ 2	38	9,4	—	—	22	15	1				
		?	47	9,3	—	7	23	12	4	1			
V 1943	20	♂ 2	26	10,7	—	—	1	9	15	—	—	1	
		?	39	10,5	—	—	2	17	20				
V 1943	23 a	♂ 2	16	10,3	—	—	1	10	5				
		?	15	10,5	—	—	—	7	8				
V 1943	23 b	♂ 2	38	9,4	—	2	21	14	1				
		?	52	9,1	3	12	22	9	5	1			
V 1943	30 a	♂ 2	29	12,4	—	—	—	—	6	9	11	3	
		?	30	12,6	—	—	—	—	3	7	19	1	
V 1943	30 b	♂ 2	44	10,9	—	—	2	11	22	9			
		?	52	11,3	—	—	—	10	26	11	2	2	1
V 1944	30	♂ 2	44	8,8	1	14	23	6					
		?	56	8,7	3	18	27	7	1				

[1] a = large *(stora)*, b = small *(små)*.

As regards spawning maturity at the end of the second year of life, Table 20 gives the result of an examination of living 2-year-old perch. No females among them were spawning. On the other hand, it may no doubt be taken for granted that the great majority of males were mature for spawning at this time. The table shows that 400 out of 900 perch, or 44,4 per cent, had a running milt. The main part of the remaining perch must then have been females. Among preserved 2-summer old perch in the autumn (Table 21), 241 out of 484 samples, or 52 per cent, were males which would be spawning in the next spring. In addition, there were 27 males which had not attained this stage of development. Among the 216 females, 11 would be spawning in the next spring in this experi-

Table 21.

Size and sexual maturity of 2-summer old perch. — *Storlek och könsmognad hos 2-somrig konserverad abborre.*

Date *Tid*	Pond *Damm*	Sex *Kön*	Number *Antal*	Mean length in cm *Ml i cm*	Length in cm — *Längd i cm*											
					5	6	7	8	9	10	11	12	13	14	15	16
H 1936	13	♂ 1	11	6,0	2	8		1								
		♂ 2	1	7,0			1									
		♀ 1	15	6,5		11	3			1						
H 1938	1—4	♂ 2	77	9,8				5	40	8	15	6	3			
		♀ 1	83	10,0				6	26	23	17	10	1			
H 1942	7—8	♂ 1	13	8,2			2	7	4							
		♂ 2	79	8,1			13	51	14		1					
		♀ 1	71	7,9			17	48	5	1						
H 1942	9—10	♂ 1	3	10,3					1	1		1				
		♂ 2	48	10,4				4	12	11	13	2	4	2		
		♀ 1	13	9,6					8	2	3					
H 1943	20	♂ 2	9	9,4					5	4						
		♀ 1	14	9,3				2	6	6						
H 1944	10	♂ 2	27	13,6									9	15	2	1
		♀ 1	9	13,9									2	6	1	
		♀ 2	11	14,7										4	6	1

ment, where the growth had been particularly good during these first two years. In spite of a length of 13—15 cm, 9 females in this experiment were still quite immature. In all the other experiments all the females were immature.

Finally, as regards the growth of these perch, it will be noticed that males and females are, on the whole, equally long. In two experiments the size was equal, in nine the mean length of the males exceeded somewhat that of the females, while in six conditions were reversed. However, the differences were altogether insignificant. Since the length of the 1-summer old perch was throughout greater among the males, the fairly equal size at the end of the second year would imply that the growth during this year had been less good among the males than among the females. This is, no doubt, due to the fact that several 1-summer old males and almost all the 2-summer old males had by then attained sexual maturity which has involved a slower growth. This will be subjected to a closer discussion later.

Table 22.

The length of 3-summer old perch. — *Längden hos 3-somrig abborre.*

Date *Tid*	Pond *Damm*	Number — *antal* planted *insatt*	Number — *antal* obtained *utfiskat*	Mean length in cm *Ml i cm*	Mean weight in grammes *Mv i gr*
1935	22	15	10	17,0	60
1936	24	13	12	17,7	80
1937	3	80	55	10,9	
1937	4	50	31	12,3	20
1937	5	150	117	10,0	10
1937	11	150	122	10,6	12
1937	16	50	34	13,4	30
1937	18	80	64	13,3	25
1937	19	30 a[1]	20	13,9	30
1937	19	30 b	36	13,3	28
1937	23	17 a	12	16,2	58
1937	23	60 b	53	14,3	37
1937	25	50	45	15,4	42
1937	28	150	152	12,5	19
1937	29	32	27	17,5	78
1937	30	92 a	66	12,0 } 11,7	17
1937	30	94 b	55	11,6	
1939	15	125	121	13,6	32
1939	23	25 a	26	16,0 } 15,4	46
1939	23	25 b	21	14,8	
1942	21	49	26	14,2	30
1943	18	202 a	160	12,9	24
1943	18	85 b	71	12,0	
1943	19	31 a	24	13,8	27
1943	19	90 b	35	13,2	
1943	30	59 a	31	14,8	31
1943	30	96 b	67	13,9	
1944	3	22	19	13,8	32
1944	4	78	57	12,3	19
				13,0	

[1] a = large *(stora)*, b = small *(små)*.

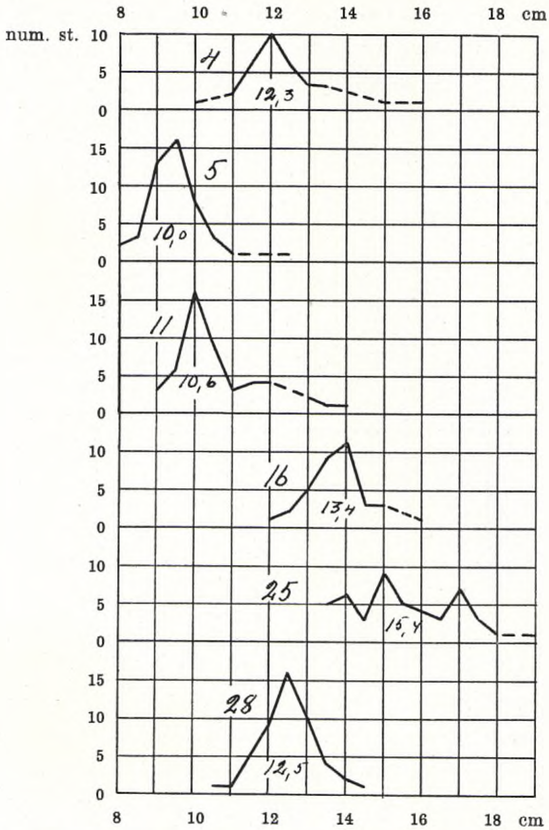

Fig. 16. The relation between size, density of population and water volume among 3-summer-old perch. Small number in nos. 4, 16 and 25, large number in nos. 5, 11 and 28. Nos. 4, 5 and 11 represent small ponds, nos. 16, 25 and 28 big ponds (cp. Table 22). — *Sambandet mellan storlek, besättningsstyrka och vattenvolym hos 3-somrig abborre. I nris 4, 16 och 25 litet antal, i 5, 11 och 28 stort antal. Nris 4, 5 och 11 äro små, nris 16, 25 och 28 stora dammar (jmf. tab. 22).*

The third year of life (Group II). Table 22 shows the growth in pond experiments during the third year of life. As regards the relationship between growth, on the one hand, and the density of the population and the size of the pond, on the other, this is even more evident at this stage than during the preceding years (1937: 4 and 5, 25 and 28, 4 and 16, 5, 11 and 28). This is more clearly illustrated in Fig. 16. All these experiments were performed in 1937 with a material of the same original size, i. e. about 9 cm. Since also the losses were very slight in this case, the results are fully comparable. In the summer ponds with a slight water volume, the mean length at a weak population was 12,3 (4) and at a dense population 10,0 (5) and 10,6 (11), being in the winter ponds, at a weak population 13,4 (16) and 15,4 (25), and at a dense population 12,5 (28) cm. The experiments disclose the fact that a strong population in a comparatively large winter pond will result in approximately the same growth and length as in the case of a weak population in a small summer pond. A still larger size is attained at a very sparse population (1935: 22, 1936: 24, 1937: 29). A compilation of all these experiments will give the following results:

	Num. of experiments	Mean length in cm
Experiments where the collected samples equalled max. 20	5	15,7
» » » » » » between 21—50	11	14,4
» » » » » » » 51—100	8	12,5
» » » » » » more than 100	5	11,8

The experiments with selected large and small samples were continued also during the third year of life and the results obtained are reproduced in Table 23. However, the differences in the increase in length between the beginning of the experiments and the end, in both the larger and the smaller groups, is now generally not so pronounced as during the second year of life, when this increase in length was mostly much greater in the individuals which were smaller from the start. This indicates that during the third year of life the growth, calculated in weight, has at any rate in certain cases been greater or equally great among the perch which were larger at the beginning of the third year than among the smaller perch. This applies to the selection spot at this age (1937: 19 and 23; 1939: 23) as well as to the cases where the experiments have formed a continuation of earlier ones (1943). This speaks in favour of the assumption that a genetic difference in growth is a determining factor in this respect.

Several experiments have been carried out with a view to ascertaining whether or not the differences in growth and size because of different densities of the population continue. As demonstrated by WALTER (1934) with regard to the carp and the tench, perch of a small size, owing to the density of the population, if put in good ponds grow much better than the larger ones of the same age. Fig. 17 gives an illustration of such a case. During the year 1936 (19 and 23), at a population of 500 and 100 1-year old perch, respectively, a mean length was obtained among 360 and 81 collected 2-summer old specimens, respectively, of 8,0 and 10,6 cm

Table 23.

Growth of 2-year-old perch, divided into large (a) and small (b) samples. — *Tillväxt under tredje sommaren hos utsorterad stor (a) och liten (b) abborre.*

Date *Tid*	Pond *Damm*	Number *Antal*	Mean length in cm *Ml i cm*	Increase in mean length in cm *Ökning i ml i cm*	Length in cm *Längd i cm*													
					7	8	9	10	11	12	13	14	15	16	17	18	19	20
V 1937	19	30 a	8,4		—	19	11											
H 1937	19	20	13,9	5,5	—	—	—	—	—	—	5	12	3					
V 1937	19	30 b	7,8		6	24												
H 1937	19	36	13,3	5,5	—	—	—	—	—	1	23	11	1					
V 1937	23	17 a	12,2		—	—	—	—	—	15	1	1						
H 1937	23	12	16,2	4,0	—	—	—	—	—	—	—	—	4	3	4	1		
V 1937	23	60 b	10,6		—	—	3	20	37									
H 1937	23	53	14,3	3,7	—	—	—	—	—	3	2	8	12	2				
V 1937	30	92 a	9,0		—	12	67	13										
H 1937	30	66	12,0	3,0	—	—	—	1	40	20	4	—	—	1				
V 1937	30	94 b	8,5		—	48	45	1										
H 1937	30	55	11,6	3,1	—	—	—	3	21	27	3	1						
V 1939	23	25 a	10,3		—	—	—	21	2	1	1							
H 1939	23	26	16,0	5,7	—	—	—	—	—	—	—	2	5	14	3	1	1	
V 1939	23	25 b	8,8		—	4	21											
H 1939	23	21	14,8	6,0	—	—	—	—	—	—	1	9	10	1				
V 1943	18	202 a	10,4		—	2	27	85	65	17	4	2						
H 1943	18	160	12,9	2,5	—	—	—	3	7	52	58	25	10	4	1			
V 1943	18	85 b	9,4		—	7	45	27	5	1								
H 1943	18	71	12,0	2,6	—	—	—	4	18	29	17	2	1					
V 1943	19	31 a	10,4		—	—	1	17	13									
H 1943	19	24	13,8	3,4	—	—	—	—	—	—	8	12	4					
V 1943	19	90 b	9,2		3	14	43	23	6	1								
H 1943	19	35	13,2	4,0	—	—	—	—	1	5	17	10	1	1				
V 1943	30	59 a	12,5		—	—	—	—	9	18	28	4						
H 1943	30	31	14,8	2,3	—	—	—	—	—	—	1	8	17	5				
V 1943	30	96 b	11,1		—	—	2	21	48	20	2	2	1					
H 1943	30	67	13,9	2,8	—	—	—	—	—	3	22	30	9	2	—	—	—	1

