TROUT CULTURE IN DENMARK

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IN 1962, DANISH EXPORTS OF POND-REARED TROUT amounted to 7.67 million kilograms (16.9 million pounds). Nearly 1,000,000 kilograms (2,132,000 pounds), or about 13 percent, were exported to the United States. Denmark is one of the world's greatest producers of pond-reared trout, and Danish trout culture is able to compete with the trout farmers in many countries all over the world.

It is difficult to say exactly why this is so, but I shall suggest later some of the advantages favoring the Danish trout farmers. First, however, I must establish one fact: Danish trout farmers and trout exporters receive absolutely no subsidies from the Government. On the contrary, fish farmers often have to pay damages to the owners of the river banks, and must compensate for any reduction in the wild fish stocks the farms may cause. I emphasize this fact because incorrect statements have been published.[1/]

The first of the Danish trout farms were established about 1890 in Jutland, the western portion of Denmark which is attached to the European Continent. In 1961, there were an estimated 500 to 525 trout farms in operation; only 6 were situated outside Jutland. Practically all the output of these trout farms is exported--as live, fresh, or frozen trout, or as eyed eggs, fry, and fingerlings. The domestic Danish market used only about 75,000 kilograms (165,000 pounds) of trout in 1961. In addition, about 49,000 kilograms (108,000 pounds) were canned. The quantity and value of exports of Danish pond trout are shown in table 1, and the importing countries in table 2.

A typical Danish trout farm is constructed in the following way: The water in a river or brook is dammed and led through two inlet channels to two rows of parallel rectangular ponds; from the ponds the water can be released into the outlet channel, which flows back into the river. The outlet channel is provided with a fish screen and is also used for trout production. So the water is used twice, first in the ponds and then in the outlet channel. Though each pond receives only a relatively small supply of water, the channel receives water from all the ponds (figure 1).

All the ponds are earthen ponds, and the channels are also excavated from the earth. I think it is significant that we do not have any need for the more expensive concrete tanks and channels, because I have been told by an American biologist that in many places in the United States it is impossible to keep water in earthen ponds. A common size for a trout pond is 30 by 12 meters (about 100 by 40 feet). Inlet and outlet pipes are made of wood. A middle-sized Danish trout farm will have 35 to 60 ponds. The species used are rainbow trout and, to a small degree, brown trout.

We do use concrete tanks in Denmark but only for special purposes. The whirling disease (caused by the sporozoan Lentospora cerebralis) is quite a problem for many hatcheries, but it is a problem

1/See The Canadian Fish Culturist, Issue 29 (November 1961), page 9.

which can be solved by keeping the fry in concrete tanks until they have reached a length of about 5 centimeters (2 inches). Thereafter, the fingerlings can be kept in earthen ponds strongly infected with Lentospora without being damaged by the parasite.

About 140 of the trout farms had hatcheries as well as ponds in 1961. Eggs, fry, and fingerlings were produced for their own use, for sale to other Danish trout farmers not possessing hatcheries, and for export. Their production is shown in table 3.

TABLE 1.--Exports of Danish pond trout: Food fish and fingerlings by quantity and value, 1950-62

[In thousands of pounds and thousands of dollars]

Year	Food fish		Fingerlings	
	Quantity	Value	Quantity	Value
1950---	4,717	$1,442	13	$47
1955---	7,998	3,132	29	167
1956---	8,680	3,604	29	139
1957---	9,583	4,121	31	181
1958---	11,579	4,852	41	184
1959---	13,267	5,502	57	226
1960---	13,216	5,651	110	233
1961---	16,505	7,336	112	244
1962---	16,878	7,851	62	263

In most hatcheries the eggs of rainbow trout are taken in February and March. The fish are anesthetized before being stripped, and the dry method of fertilization is used. The eggs are hatched in rectangular trays placed in long troughs. The frame of the trays is made of wood; the bottom, of perforated aluminum. After hatching and absorption of the yolk sac, the fry are placed in earthen ponds, or in concrete tanks to guard against Lentospora. Normally the fry are not kept in concrete tanks for more than 8 weeks because a longer period often favors diseases--especially fin rot.

In the ponds the fry are fed minced fish, but in tanks they are fed pellets exclusively. For some time Denmark has imported pellets for trout fry from the United States. Thus, the dry feed is sent to Denmark to be converted into trout which, in part, are sent to the United States. By mid-1963, Denmark will have a domestic source of pellets for trout feed. A group of Danish trout farmers has obtained the rights to manufacture the pellets according to a U.S. formula and is constructing a plant in Jutland.

In the feeding of trout, I think the Danish trout farmer has an advantage over his competitors in most countries. Denmark has fishing grounds near the coast and large stocks of fish used for fish-meal production and trout feeding. The boats leave for the fishery early in the morning and land their catches in the afternoon. During the following night fresh fish are transported by truck to the trout farms all over the country. The distances are relatively short and the roads excellent.

Would not the trout farmer of North America think he was dreaming if, every morning, he found his grinding room filled with all the fresh salt-water fish his trout could eat--ready to grind and broadcast on his ponds? For the Danish trout farmer this is a reality. He has no problems with

TABLE 2.--Exports of Danish pond trout: Importing countries by quantity, 1962

[In thousands of pounds]

England----------	2,373	Holland----------	190
American forces-----	161	Norway----------	173
Western Germany-----	1,740	Sweden----------	1,865
Austria----------	93	Finland----------	150
Italy----------	3,975	Canada----------	370
Switzerland---------	1,119	U.S.A.----------	2,132
France----------	280	Various countries	167