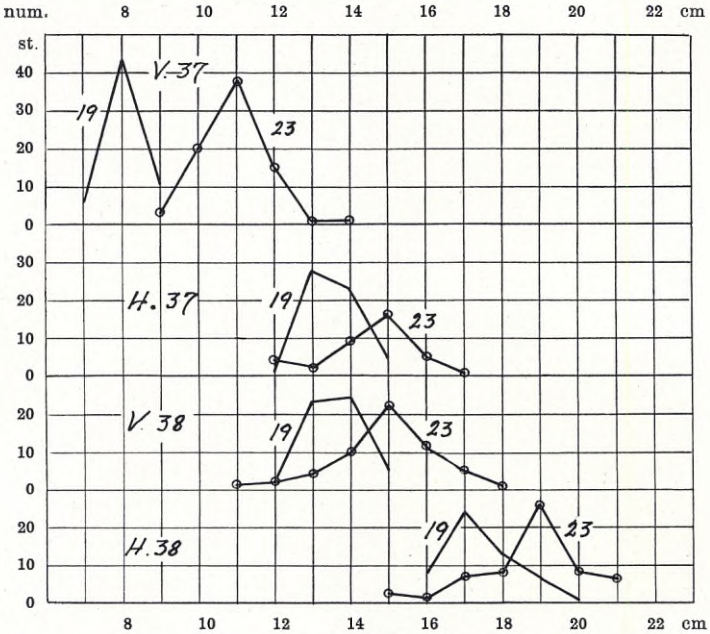

Fig. 17. Size distribution in different years among large (o—o—o) and small (———) perch (num. of samples). — *Storleksfördelningen under olika år hos stor (o—o—o) och liten (———) abborre (antal ex.).*

i. e. a difference of 2,6 cm. During 1937, this experiment was continued with 60 small samples and 77 large ones in the same ponds (19 and 23), a classification of large and small individuals being made in each group (see Table 23). In the Autumn, the mean length equalled 13,5 and 14,6 cm. The difference in length had accordingly decreased to only 1,1 cm. In the following Spring, the size was approximately the same in both the now 3-year-old groups. In the Autumn of 1938, the mean length of 52 small and 58 large 4-summer-old samples was 17,5 and 18,9 cm, respectively, with a difference in length of 1,4 cm. However, Table 24 shows that the number of males was considerably greater in the stunted population (19), the number of females being, on the contrary, particularly great in the large-sized population (23). This is, no doubt, the reason for the continued difference in growth. This larger male and female surplus, respectively, must however be attributable purely to chance.

The different results obtained in these experiments with selected large- and small-sized perch and with perch of different sizes dependent on the various populations are, apparently, due to the fact that the difference

Table 24.

Size and sexual maturity of 3-year-old perch. — *Storlek och könsmognad hos 3-årig levande abborre.*

Date *Tid*	Pond *Damm*	Sex *Kön*	Number *Antal*	Mean length in cm *Ml. i cm*	Lenght in cm — *Längd i cm*													
					9	10	11	12	13	14	15	16	17	18	19	20	21	22
V 1938	19	♂ 2	30	13,4	—	—	—	—	18	11	1							
		♀ 2	14	14,0	—	—	—	—	3	8	3							
		?	8	13,9	—	—	—	—	2	5	1							
V 1938	23	♂ 2	20	14,4	—	—	1	1	3	4	7	3	1					
		♀ 2	13	15,2	—	—	—	—	—	3	6	3	1					
		?	22	15,4	—	—	—	1	—	3	9	5	3	1				
V 1938	25	♂ 2	67	11,8	10	4	14	18	15	—	3	1	1	1				
		♀ 2	30	14,3	—	—	—	5	10	1	6	3	3	2				
		?	43	11,4	4	13	4	10	9	2	—	1						
V 1938	29	♂ 2	10	16,2	—	—	—	—	—	2	—	4	2	2				
		♀ 2	17	18,6	—	—	—	—	—	—	—	2	3	2	6	2	1	1
V 1940	15	♂ 2	65	13,6	—	—	—	5	31	16	10	2	—	1				
		♀ 2	23	15,3	—	—	—	—	4	5	5	4	4	—	—	—	—	1
		?	53	14,0	—	—	—	2	10	28	11	1	1					
V 1944	18	♂ 2	101	12,6	—	2	14	36	28	16	4	—	1					
		?	141	13,0	—	3	8	41	52	22	8	6	1					
V 1944	19	♂ 2	25	13,2	—	—	—	2	16	7								
		?	32	13,4	—	—	2	3	11	11	5							
V 1944	29	♂ 2	38	13,6	—	—	2	—	17	14	4	1						
		♀ 2	4	15,5	—	—	—	—	—	3	—	—	—	—	—	1		
		?	58[1]	14,1	—	1	—	4	11	19	20	3						

[1] 11 males of these spawned in 1943.
Av dessa nu ej lekmogna ex. voro 11 ♂ i lek 1943.

in size during the first year of life is in certain cases accidental (the last-mentioned one) and, in other cases, dependent on genetic factors. Still, it is evident that a difference in growth owing to the latter reasons does not make itself as noticeable during the first year of life, nor during part of the second year, as later on.

Tables 24 and 25 disclose the relationship between size, age and sexual maturity. With the exception of isolated instances, all the males are by

Table 25.

Size and sexual maturity of 3-summer old perch. — *Storlek och könsmognad hos 3-somrig konserverad abborre.*

Date *Tid*	Pond *Damm*	Sex *Kön*	Number *Antal*	Mean length in cm *Ml. i cm*	Length in cm — *Längd i cm*							
					9	10	11	12	13	14	15	16
H 1937	3	♂ 1	2	13,0	—	—	—	—	2			
		♂ 2	24	10,9	—	10	9	4	—	1		
		♀ 1	28	10,6	2	13	10	2	—	—	—	1
		♀ 2	2	11,0	—	—	2					
H 1937	30	♂ 1	3	10,7	—	1	2					
		♂ 2	56	11,5	—	2	31	19	2	1	—	1
		♀ 1	38	11,8	—	2	8	25	3			
		♀ 2	23	11,9	—	—	5	16	2			
H 1943	21	♂ 2	9	14,0	—	—	1	—	2	2	3	1
		♀ 1	16	13,2	—	1	3	2	1	4	5	
		♀ 2	2	14,5	—	—	—	—	1	—	—	1
H 1944	3	♂ 2	10	13,7	—	—	—	1	3	4	2	
		♀ 2	9	13,8	—	—	—	—	1	1	5	2
H 1944	4	♂ 2	29	12,2	—	—	2	19	8			
		♀ 1	3	12,0	—	—	—	3				
		♀ 2	25	12,7	—	—	—	11	10	4		

this time sexually mature, i. e. 356 or 45,4 per cent out of 787 specimens examined during the Spring, and 128 or 46,1 per cent out of 279 perch examined in the Autumn. As regards the females, all had reached spawning maturity in experiments where the growth had been particularly good (1938: 29), while in the majority of experiments only a lesser amount of females and, in a few experiments, not any females at all have attained this stage of development. Further, each experiment has clearly shown that it is the larger females that are mature for spawning or approaching this stage. In experiment 29: 1944, 11 males were found among the not spawning specimens, which were spawning in the Spring of 1943. Among the perch examined in the Spring, 101 out of 787 or 12,9 per cent were spawning females, while among the perch examined in the Autumn only 6 out of 279 or 2,1 per cent were females which would spawn in the following Spring.

As regards growth, the tables show that at the age of 3 years, the

Table 26.

The length of 4- and 5-summer old perch. — *Längden hos 4- och 5-somrig abborre.*

Date *Tid*	Pond *Damm*	Age *Ålder*	Number — *antal* planted *insatt*	obtained *utfiskad*	Mean length in cm *Ml i cm*	Mean weight in grammes *Mv i gr*
1936	22	4	7	7	21,1	114
1937	20	4	12	11	18,8	73
1938	16	4	80	77	16,9	53
1938	18	4	320	290	15,7	44
1938	19	4	19 a[1]	19	18,1	} 58
1938	19	4	35 b	33	17,1	
1938	23	4	16 a	18	19,9	} 81
1938	23	4	40 b	40	18,3	
1938	33	4	27	27	21,7	131
1940	31	4	140	121	17,6	69
1944	18	4	242	112	14,3	36
1944	19	4	57	44	15,9	55
1944	25	4	100	66	16,3	49
					16,8	
1937	24	5	7	7	23,0	143
1938	20	5	11	11	21,7	155
1939	16	5	158	158	18,7	89
1939	18	5	210	181	16,7	58
1939	33	5	136	124	20,1	141
1941	26 ♀	5	71	68	21,3	88
1941	28 ♂	5	49	39	19,7	90
					18,7	

[1] a = large *(stora)*, b = small *(små)*.

females are larger than the males, with the exception of two experiments. The previously ascertained somewhat increased growth during the second year among the females as compared to the males has become still more conspicuous during the third year. At the age of 3 years a distinct differentiation between the sexes is apparent.

The fourth year of life (Group III). Table 26 shows the growth during the fourth and fifth years of life. The different quantities of equal-sized specimens still has (1938: 16, 18) the effect of causing a difference in the mean length of over 1 cm at the end of the summer. The perch, earlier

Table 27.

Size and sexual maturity of 4-year-old perch. *Storlek och könsmognad hos 4-årig levande abborre.*

Date *Tid*	Pond *Damm*	Sex *Kön*	Number *Antal*	Mean length in cm *Ml. i cm*	Length in cm — *Längd i cm*																			
					12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
V 1939	16	♂	38	15,9	—	1	6	9	11	4	4	2	1											
		♀	29	17,6	—	—	—	1	7	9	5	5	1	—	—	—	1							
		?	9	16,0	—	—	4	1	—	2	1	—	—	1										
V 1939	18	♂	149	14,7	3	12	37	39	41	10	1	5	—	1										
		♀	74	16,8	—	—	8	7	24	19	1	9	2	1	3									
		?	63[1]	15,0	2	2	26	17	9	3	1	2	—	—	—	—	1							
V 1939	23	♂	59	18,0	—	—	—	1	5	26	6	11	3	4	3									
		♀	77	19,8	—	—	—	—	—	8	8	30	7	9	4	7	1	1	1	1				
V 1941	18	♂	51	19,6	—	—	—	—	1	9	11	10	6	1	3	6	3	1						
		♀	59	22,1	—	—	—	—	—	2	10	5	5	8	4	4	3	7	3	6	1	—	—	1
V 1945	{ 15 26 }	♂	78	14,9	3	7	21	25	14	5	3													
		♀	51	16,5	—	3	3	11	6	12	11	4	—	—	1									
		?	14	13,9	1	4	5	4																

[1] Many were females who would spawn in the following year.
Många undersökta voro honor som skulle leka först nästa år.

large-sized owing to a sparse population (1938: 33), still reveal a considerable advantage in size.

The size still varies in the earlier divided groups of larger and smaller specimens (1938: 19, 23). The increase in mean length has been approximately equal in all these cases, i. e. in pond 19 among the larger samples 4,2, and among the smaller ones 3,8 cm, and in pond 23, among the larger samples 3,8, and among the smaller ones 3,9 cm.

Table 27 illustrates the relationship between size and spawning maturity at the end of the fourth year of life. Among 751 examined 4-year-old perch, only 86, or 11,6 per cent, were not spawning. 375 of the rest, or 49,9 per cent, were spawning males and 290, or 38,5 per cent, spawning females. In the two experiments where all the perch had reached spawning maturity, the mean length considerably exceeded that of the two experiments where some of the females were immature. The shortest mean length was noted in the experiment with the most immature females (1939: 18). Among 44, 4-summer old perch (19) examined in the Autumn of 1944, consisting of 23 males and 21 females, all the males and all the females but 2 would be spawning in the following Spring. The mean length equalled 15,8 cm for the males and 17,1 cm for the females, with the exception of the 2 which were not going to spawn, whose lengths only amounted to 15,3 and 15,4 cm, respectively. The relationship between spawning maturity and growth is therefore evident also among the 4-year-old perch. Moreover, in one and the same experiment, the mean length is greater among those sexually mature than among immature ones. It is, therefore, clear, that the large females are the first to reach the stage of spawning maturity. The smaller 4-year-old females wait until their 5th year.

The difference in the mean length between males and females is, at the end of the 4th year, still more pronounced than at the end of the 3rd year, as may be seen from Table 27. There is, in this case, a certain connection with the growth, in so much as the difference in size between the sexes is more marked when the growth is better. Further, it should be noted that the mean length of also the females which have not attained sexual maturity is generally greater than that of the males.

The fifth to tenth year of life (Group IV—IX). The growth during the fifth and the following years of life is illustrated in Tables 26 and 28. A comparison between the size in different experiments during the various years shows that the earlier larger perch are still larger than the others, and the earlier smaller ones remain smaller. In order to throw more light on this

Table 28.

The length of 6—10-summer old perch. — *Längden hos 6—10-somrig abborre.*

Date *Tid*	Pond *Damm*	Age *Ålder*	Number — *antal*		Mean length in cm *Ml i cm*	Mean weight in grammes *Mv i gr*
			planted *insatt*	obtained *utfiskad*		
1940	16	6	134	117	21,3	170
1940	24	6	170	151	18,9	134
1940	33	6	121	116	22,1	162
1942	26 ♀	6	66	66	21,4	136
1942	28 ♂	6	46	33	20,1	119
					20,8	
1941	16	7	110	100	23,1	192
1941	33	7	94	87	24,6	203
1943	20 ♀	7	28	26	21,2	108
1943	24 ♂	7	60	59	22,9	161
					23,3	
1942	24	8	106	98	24,5	214
1942	33	8	84	76	26,2	276
1944	24	8	40	33	22,6	152
					24,5	
1943	23	9	90	88	25,3	233
1943	33	9	70	73	27,2	301
					26,1	
1944	21	10	83	80	25,4	263
1944	33	10	73	61	28,0	339
					26,8	

phenomenon, as well as on the above-mentioned relationship between sex and growth, several experiments have been performed of sorting out into more size groups than two. Some of these experiments, which have naturally been made on material of a homogeneous descent and have all given approximately the same results, will be referred to below.

In the Spring of 1939, an experiment was initiated of classifying 4-year-old perch into 3 size groups. The original material in this particular experiment derived from 1-summer old specimens from ponds nos. 26 and 28 of the year 1935, both being spawn from the Perch Tarn II. The material has than been made use of in various experiments (in 1938 in the ponds nos.

19, 23 and 33). In the Autumn of 1938, all these perch were planted in one and the same pond (23) and were then found to have the following lengths in cm:

Pond no.	15	16	17	18	19	20	21	22	23	24	25	26	27	Num. of samples	Mean length in cm
19	—	7	24	13	7	1	—	—	—	—	—	—	—	52	17,4
23	2	1	7	8	26	8	6	—	—	—	—	—	—	58	18,8
33	—	—	1	1	1	6	5	5	5	2	1	1	1	29	21,7
Total	**2**	**8**	**32**	**22**	**34**	**15**	**11**	**5**	**5**	**2**	**1**	**1**	**1**	**139**	
	64				**49**		**26**								

In the Spring of 1939, these perch were divided into 3 size groups as follows:

A with a length of 15—18 cm
B » » » » 19—20 »
C » » » » 21—27 »

The number of specimens in group A was 54, in group B 51, and in group C 31. The number of specimens of the same size groups equalled, in the preceding autumn, 64, 49 and 26, i. e. a certain increase in length, though but slight, had taken place during the winter. Group C chiefly consisted of (cp. the length in the Autumn of 1938 and the Spring of 1939) the sorted out samples in the Spring of 1936 of large and, owing to the sparse population, rapidly grown perch originating from pond no. 33. The number of females in this group predominated, being 24 to 7. This can be explained by the fact that the earlier selected largest 2-summer fingerlings were included among them. In the middle group, the female quantity was also big, i. e. 37 to 14. This group comprised perch from all three ponds, those from pond no. 23 predominating. The latter had, owing to a more sparse population in 1936, become more large-sized than the more numerous specimens in pond no. 19. However, since no selection of large samples has taken place, the female preponderance must be due to chance. Finally, the majority of the perch from pond no. 19 belonged to group A, several from pond no. 23, and possibly also occasional samples from pond no. 33. In this group, the number of females equalled only 16 to 38 males. The explanation lies, no doubt, in a selection of small samples which has taken place at the sorting out in the Spring of 1937. In all, the number of males was 59, that of females being 77.

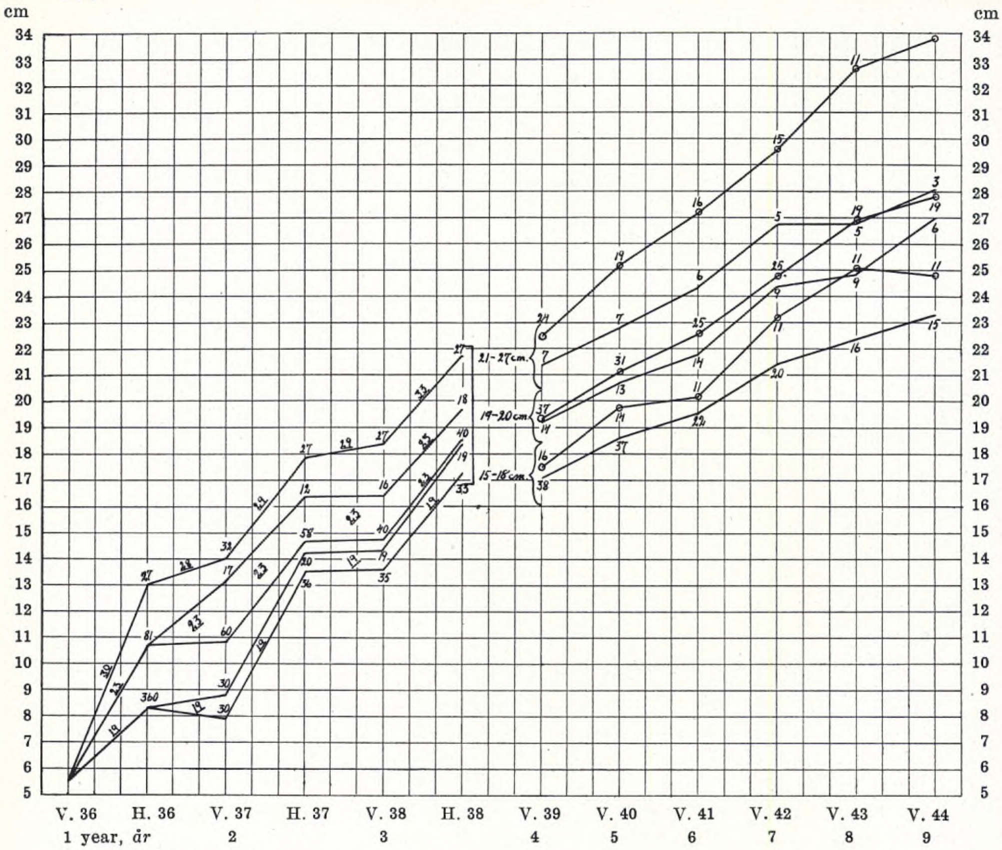

Fig. 18. Growth rate (mean length) in different years of perch divided into different groups (o—o—o = ♀, ——— = ♂). The experiment was initiated in the spring of 1939, but the results of earlier experiments have also been included in the figure (cp. Tables 26 and 28). The figures of the spring (V) and autumn (H) denote the number of samples, the underlined figures the number of the pond. — *Tillväxten (medellängd) under olika år hos i olika grupper sorterade abborrar (o—o—o = ♀, ——— = ♂). Försöket påbörjat våren 1939, men i figuren även inlagda resultaten av tidigare försök (jmf. tab. 26 och 28). Siffrorna för vår (V) och höst (H) angiva antal exemplar, siffror med streck under beteckna dammens nummer.*

The continued growth of these size groups is shown more in detail in Fig. 18. Evidently, the females were considerably larger than the males in each group, and this difference increased with the years, as also — though not as obviously — the difference in size between the three groups. Further, the decrease in growth of the males was particularly conspicuous during the last two years.[1] The increase in the mean length may be seen from the

[1] Owing to strong decimation in the Winters of 1944 and 1945, due to minks, the material was too restricted for inclusion in the Spring of 1945.

following figures, computed at the beginning of the experiments and at the end, the number of samples being denoted in brackets:

	A	B	C
Males			
Spring 1939	17,1 cm (38)	19,2 cm (14)	21,4 cm (7)
Spring 1944	23,3 cm (15)	27,0 cm (6)	28,0 cm (3)
Increase	5,3 cm	7,8 cm	6,6 cm
Females			
Spring 1939	17,5 cm (16)	19,3 cm (37)	22,5 cm (24)
Spring 1944	24,8 cm (11)	27,9 cm (19)	33,8 cm (12)
Increase	7,3 cm	8,6 cm	11,3 cm

This increase was, as may be seen, considerably larger among the females and, in particular, in the from the start largest groups.

The results from an experiment of classification into 5 different groups are, broadly speaking, the same. The original material, also in this case, consisted of perch deriving from spawn in Perch Tarn II (Pond no. 28 of the year 1935) which had been included in a number of experiments with varying populations during the year 1937. In the Autumn of 1937, all the by then 3-summer old perch were planted in one and the same pond, and in the Spring of 1938 they were divided into two, with a dense population in pond no. 18 and a sparse population in pond no. 16. The mean length in the Autumn of 1938 equalled, in pond no. 16, 16,9 cm and in pond no. 18, 15,7 cm. In the Spring of 1939, 111 perch were removed from pond no. 18 and distributed in three different size groups (a, c and e) and 50 perch were taken from pond no. 16, i. e. 25 large ones (b) and 25 small ones (d). In this way, 5 groups were obtained of successively increasing sizes (Table 29). Since not all the samples were at the spawning stage, no sex distribution could be performed. In the Spring of 1940, spawning had already taken place before the ponds were drawn. Not until the Spring of 1941, therefore, could the size of the two sexes be examined. The number of males and females then equalled 34 and 39, respectively, of perch from pond no. 18, and 17 and 20, respectively, of perch from pond no. 16. A distribution is found in the various size groups, similar to that of the previous experiment. In the two largest groups, there are 34 females to 11 males, in the middle group 12 females to 11 males, and in the two smaller groups only 13 females to 29 males. Apparently, the difference in growth between the sexes even among 4-summer fingerlings was so marked as to

Table 29.

Increasing mean length in different size groups. — *Längdökning hos olika storleksgrupper.*

Date *Tid*	Grupp a		Grupp b		Grupp c		Grupp d		Grupp e	
	Mean length in cm *Medellängd i cm*	Increase *Ökning*	Mean length in cm *Medellängd i cm*	Increase *Ökning*	Mean length in cm *Medellängd i cm*	Increase *Ökning*	Mean length in cm *Medellängd i cm*	Increase *Ökning*	Mean length in cm *Medellängd i cm*	Increase *Ökning*
V 39	19,0 (36)[1]	—	18,4 (25)	—	16,3 (36)	—	14,5 (25)	—	13,7 (39)	—
H 39	22,5 (36)	3,5	20,6 (25)	2,2	18,3 (35)	2,0	17,0 (24)	2,5	16,2 (37)	2,5
V 40	22,1 (31)	— 0,4	20,6 (23)	0	18,0 (32)	— 0,3	17,3 (18)	0,3	16,1 (30)	— 0,1
H 40	25,7 (31)	3,6	22,9 (22)	2,3	19,5 (22)	1,5	19,1 (18)	1,8	18,0 (24)	1,9
V 41	25,1 (24)	— 0,6	23,1 (21)	0,2	20,2 (23)	0,7	19,3 (16)	0,2	18,0 (26)	0
H 41	28,1 (25)	3,0	24,6 (19)	1,5	22,1 (20)	1,9	20,3 (14)	1,0	19,8 (22)	1,8
V 42	27,9 (25)	— 0,2	24,4 (18)	— 0,2	22,0 (21)	— 0,1	21,0 (18)	0,7	19,7 (24)	— 0,1
H 42	30,0 (21)	2,1	26,7 (19)	2,3	23,8 (21)	1,8	22,1 (14)	1,1	20,9 (23)	1,2
V 43	29,0 (19)	— 1,0	25,5 (17)	— 1,2	23,5 (21)	— 0,3	21,1 (12)	— 1,0	20,7 (20)	— 0,2
H 43	31,0 (18)	2,0	26,5 (16)	1,0	24,6 (21)	1,1	22,0 (11)	0,9	21,6 (22)	0,9
V 44	30,8 (17)	— 0,2	26,1 (17)	— 0,4	24,2 (20)	— 0,4	21,2 (10)	— 0,8	21,7 (23)	0,1
H 44	31,4 (17)	0,6	26,2 (15)	0,1	25,3 (18)	1,1	23,5 (11)	2,3	22,4 (19)	0,7

[1] Number in brackets — *Antal inom parentes.*

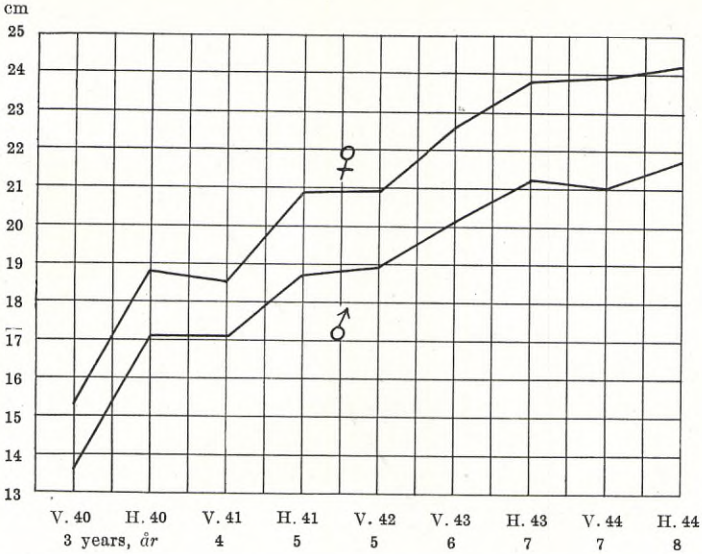

Fig. 19. Growth rate (mean length) of males and females during different seasons. — *Tillväxten (medellängd) hos hanar och honor under olika årstider.*

make the classification into size groups involve also a certain distribution into different sexes.

The increase in growth is most marked in the largest group, naturally due to the large number of females as in the previous experiment. In the rest, the increase varies more irregularly.

The difference in the growth of the sexes has been subjected to a special experiment, where a certain number of males and females at the age of 3 years have been separated into different ponds. As shown in Fig. 19, the growth of the females is better throughout. This, apparently, does not apply to the last years owing to the fact that some of the largest females have disappeared (either by death or in some other way). The better growth of the females is also disclosed in the considerably greater distribution.

In addition, this experiment discloses — like all the other experiments — the but slight growth during the winter, i. e. between the beginning of October and the end of May. Sometimes even the mean length decreases, in certain cases owing to the fact that large samples have been removed for use as illustration objects. Still another experiment of sorting out different length groups has only served to confirm the above statements.

The following may be said in summing up the results of these pond experiments. The growth of perch reared in ponds is greatly dependent on the size of the pond and its depth, as well as on the density of the population. It is at first, throughout, at least as good and mostly better than in lakes with large-sized perch populations. However, it is less good at a higher age. The growth takes place chiefly during the summer and is very insignificant in the winter. No difference in growth as between the offspring of stunted populations and large-sized ones has been ascertainable.

Selected large or small perch from one and the same population and of the same age show that, provided the selection has taken place during the first or second year of life, a certain difference occurs in the increase of growth during the following years, in so much as the small perch disclose, on an average, a somewhat greater increase than the large ones. However, this is not noticeable at a higher age. Therefore, it may be stated that the specimens which have throughout had a better growth from the start will continue in this way, while those with a less good original growth will be smaller in size. Thus, the difference in growth must be due to a certain extent to genetic factors.

III. Growth and sexual maturity.

The experiments performed in the present investigations show that the growth and size of the perch in various populations are principally dependent on the supply of food and the environment, as well as on genetic factors, when the different individuals in one and the same population are concerned. Since there is a certain regularly recurring difference in growth between the sexes of this species, and further, considering that sexual maturity, i. e. the stage at which spawning takes place for the first time, invariably occurs earlier among the males than among the females, a relationship no doubt also exists between sexual maturity, on the one hand, and growth and size, on the other.

It has been pointed out by several investigators that a certain relationship exists between the sexual maturity and the size of the fishes. GEYER (1939), in particular, has subjected this question to intensive studies on certain *Cyprinides*. His results indicate that, as a rule, early sexual maturity and bad growth, as well as late sexual maturity and good growth are interrelated. WUNDSCH (1940) makes a similar statement with regard to the bream. Among the trout, the river-trout which has normally a slow growth becomes sexually mature earlier than the more rapidly growing lake-trout (ALM, 1939). However, GEYER (1939) has later drawn attention to very pronounced exceptions from this rule, viz., sexual maturity sets in very early at unusually good growth in the Fertö lake in Hungary which is undoubtedly very favourable from the point of view of environment (high and steady summer temperature, pH over 8). A compilation of the results of these and other investigations has been made by LASKAR (1940). Although this compilation of his of available data in the literature does not seem to offer satisfactory evidence of this matter, he has, nevertheless, strongly affirmed that bad growth and early sexual maturity are interrelated, just as good growth and late sexual maturity, except in cases where an unusually good growth has caused early sexual maturity. The latter phenomenon is not uncommon as demonstrated by SCHOLZ (1932) on the pike. In addition, WUNDER (1934, 1940) pointed out that the rapidly growing, Galizian race of the carp becomes sexually mature at an earlier stage than races with slower growth. Further, RÖPER (1936) mentioned the occurrence of early sexual maturity in perch with

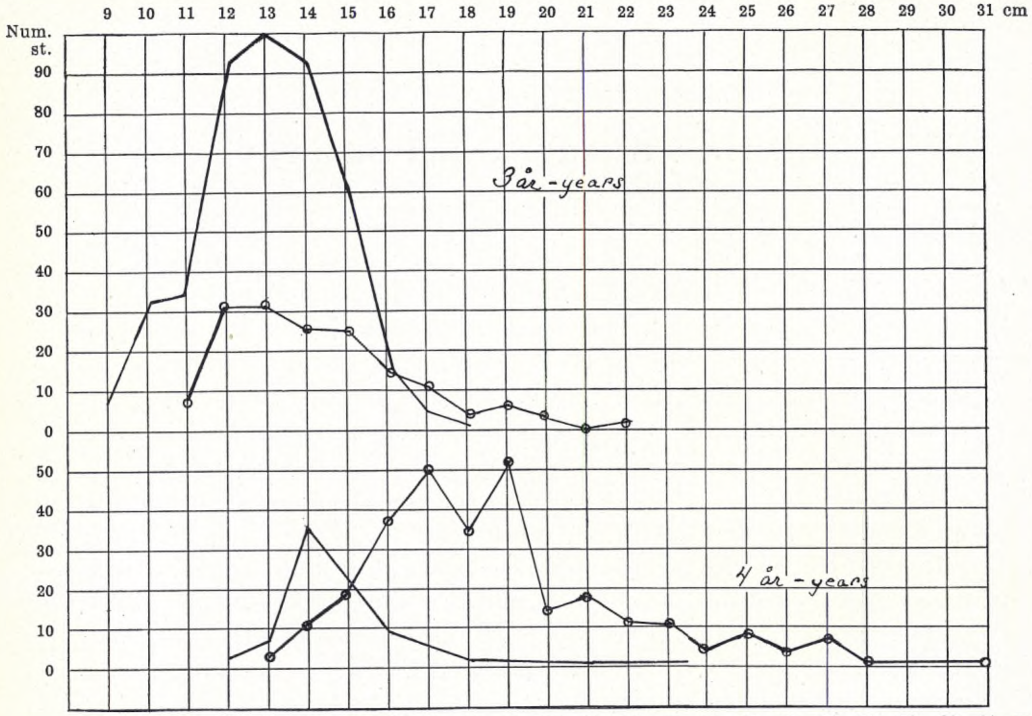

Fig. 20. The relationship between sexual maturity, size and age of 3- and 4-year-old female samples (——— = sexually immature, o—o—o = sexually mature). — *Sambandet mellan könsmognad, storlek och ålder hos 3- och 4-åriga honor. (——— = icke könsmogna. o—o—o = könsmogna ex.).*

good growth. OLOFSSON (1924) found that sexual maturity among gwyniad, which have been transferred to new lakes and there attained better growth, sets in, nevertheless, at the same age as in the original stunted populations. Finally, in direct experiments, SVÄRDSON (1943) has been in a position to ascertain on the *Lebistes* that the sexual maturity of the males at very good growth invariably occurs at a low age and small size, being postponed to a higher age and greater length at medium-good growth, and being manifested among individuals with the most unsatisfactory growth at a still higher age but with, again, smaller body size. In the latter case, SVÄRDSON'S results deviate from the above-mentioned ones concerning the age and sexual maturity in different populations.

The forementioned pond experiments on the perch have, as shown in the previous chapter, offered some guidance with regard to an elucidation of these problems. The matter may be summarized as follows: At the age

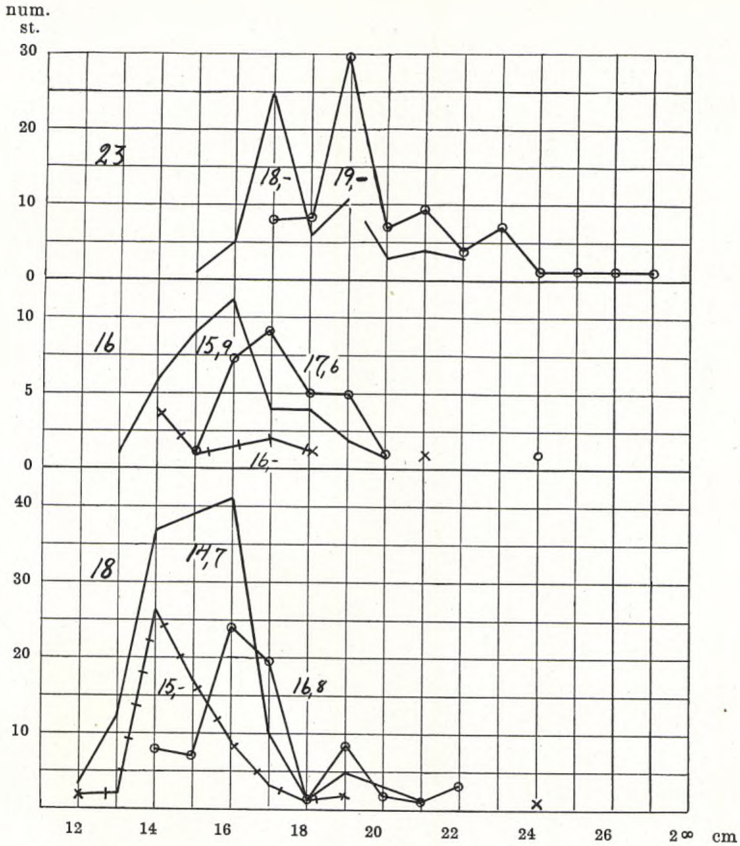

Fig. 21. The relationship between size and sexual maturity of 4-year-old perch (——— = = sexual maturity in males, o—o—o = sexual maturity in females. ı—ı—ı = sexually immature samples). — *Sambandet mellan storlek och könsmognad hos 4-årig abborre (antal ex.) (——— = könsmogna♂, o—o—o = könsmogna ♀, ı—ı—ı = icke könsmogna ex.).*

of 1 year, the males which have had a particularly good growth (7 cm long or more) become sexually mature. When a whole population has grown especially well owing to favourable environment, all the males become sexually mature, while no males would attain this stage if the opposite should occur. At the age of 2 years, the majority of the males become sexually mature and have a length of, as a rule, 9—14 cm, only a small number of males (5—6 per cent) with particularly bad growth (now 6—8 cm) still being sexually immature. At the age of 3 years, all the males have become sexually mature, with but a few exceptions. On the other hand, none of the females become sexually mature at the age of 1 year, and only a few particularly large ones with a length of 14—15 cm do so at the age of 2. At 3 years of age, about 10 per cent of all the

Table 30.

Number of males of different lengt-groups which will spawn (k) or not (0) in the next spring. — *Antal hanar av olika längd som skola leka (k) eller ej (0) nästa vår.*

Lake *Sjöns namn*	Sexual maturity *Köns-mognad*	Length in cm — *Längd i cm*														Mean length in cm *Medellängd i cm*
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Abborrtjärn I	0	—	—	—	3	19	14	3	1	1	—	1	—	—	—	9,7
	k	—	—	—	7	13	47	57	30	7	6	—	—	—	—	10,8
Abborrtjärn II	0	—	—	—	—	4	2	5	3	3	—	1	1	—	—	11,4
	k	—	—	—	11	38	46	42	42	14	4	5	4	3	1	11,0
Abborrtjärn III	0	—	—	—	6	1	8	11	5	3	1	—	—	—	—	10,6
	k	—	—	—	—	6	10	23	21	15	16	22	20	5	2	13,2
Hjälmaren	0	—	—	—	—	—	1	3	—	14	22	47	16	3	—	14,6
	k	—	—	—	—	—	—	—	1	10	83	64	17	5	2	15,1
Mälaren	0	52	49	12	—	3	5	30	19	15	6	2	—	—	—	11,9
	k	—	—	—	—	—	9	21	31	59	61	51	20	2	8	14,2
Dammar, 1 år	0	71	19	18	5	2	2	1	—	—	—	—	—	—	—	5,8
	k	—	3	61	78	77	83	118	46	16	4	1	—	—	—	9,7
Dammar, 2 år	0	2	8	2	8	5	1	—	1	—	—	—	—	—	—	7,5
	k	—	—	14	60	71	23	29	8	16	17	2	1	—	—	9,8
Dammar, 3 år	0	—	—	—	—	—	1	2	—	2	—	—	—	—	—	11,6
	k	—	—	—	—	—	12	43	43	15	8	5	2	—	—	11,9

females, principally the large ones, have become sexually mature, while at the age of 4 years the main part of the females are sexually mature and only about 10 per cent of particularly small ones have not as yet attained this stage of spawning maturity.

These results, which have been summarized in Tables 30 and 31, thus conform with those obtained by Svärdson in experiments on the *Lebistes* in so much as sexual maturity is attained, at good growth, at a lower age — as well as at a smaller size — than in the case of bad growth when sexual maturity does not occur until an increasingly higher age. However, the length factor varies rather, but broadly speaking in such a way as to be longest at medium-good growth and, in spite of the high age, again shorter at less good growth. This applies to different pond experiments as well as to the individuals in one and the same experiment. Fig. 20 illustrates this relationship between the sexual maturity and age

Table 31.

Number of females of different length-groups which will spawn (k) or not (0) next spring. — *Antal honor av olika längd som skola leka (k) eller ej (0) nästa vår.*

Lake *Sjöns namn*	Sexual maturity *Könsmognad*	Length in cm — *Längd i cm* 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Mean length in cm *Medellängd i cm*
Perch Tarn I	0	—	—	2	19	35	25	11	2	1	1	—	—	2	—	—	—	—	—	—	—	—	—	—	—	10,6
Abborrtjärn I	k	—	—	1	1	6	28	26	24	22	10	14	6	4	1	1	—	—	—	—	—	—	—	—	—	13,2
Perch Tarn II	0	—	—	7	23	28	19	15	5	3	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	10,5
Abborrtjärn II	k	—	—	—	—	14	25	50	59	34	26	20	11	11	1	2	1	2	—	—	—	—	—	—	—	13,6
Perch Tarn III	0	—	—	6	3	12	14	22	8	5	5	4	2	—	—	1	1	—	—	—	—	—	—	—	—	12,1
Abborrtjärn III	k	—	—	—	—	—	—	—	7	10	8	9	17	17	7	7	1	2	—	—	—	—	—	—	—	16,8
Gransjön	0	—	—	—	—	—	—	—	4	10	5	4	—	2	—	—	—	—	—	—	—	—	—	—	—	14,7
	k	—	—	—	—	—	—	—	1	5	7	8	6	8	—	2	—	1	—	—	—	—	—	—	—	16,4
Hjälmaren	0	—	—	—	—	—	7	—	5	21	34	11	4	—	—	—	—	—	—	—	—	—	—	—	—	14,5
	k	—	—	—	—	—	—	—	—	19	26	19	4	1	—	—	—	—	—	—	—	—	—	—	—	15,2
Mälaren	0	38	11	1	3	13	55	50	49	22	8	6	—	—	—	—	—	—	—	—	—	—	—	—	—	12,4
	k	—	—	—	—	—	—	3	9	4	35	13	4	3	1	1	1	1	—	—	—	—	—	—	—	15,3
Ponds *Dammar* 2 yrs	0	11	20	56	45	33	20	10	3	6	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9,1
	k	—	—	—	—	—	—	—	—	4	6	1	—	—	—	—	—	—	—	—	—	—	—	—	—	14,7
» 3 yrs	0	—	—	—	6	33	35	93	99	94	59	16	5	1	—	—	—	—	—	—	—	—	—	—	—	13,0
	k	—	—	—	—	—	7	32	31	25	25	15	11	4	6	3	1	2	—	—	—	—	—	—	—	14,4
» 4 yrs	0	—	—	—	—	—	—	3	6	35	22	9	5	2	2	—	1	—	—	1	—	—	—	—	—	14,9
	k	—	—	—	—	—	—	—	3	11	19	37	50	35	53	15	18	12	11	5	8	4	7	1	1	18,7

of females, while Fig. 21 gives the relationship between the sexual maturity and growth of 4-summer old perch of different sizes. In the latter case, the material in pond nr. 23 consists of earlier, selected large specimens (1936: 29) and large ones obtained from sparse populations (1936: 30). Other samples from the same experiments had, during the Summer of 1938, owing to a sparse and a dense population in ponds nrs. 16 and 18, respectively, achieved a better and less good growth and size,, respectively. In this population (pond 23), where the growth was the best, all the fishes were sexually mature, while in the population with the most unsatisfactory growth (pond 18) a large number — probably mostly females — had not as yet attained sexual maturity.

Thus, the occurrence of sexual maturity among perch reared in ponds has been made fairly clear. In an ordinary lake, however, it is a more complicated matter to ascertain when the sexual maturity sets in, above all when large-sized populations are concerned. Yet an experiment has been made for the purpose of studying the sexual maturity of the smaller sizes in these populations, being based on a comparison between the relative number of sexually mature perch of the same size in a few lakes with differently growing perch populations. Collection and examination has taken place in the autumn. It may be easily determined which samples will spawn in the following spring. It may, no doubt, be taken for granted that the perch will keep to the same localities, whether they will be spawning in the next spring or not, which, on the other hand, does not happen during the spawning run. The results are recorded in Tables 30 and 31. In this connection, a comparison should be made with Table 8, where a conception is obtained of at least the size of the fish at the occurrence of sexual maturity among stunted populations. In addition, the forementioned figures of sexually mature and immature perch from the pond experiments, classified according to age, have been included in the tables.

In further illustration of this question, Olstad's (1919) statements should be mentioned here regarding the sexual maturity of the perch in Stora Öjvand, Norway, and the present authors results from the planting of perch in Bodtjärn (page 84) where the growth was exceedingly good and the majority of the females had attained sexual maturity, as early as at the age of 3 years, and at a mean length of 20 cm. Otherwise, only rather fragmentary reports are to be found in the literature on the subject of the sexual maturity of the perch. A compilation of some of the abovementioned data and the results from Tables 30 and 31 has been made in Table 32.

Table 32.

Relationship between environment, growth and sexual maturity. — *Samband mellan miljö, tillväxt och könsmognad.*

Lakes, ponds *Sjöar, dammar*	Environment *Miljö*	Growth *Tillväxt*	Sexual maturity at *Könsmognad vid* age of *ålder i år* ♂	♀	length *längd i cm* ♂	♀
Fertösjön, Ungarn	Very good *Mycket god*	Very good *Mycket god*	—	2	—	17
Bodsjön, Kälarne	— » —	— » —	—	3 (2)	—	20
Ponds, Älvkarleby	— » —	— » —	1	—	7–10	—
Ponds, Kälarne	Good *God*	Good *God*	2	3–4	9–14	15–17
Mälaren, Hjälmaren	Medium-good *Medelgod*	Medium-good to good *Medelgod-god*	3–4	5	11–15	17–18
Oppmannasjön	— » —	— » —	3–4	5	12–14	17–18
St. Öjvann, Norway	Less good *Mindre god*	Less good *Mindre god*	3–4	5–6	9–11	17–18
Abborrtjärn I (Perch Tarn I)	Very bad *Mycket dålig*	Soon decreasing and very slight *Snart avtagande och mycket ringa*	2–5	3–5	8–12	9–12

From this, it may be seen that, concerning the various perch populations, the sexual maturity sets in at a low age and small size, when the growth is particularly good (the pond experiments and the Fertö and Bodsjö lakes), occurring at a higher age and greater length when the growth is medium-good (large-sized populations in ordinary lakes), and at approximately the same or, frequently, a lower age and, again, at a small size when the growth is particularly bad (Perch Tarn nr. I). These observations have, in a slightly schematic form, been recorded in Fig. 22 and are in agreement with GEYER'S (1939) and LASKAR'S (1940) findings. On the other hand, they deviate partly from the results obtained in the pond experiments and those of the *Lebistes* experiments. Apparently, a certain fundamental

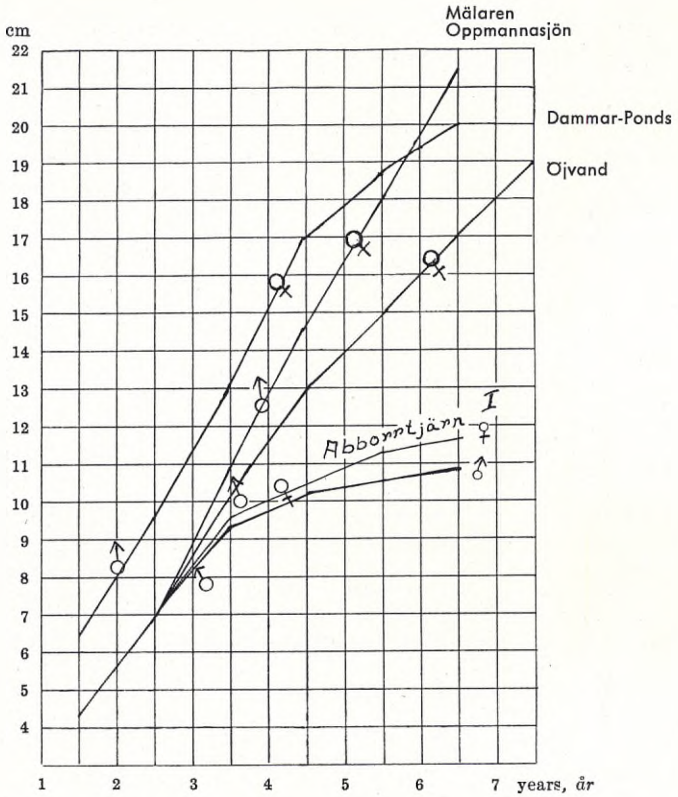

Fig. 22. Relationship between growth and sexual maturity. ♂ and ♀ indicate the approximate time for sexual maturity. — *Sambandet mellan tillväxt och könsmognad. ♂ resp. ♀ -tecken antyda den ungefärliga tiden för könsmognad.*

difference occurs, as pointed out also by Svärdson (1943, 1944). This difference is illustrated in the following table regarding the occurrence of sexual maturity under different environmental conditions:

		Environment		
		Very good	Good	Very bad
Same population	Age	low	medium	high
	Size	small	medium	small
Different populations	Age	low	medium	low
	Size	small	medium	small

Within a certain population, there is a direct connection between environment, growth and the age of sexual maturity. Thus, the better the environment and the growth, the lower the age at which sexual maturity sets in, and vice versa. This applies to all pond experiments. Apparently, these experiments cannot be compared, in spite of varying density of population, to the populations of small- and large-sized perch from different lakes. On the other hand, if such populations are compared *inter se,* the forementioned relationship between them only holds good so long as a particularly good and medium-good growth occurs, when compared with one another. Sexual maturity sets in, in the former case at a lower age than in the latter. If the growth of a population is particularly bad, this does not involve a further retardation of sexual maturity and its postponement to a higher age, as *within* a certain population. Instead the opposite takes place, i. e. sexual maturity comes at a lower age, as in the case of very good growth.

It seems appropriate, before entering further upon this problem, to say a few words regarding the relationship between growth and sexual maturity, in particular. The question then arises: Is growth determined by the occurrence of sexual maturity, or vice versa? Further, is the environment of direct significance with regard to sexual maturity? In the literature, sexual maturity has, generally, been considered to cause a decrease in growth. Earlier investigators have regarded this as due to the quantity of vital and nourishing substances required for the development of the sexual products which cannot, consequently, be used for ordinary body growth. However, as mentioned earlier, SVÄRDSON'S interesting experiments on the *Lebistes* (1939) have shown that it is primarily the hormones, produced in connection with sexual maturity, that cause a decrease in growth. Thus, considering that, for instance, sexual maturity is attained at an earlier stage by the males than by the females, the former should disclose a less good growth. Even though this does not always hold good, probably on account of the chemical differences occurring in the forementioned hormones, it does apparently apply to a certain extent to the perch — while, among the Salmonoids, for instance, neither sex reveals any clear difference in growth notwithstanding the fact that the males attain sexual maturity earlier than the females. Thus, it has been contended above that the occurrence of sexual maturity reduces the growth of the perch males. Thus in the first year the growth of the males is better than that of the females, decreasing during the second and third years, and after this time it becomes smaller.

However, this inhibiting effect of the sex hormones on the growth of the perch cannot remain particularly strong for long and cannot, in any case, be decisive with regard to the difference in growth and individual size in different perch populations. This is, for instance, illustrated by the good growth of the stunted perch transplanted to ponds. These perch have earlier had a bad growth and attained sexual maturity at a low age, but in their new, favourable surroundings males as well as females have shown improved growth. Further, the perch in the pond experiments, which have attained sexual maturity at the earliest stage, have consisted of the individuals with the best growth which has, moreover, continued to be best also in the future. If the inhibited growth had been very marked by this early sexual maturity, these individuals should, on the contrary, have lagged behind in size, instead of the opposite. These data therefore indicate that sexual maturity and the growth-inhibiting hormones appearing in connection with it may hardly be considered as decisive factors with regard to the growth and size of the perch. Furthermore, the early onset of sexual maturity in certain cases of unfavourable environment and bad growth cannot be the reason for the continued bad growth. They must both rather be viewed as parallel phenomena. It may therefore, no doubt, be taken for granted that the growth of our common fishes is not, to any marked extent, dependent on whether or not sexual maturity occurs at a low or at a high age.

Since, accordingly, sexual maturity does not play a decisive part with regard to the growth of the perch, it may perhaps instead be assumed that the time for the sexual maturity is determined by the varying growth (indirectly, the size and age) in connection with some factors directly affecting the sexual maturity. Assuming that a certain size as well as a certain age are necessary for attaining sexual maturity — correct from a physiological point of view — it will be seen that perch, in exceedingly favourable surroundings and with particularly strong growth, attain the size required for the occurrence of sexual maturity at the low age of 1 year among males, and 2 years among females. The same applies to the individuals within a certain population which have, for various reasons, a particularly good growth. In a medium-good environment, and among individuals in a population where the growth is not so marked, this size is not attained until later, at the age of 2—3 and 3—5 years, respectively. However, the length is then greater than among the individuals which have attained sexual maturity 1 year earlier or even before then. In a less favourable environment, or among individuals in a population which has, for various reasons a less good growth, the bad growth will further postpone the attainment of a length required for sexual maturity. However, the higher age, which undoubtedly has an accelerating effect on the sexual maturity, now must be taken into account. Also the external, increasingly unfavourable environmental factors, causing deteriorated growth probably cause an earlier sexual maturity. In this connection it is of great interest to note that certain anatomical changes take place in the testicles in connection with the variation in growth. Thus, it has been demonstrated in the previously mentioned experiments performed by SVÄRDSON that the growth of the testicles of the *Lebistes* is directly connected with growth of the body, but that in the case of less good growth spermatogenes will occur to a greater extent, relatively speaking, than in the case of good growth. It seems, therefore, highly probable that, at particularly bad growth due to unfavourable environmental factors, also the testicles are affected so as to bring about a more rapid spermatogenesis — i. e. earlier sexual maturity — than under normal circumstances. Provided that these results are applicable also to other fish species — which seems likely — it may be assumed that the less favourable the environment, the less good the growth, involving also an increase in the significance of the factor or factors causing the spermatogenesis, in other words, eliciting the sexual maturity. This would then be the explanation to the phenomenon of sexual maturity occurring at lower age, under the most unfavourable environmental conditions, than in medium-good environment.

In this connection, it should be borne in mind that the environmental differences between a good perch lake, with a large-sized population, and a small tarn of a quagmire type are far more conspicuous than those observed in the various experiments at Kälarne, which also applies to a rapidly growing and a slowly growing individual in a certain pond-experiment, or in one and the same lake-population. In the latter case, the fundamental environmental conditions, above all the qualities of the water, are identical. In the former, considerable discrepancies exist in this respect which may, perhaps, in one lake retard and in the other accelerate the onset of sexual maturity, while simultaneously affecting the growth, whether directly or indirectly. This would then account for the fact that the results from various pond experiments resemble those obtained in one and the same experiment of this kind. The differences in density in the populations in these experiments do not, apparently, equal in importance a change in environment, in spite of the changes caused in the supply of food for the individual specimens. This can also be expressed as follows: In one and the same population (i. e. in a certain environment) or in a number of pond experiments, the prerequisites of different growth can hardly become strong enough to extend from one extreme pole to the

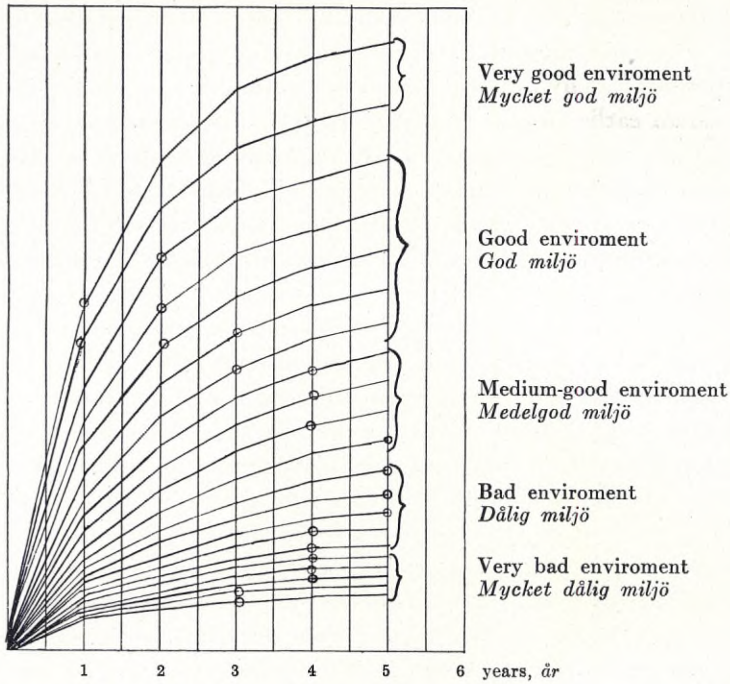

Fig. 23. A schematic diagram of the relationship between sexual maturity, growth and age under different environmental conditions (o = sexual maturity). — *Schematisk framställning av sambandet mellan könsmognad, tillväxt och ålder under olika miljöbetingelser (o = könsmognad).*

other, viz., from »very good» to »very bad». Particular attention should be directed to the fact that it has not been possible to reproduce in pond experiments the very unfavourable environment occurring in tarns where there is, in all likelihood, not only a deficiency in food but also, as already pointed out, several other injurious factors which have to be taken into account. Since this extremely unfavourable tarn environment, for some reason or other, probably hurries the development of sexual maturity, it is easy to understand the failure in the pond experiments of producing the state at which sexual maturity, in connection with particularly bad growth, occurs at a low age. Fig. 23 has been presented in order to give a more detailed illustration of this phenomenon, further explanations, over and above what has already been stated, not being required.

It should also be mentioned in this connection that, among certain fish, races are apparently to be found where the appearance of sexual maturity comes at different times, owing to various genetic reasons. This has been reported earlier with regard to the carp. As regards the trout, the present author (ALM 1945) has recently found that, at growth under the same environmental conditions, even the offspring of the second generation of river trout become sexually mature earlier than do the lake trout, in spite of the fact that the growth of these two races is here approximately equal, while differing considerably in their natural surroundings. However, these pond experiments with trout have shown simultaneously that, in the various populations, the individuals with the most rapid growth become sexually mature at an earlier stage than do those with a slower growth.

The particular factor — or factors — provoking this early sexual maturity under bad environmental conditions still remains unknown. It may, perhaps, be the lack of certain nourishing substances, or the degree of acidity of the water, or the content of oxygen-gas, or the temperature, or again some other hitherto unknown factor. Investigations on the trout (S. SÖMME 1930, ALM 1939) have shown that a low temperature accelerates the sexual maturity. Reference may also be had to KAJ BERG'S (1934) experimental investigations of the relationship between the appearance of sex generations and the accumulation of excretion products among the *Cladoceres* on the one hand, and the ascertained transition from a parthenogenetic to a sexual propagation of these animals at the beginning of the winter season, on the other. It is also known from the plant kingdom that deteriorated nourishment produces an earlier flower and seed than do more favourable environmental conditions.

Evidently, an intimate relationship exists between environment, growth, size and sexual maturity. Nevertheless, there is room for experimental research of great practical significance. However, the above data suggest that an early sexual maturity occurring under the best environmental conditions and the consequent particularly favourable growth do not, as hitherto frequently assumed (TÄGTSTRÖM 1939), involve a more marked deterioration in growth and size. Further, the results indicate that the individuals in a certain population — and in a certain pond experiment — which have the best growth and become sexually mature at the earliest stage, form the best planting and propagation material, owing to the fact that they have probably a genetically good capacity of growth, strong power of competition, etc., as well as forming the individuals which most quickly attain a certain size, and also most likely become the largest specimens.

IV. A general survey of the reasons for the occurrence of stunted fish populations and the possibilities of utilizing lakes with such populations.

The following may be derived from a summary of the most important results from the experiments and investigations dealt with in the present work, compared and supplemented with the results of similar experiments on other fish species.

The growth of different fish populations is entirely or, at any rate, principally dependent on the environment, being above all a question of nourishment. This has been clearly demonstrated regarding the perch, as earlier on the trout (ALM 1939, LEHMANN 1942). This is also in agreement with the results of experiments performed at Kälarne regarding the growth of the grayling and the char, as well as with BUSCHKIEL'S experiments on the carp (1932, 1933). The various experiments with transplantation, which have been carried out with small forms of the gwyniad (OLOFSSON 1934, RUNNSTRÖM 1944) and the lake herring (MOLIN 1945), point in the same direction. This also applies, according to verbal communications from H. NORDQVIST and B. JOHANSSON at Växjö, to experiments with the transplantation of stunted bream to ponds and new lakes.

Thus, even though a more pronounced, genetic capacity of growth, whether good or bad, in different fish populations is generally not noticeable, this does not preclude the possibility of its existence. It has been proved (ALM 1939, 1945) that, as regards the trout, the offspring of the river trout grow somewhat less than those of the lake trout under similar environmental conditions, and that, for instance, the occurrence of sexual maturity is dependent on genetic circumstances. Further, experiences from the breeding of fish in ponds have shown that there are different forms of the carp and the tench, distinguishable, inter alia, from one another by good or bad growth under similar environmental conditions (NORDQVIST 1936, TÄGSTRÖM 1939, WALTER 1934, WUNDER 1934, 1940). Accordingly, as regards the three forementioned fish species, there is justification for speaking of races with different, hereditarily fixed qualities, the capacity of growth being one of them. This, possibly, also concerns the dwarf forms of the char, which are occasionally met with, and whose inherent capacity of growth has not as yet been tested, whether by transplantations or by direct experiments. It is, therefore, conceivable that future investigations will disclose the fact that, among several of our common fish species, different races occur with genetically different capacities of growth. However, irrespective of this, it is certain that the environment plays the most important part with regard to the growth.

Nevertheless, the significance of the environment with regard to the growth of a fish population may vary. While a good growth and a large-sized population may be accepted as the normal state, the attention is in the first place drawn to the environment involving bad growth and stunted populations. The perch experiments show that there are two kinds of unfavourable environment, viz., an absolute or permanent one, and a relative or temporary one. However, there is a series of transitions between these two forms.

The first case occurs in the typical forest tarns of a quagmire type. These lakes are of such an unfavourable type, as regards the nature of the food and the supply of it, the temperature and oxygen-gas conditions, and possibly also the pH value, as to render almost impossible the existence of large-sized perch populations. A decimation of the population offers but little help in this respect, since only a few individuals have the opportunity of growing up, and new year-classes reappear with again a small mean size. The planting of predatory fish in large samples may be a means of utilizing the stunted population for the time being. However, it is difficult to produce a true state of balance owing to the fact that propagation is hardly to be expected on account of the abundant perch population and the unsuitable spawning locality. The stunted perch, with their inherent good growth, on the other hand, may be caught to advantage and planted in waters of this more nourishing and in other ways more favourable type, where perch are desired and the spawning facilities are inconsiderable for various reasons (water regulations).

Many spring rivulets, with too low a summer temperature, and several mountain lakes with similar characteristics must be considered to offer a permanently unfavourable environment for the trout on account of the too short period allowed them for growth. Also in these cases, hardly anything can be done to improve this state of affairs.

A temporary deterioration in the environment, or a relatively unfavourable environment, on the other hand, may be more easily set right. For such a condition is, apparently, not dependent on whether the environment itself is unfavourable or not, but on the more temporary relationship between the fish species and the environment. If a fish population has become too numerous in proportion to the production of nourishment, owing to too little fishing and omitted decimation by predatory fish, or unusually abundant propagation, a deficiency in food occurs which involves a temporary deterioration in the environment. The consequences are decrease in growth and a stunted fish population. The perch in Stora Holmtjärn serve as an illustration in this respect (page 77). An intensive reduction by fishing may neutralize this deterioration in the environment, restore the population to its correct number in proportion to the environment, and renew the former good growth. This has been proved by the previously mentioned experiment in Holmtjärn, and by earlier experiments performed by DAHL (1910) on the trout in overpopulated trout lakes. It is, of course, more difficult to cause a reduction of the population merely by fishing in a large lake with a small sized perch population. Here the planting of large predatory fish, such as the pike, the pike-perch, or Salmonoids, is the correct procedure.

Similar, relatively unfavourable environmental conditions occur when unusually abundant year-classes are produced. This particularly concerns fish living in large shoals, owing to the too small supply of food for the individual specimens. Thus, JÄRVI (1942) has demonstrated with regard to the lake herring, and several other scientists with regard to sea fish, that the growth deteriorates among the individuals of a very rich year-class. Also WILLER (1929) has interpreted the varying size of different populations of shoal fish in this way. This is confirmed by SCHNEBERGER'S (1935) forementioned data regarding the growth of the perch in various lakes, as well as by the present perch experiments and investigations of growth. The question is whether these factors do not also play a part with regard to the growth of different forms of the gwyniad. The stunted forms of the gwyniad, which are very common and sometimes occur in a lake simultaneously with large-sized ones, are typical shoal fish. These shoals undoubtedly live under more unfavourable environmental conditions as regards feeding and competition than do the larger forms of the gwyniad which only come in smaller groups or are more isolated. It follows that the growth of the former naturally becomes less marked than that of the latter, in spite of a good latent capacity of growth. Furthermore, it is equally natural that the growth will rapidly increase provided these small gwyniad are transferred to a new water where the number of individuals included in the shoals is less great. This case resembles that of the perch which were transferred to another water and there attained better growth. In a few cases, this good growth of the gwyniad seems to have been maintained for several generations, in other cases however, it has, even when good during the first hatched generation in the new lake, again decreased after a few generations. The reason is, in all likelihood, that the new generations have gradually become too numerous in individuals in proportion to the supply of food. The relative deterioration in the environmental conditions has then again set in and the growth decreased accordingly. As regards the lake herring, MOLIN (1945) has ascertained completely analogous circumstances. Another typical case of this type is the experiment with the planting of perch in Bodtjärn (page 84) which was earlier devoid of fish.

Thus, apart from the fact that the growth of various fish populations depends, in the first place, on the environment, the experiments have shown simultaneously that the varying growth of the individuals in one and the same population is, probably, due to some extent to genetic factors. Certain individuals have an inherent, better capacity of growth, are in addition more capable of utilizing their food, and more easily assert themselves in the general competition, etc. Therefore, these individuals have a better growth and this state continues throughout their lives. In a good and nourishing environment, the early advantage in size may give them a lead in the general competition, facilitate a greater consumption of food, and further increase their growth. On the other hand, when the environment is less favourable, particularly when there is a deficiency in food, the possibilities for the larger individuals of finding a sufficient amount of food will be smaller, causing the advantage in growth to become gradually neutralized.

However, provided the conclusion is correct that the hereditary factor plays an important part in this respect, it should be possible by direct breeding to produce forms and races among our common fish, differing in growth in spite of identical external conditions. Wide spheres of research here offer themselves.

V. Summary.

The perch occurs in large-sized as well as stunted populations, the former being typical of large lakes, and the latter of small lakes and tarns.

Among the larger perch in a certain population, the number of females in the spawning run exceeds that of the males, conditions being reversed among the smaller perch. However, the actual sex ratio of large-sized and stunted populations equals approximately 50: 50.

The mean weight of a certain length is, generally, greater among the large-sized populations than among the stunted ones, although several exceptions are to be found.

The variation in individual size is principally due to the growth, which is good in the large-sized populations and continues thus up to a higher age. In the stunted populations, on the other hand, the growth can be fairly good during the first years, only to decrease rapidly and soon cease altogether, without involving the death of the perch. In both cases, the females have a better growth than the males from the second and third years of life and, consequently, attain a larger size.

The individual number in the year-classes varies considerably, sometimes affecting the average size of the population.

The bad and soon discontinued growth of the stunted populations can be explained in the following way:

a) The population has, owing to abundant propagation and insufficient fishing, become too large in proportion to the supply of food. The perch have therefore had to feed on plancton and insect larvae, and only a few have attained the size at which (14—15 cm) they can begin to feed on small fish which would stimulate to better growth.

b) The environment is unsuitable (low temperature which reduces the consumption of food and abbreviates the period of growth, restricted feeding area owing to a deficiency in oxygen-gas in the hypolimnion, possibly, also too great acidity of the water, as well as a sparse development of shore and bottom fauna, and the frequent occurrence of a large perch population, i. e. a scarcity of food). In this case, the number of perch attaining the fish-eating stage is still less than in the former case. Case a) applies to lakes of a eutrophic and oligotrophic type, case b) to lakes of a dystrophic and quagmire type.

In the former case, a strong reduction of the population involves, whenever this is possible for practical reasons, an improved growth and increased individual size. In the latter case, this only concerns a few individuals and the population as such remains stunted. The main purpose of a reduction process is to obtain the greatest possible amount of perch in the size where they can change over to a fish diet. This is more easily achieved in a lake with numerous small fish of various kinds than in a tarn where only perch exist. For this reason, suitable minnows (small roach and small alburn) can be planted.

A stunted perch population can also be utilized by the planting of fish of prey in the form of large youngs of principally the pike, but sometimes also of the trout. In some lakes with stunted populations of perch, large youngs of gwyniad may be planted simultaneously, thereby increasing the yield in this lake and rendering it more variable.

Apparently, hereditary, bad growth in a certain population has not been observed. Thus, stunted perch discloses a good growth at transplantation to a more favourable environment, and the spawn of roe from stunted populations shows equally good growth when compared to the spawn of large-sized populations. Perch from stunted populations can, therefore, be utilized for planting in waters deficient in perch. However, perch should not be planted in lakes devoid of perch of the above-mentioned type b). Even if the first generation should grow well and yield good results, this growth will rapidly decrease and a stunted population will be obtained owing to the often unsuitable environment. Lakes devoid of fish of this type may, in many instances, be better utilized by the planting of more valuable fish such as the gwyniad, the trout and, sometimes, even of the char. Moreover, in lakes of this kind, these species will be subjected to propagation only to a limited extent and there is, consequently, no risk of overpopulation. However, the value of the yield of such fish would be greater than that of the perch.

Growth at the breeding of perch in ponds is reversely proportionate to quantity and directly proportionate to area and water volume. In all likelihood, the same applies to the breeding of perch in lakes. Some individuals have a better initial growth, others being less good. As a rule, this discrepancy continues throughout their lives and is partly due to the varying suitability of the environment with regard to different individuals, and partly to genetic factors.

Sexual maturity in a certain population sets in at very good growth at a low age, at medium-good growth the age is higher, i. e. 2—3 years among males and 3—5 years among females, and still somewhat later at bad growth, i. e. 3—6 years among males and 5—7 years among females. The length at the occurrence of sexual maturity is shorter in the latter case than at medium-good growth. In very stunted populations, living in unfavourable surroundings, sexual maturity occurs at a low age. The occurrence of sexual maturity is dependent on internal as well as external factors.

VI. Svensk sammanfattning.

Småväxta fiskbestånd äro vanliga hos flera fiskarter och oftast av ringa ekonomiskt värde. Det är av vikt att närmare utreda orsakerna härtill och möjligheterna att förbättra förhållandena. Ingående försök häröver upptogos därför på fiskeriundersökningsanstaltens program, varvid som försöksmaterial främst valdes abborren.

I. Beståndens individstorlek i olika sjöar.

I ett flertal större och mindre sjöar av olika typ, dels i närheten av Kälarnes fiskeriförsöksstation, dels i andra delar av landet, har uppmätning företagits av längden hos framför allt lekande abborre. Tab. 1 och fig. 1 utvisa att storleken är mycket växlande och i allmänhet större i stora och mindre i små sjöar, särskilt i sådana av tjärntyp. I de senare är medellängden oftast blott 12—14 cm, i de större sjöarna vanligen 20—25 cm. Storleken kan ibland vara ganska lika under flera år (fig. 2), ibland åter olika beroende på uppträdandet av nya årsklasser (fig. 3, 8, 11 och 13).

Könstalet som framgår av tab. 1 och 3 är under leken ganska växlande. Hos de storväxta bestånden äro oftast honor i majoritet, medan hos de småväxta bestånden hanarna alltid dominera i antal och ibland uppgå till 80—90 % av samtliga då fångade abborrar. Vid fångsten i dessa sjöar under andra årstider äro emellertid hanar och honor ungefär lika vanliga, och detta är även fallet hos i dammar uppfödda abborrar (tab. 3). Det stora hanantalet vid leken i många småsjöar är alltså endast skenbart och motsvarar icke det verkliga könstalet.

Förhållandet mellan längd och vikt (tab. 4, fig. 4 och 5) den s. k. relativa vikten är oftast större hos de storväxta än hos de småväxta bestånden, men många undantag härifrån finnas. Ofta är sålunda flertalet individ inom ett småväxt bestånd tämligen feta och uppvisa en ganska hög relativ vikt. Vikten växlar ibland under olika årstider och under olika år, säkerligen beroende på varierande näringstillgång.

Beståndens olika individstorlek i olika sjöar sammanhänger med tillväxten (tab. 5 och 6, fig. 6 och 7). Hos de storväxta bestånden är denna ganska lika under många år framåt, hos de småväxta bestånden avtager den redan efter 3 à 4 år och upphör småningom nästan helt, utan att abborrarna därför dö bort. I senare fallet ha dock vissa exemplar en tillväxt som påminner om den hos storväxta bestånd, tydligen beroende på större konkurrensförmåga och sannolikt tidig övergång till fiskdiet. Genom att följa olika årsklassers ökning i medellängd i vissa småsjöar har erhållits en för småväxta bestånd typisk tillväxtkurva som inlagts på fig. 7.

Överallt växa honorna efter några år bättre än hanarna. De förra bli därför alltid större, och hos vissa bestånd kunna skillnaderna i medellängd vara ganska stora (fig. 1, 9 och 12).

II. Försök i sjöar och dammar.

Ovan har fastslagits att abborrbeståndens olika individstorlek främst beror på den olika tillväxten. Frågan blir då, av vilken anledning denna är olika i olika sjöar. Främst står detta i samband med tillgången på lämplig föda, vilken växlar ganska mycket.

Födan och tillväxten.

Undersökningar över födan (tab. 7) ha visat att under de tidigare åren plankton och insektlarver äro viktigast, medan från och med en storlek av 15—20 cm fisk utgör huvudfödan. I sjöar med uteslutande abborre övergår emellertid endast ett ringa antal exemplar till fiskdiet, medan procenten fiskätande abborrar av motsvarande storlek är större i en sjö med annan småfisk (mört, nors, löja). Detta visar att de sistnämnda fiskarterna äro mera begärliga som föda för den halvstora abborren än abborrungar. Redan detta kan vara en förklaring till abborrens snart avtagande tillväxt och mindre storlek i småsjöar med uteslutande abborre. Samtidigt äro dessa sjöar oftast näringsfattigare och erbjuda en ogynnsammare miljö än större sjöar av olika typer.

Försök i sjöar med småväxta bestånd.

För att undersöka beståndens storlek och sammansättning under olika år i följd samt möjligheterna att genom intensiv utfiskning förbättra tillväxten och höja beståndens ekonomiska värde ha systematiska försök pågått i flera sjöar under åren 1933—1945. Tre av dessa sjöar, Abborrtjärnarna I—III, voro mer eller mindre typiska gungflytjärnar, medan den fjärde, Holmtjärn, var en vanlig oligotrof sjö (tab. 2). Genom märkning med fenklippning kunde olika grupper isärhållas och en viss uppfattning erhållas över beståndens individrikedom. Beståndens storleks-sammansättning och riklighet i Abborrtjärnarna samt resultaten av utfiskning och märkning framgå av tab. 8—12 och fig. 8—14.

Sålunda har man genom intensiv utfiskning kunnat avsevärt reducera bestånden. Detta har dock icke orsakat någon genomgående ökad tillväxt och storlek annat än för vissa individer. Nya påvisbara årsklasser ha endast uppstått vissa år och oberoende av antalet lekande individ. Dessa rikare årsklasser ha ibland kunnat följas under många år framåt, utvisande en långsam och småningom nästan helt upphörande tillväxt. Genom en år efter år skeende ackumulation av dylika i växten snart avstannade individ, och genom att under vissa år nya årsklasser äro obefintliga, uppstå bestånd med flertalet individ av storleken 10—15 cm och endast sparsamma större och ofta även sparsamma mindre individ.

Orsakerna till den snart upphörande tillväxten ligga främst i näringsknapphet men troligen även i ogynnsamma miljöförhållanden. I sjöar av denna typ är större delen av den undre vattenmassan nästan eller helt syrgasfri och uppvisar därjämte en mycket låg och ur näringssynpunkt ogynnsam temperatur. Oftast är vattnets pH-värde omkring eller under 6. Stränderna utgöras på flera håll av gungflyn, varigenom strandregionen får en mycket liten areal.

En uppväxande årsklass av abborre har i dylika sjöar under de allra första åren relativt god tillgång på föda i det ganska rikliga djurplankton, som här finnes. Abborrarna växa då tämligen normalt och kunna, som ovan nämnts, även uppvisa en ganska hög relativ vikt. Allteftersom abborrarna bli större och fordra större organismer till föda, gör sig den sparsamma tillgången härpå alltmera märkbar. Endast ett mindre antal individ uppnår den storlek, då en tillväxtbefordrande övergång till fiskdiet plägar äga rum. Emellertid finnes då oftast till förfogande endast mindre begärliga abborrungar eller under vissa år, då uppväxande årsklasser saknas, inte ens dylika. Samtidigt nedsätta sannolikt de ogynnsamma miljöförhållandena direkt matlusten, och i varje fall förkortar den låga temperaturen den egentliga tillväxtperioden. Sannolikt kan man därför i sjöar av dessa typer icke genom utfiskning och beståndsdecimering förbättra tillväxten hos ett helt bestånd.

Dessa bestånd kunna då i vissa fall i någon mån utnyttjas genom insättning av rovfisk, gädda och laxöring, men dylika böra utplanteras som större sättfisk, så att de dels ej kunna slukas av abborren, dels äro tillräckligt stora för att genast börja förtära den småväxta abborren. Troligen kan man dock ej räkna med att få upp rikligare bestånd av dessa fiskslag. Detsamma gäller sik, som även har inplanterats i gungflysjöar med småabborre och som gått relativt bra till, ehuru utan all inverkan på abborrbeståndet och utan att föröka sig.

I sjöar av mera normal typ har däremot en intensiv utfiskning en helt annan effekt än i de nyssnämnda sjöarna. Detta visas av försöket i Holmtjärn. Här fanns tidigare ett storväxt abborrbestånd, men omkring år 1920 förbjöds av fruktan för överfiskning allt fiske i sjön. Detta förbud respekterades. När man åter i början av 1930-talet började fiska fanns i sjön inte mera någon stor abborre, utan endast mängder av småväxt dylik. Genom systematiska, årligen upprepade utfiskningar har sedermera i denna sjö medellängden ökat (fig. 15), så att beståndet nu återigen är tämligen storväxt och samtidigt ändock rikligt. Tab. 13 visar de härvid vunna resultaten jämförda med utfiskningsresultaten i Abborrtjärn I.

I sjöar av Holmtjärns typ beror därför småväxtheten på att beståndet blivit för stort i förhållande till näringstillgången. I sådana fall hjälper en intensiv utfiskning, vilken återför beståndet till dess normala tillväxt. Huvudsaken är härvid att få upp största möjliga antal abborrar i den storlek att de övergå till fiskdiet, och att samtidigt som föda lämplig småfisk finnes. I Abborrtjärnarna och liknande sjöar beror småväxtheten visserligen också på näringsbrist, men därjämte även på olämplig miljö, varför här en utfiskning icke får önskad effekt.

Överflyttning av småväxt abborre till andra vatten.

Det ligger med stöd av ovanstående, i vissa fall negativa resultat nära till hands att antaga, att i sjöar av tjärntyp de småväxta abborrbestånden under tidernas lopp fått en genetiskt betingad dålig tillväxt och ringa storlek. För att utröna huru härmed förhåller sig ha flera serier av olika försök gjorts.

Sålunda ha till en början lekmogna abborrar från småväxta bestånd flyttats över till andra sjöar och till dammar. I förra fallet ha åtskilliga återfångade exemplar uppvisat synnerligen god tillväxt, t. ex. i Barntjärn under 3 år från 12—16 cm till 26—28,5 cm. Vid systematiska försök i dammar, där längdökningen kunnat uppmätas och kontrolleras år efter år, har kunnat fastslås, att samtliga överförda individ uppvisat en relativt god tillväxt (tab. 14) med i genomsnitt 20 cm under 10 år i ett försök och 13,5 cm under 9 år i ett annat försök. I ett tredje försök var tillväxtökningen under 1 år i genomsnitt ända till 6 cm.

Vid utplantering i den fisktomma Bodtjärn av dammuppfödda, 1-somriga, 4—7 cm långa abborrungar, härstammande från Abborrtjärn II erhölls efter 2 år åtskilliga exemplar, samtliga med mycket god tillväxt och en genomsnittsökning av 7 cm per år (tab. 15). I fortsättningen fångades åtskilliga exemplar av denna första generation, men den åtföljdes snart av nya generationer, hos vilka i samband med ökande individrikedom tillväxten hastigt avtagit.

Resultaten från alla dessa försök visa emellertid att någon ärftligt betingad dålig tillväxt icke förekommer, utan att abborrar från småväxta bestånd äga en god tillväxtförmåga, trots att densamma oftast inte kommer till synes. De kunna därför med fördel utnyttjas för utplantering i abborrfattiga, men i övrigt för denna fiskart lämpliga vatten. Härvid är det samtidigt av stor vikt, att genom intensivt fiske förebygga överbefolkning och hålla storleken uppe.

Uppfödningsförsök i dammar.

Ett stort antal försök med uppfödning av abborryngel i dammar har gjorts för att närmare undersöka tillväxten under olika miljöbetingelser, tillväxtens beroende av beståndens härstamning, könstalet, könets inverkan på tillväxten etc. Dessa försök, vid vilka genom fenklippning olika grupper isärhållits, ha givit åtskilliga mycket värdefulla resultat.

Till en början ha de visat att ynglets härstamning från stor- eller småväxta bestånd icke medfört någon påtaglig skillnad i tillväxt, utan att härvid besättningsstyrkan, könet och individuella egenskaper varit bestämmande. Tillväxten i de olika försöken under första till tionde levnadsåren framgår av tab. 16, 17, 19, 22, 26 och 28. Vid gles besättning har tillväxten varit bättre än vid tät besättning, i båda fallen i likstora dammar. I större vinterdammar har vid lika stor besättning tillväxten varit bättre än i små sommardammar (fig. 16). I sådana försök, där medelstorleken blivit mindre på grund av sämre tillväxt i samband med tät besättning och små dammar, har i fortsättningen vid överföring till större dammar eller under glesare besättning tillväxten förbättrats. Vid utsortering av mindre och större individ ur en och samma besättning har detta också ibland varit fallet, men i stort sett ha skillnaderna bibehållits, endast att spridningen småningom blivit allt större och därför uppdragna storlekskurvor gripit allt mera över i varandra (tab. 23, fig. 17). Härvid har framgått att vissa individ redan från början växa bättre, andra sämre och att detta, såvida ej särskilda omständigheter tillkomma, fortsätter under hela livet. Orsakerna härtill torde vara större konkurrensförmåga, bättre matlust, större förmåga att tillgodogöra sig upptagen näring och möjligen även genetiskt betingad bättre tillväxt hos vissa individ. Vid utsortering av olikstora grupper kommer detta särskilt tydligt fram, ävensom den olika tillväxten hos könen under senare år (fig. 18 och tab. 29).

Under första året växa hanarna något bättre (tab. 18), under andra året är tillväxten ungefär lika hos båda könen, men från och med tredje och än mera fjärde åren är tillväxten hos honorna bättre, varför de också som förut nämnts, bli större (fig. 19). Detta står i visst samband med könsmognaden, såtillvida som i och med första inträdande könsmognad tillväxten tydligen nedgår. Könsmognad inträder hos hanarna vid 1 års ålder, där tillväxten varit god, i annat fall, och detta är vanligast, vid 2 års ålder, samt hos särskilt långsamt växande individ först vid 3 års ålder. Honorna bli i allmänhet icke könsmogna förrän vid 3 års (ca 10 %) och huvudsakligen 4 års ålder. Endast ett ringa antal honor blir könsmogna redan vid 2 års eller först vid 5 års ålder. Även här är det de bättre växande individen som först bli könsmogna, medan de mera trögväxande uppnå detta stadium vid högre ålder. Tab. 8, 18, 20, 21, 24, 25, 27, 30 och 31 samt fig. 20—22 utvisa närmare dessa förhållanden.

Det råder sålunda ett tydligt samband mellan könsmognad och tillväxt, vilket kan sammanfattas på följande sätt. *Inom* ett visst bestånd inträder könsmognad tidigare vid god tillväxt och senare vid dålig tillväxt, men i båda fallen vid relativt ringa storlek, medan vid medelgod tillväxt storleken vid könsmognadens inträdande blir något större. Vid jämförelse mellan *olika* fiskbestånd gäller samma sak ifråga om sambandet mellan könsmognad och storlek. Beträffande åldern råder däremot det till synes egendomliga förhållandet, att vid särskilt dålig tillväxt i samband med näringsbrist och dålig miljö, könsmognad ofta inträder vid lägre ålder än vid medelgod tillväxt (tab. 32). Tydligen få under sådana ogynnsamma förhållanden de yttre och inre faktorer som utlösa könsmognaden en så kraftig inverkan, att detta stadium blir framskjutet i stället för såsom annars är fallet fördröjt. Fig. 23 utvisar schematiskt detta ganska egendomliga, men på så sätt förklarliga faktum.

Som slutligt sammanfattningsresultat kan fastslås att försöken i sjöar och dammar samstämmigt visa att miljön spelar största rollen när det gäller olika fiskbestånds genomsnittliga individstorlek, men att inom vart och ett bestånd även genetiska faktorer äro av stor betydelse för den varierande tillväxten hos olika individ. Allt visar också att ett mycket intimt samband finnes mellan miljö, tillväxt, storlek och könsmognad, och att här finnes rum för experimentell forskning av stor praktisk betydelse.

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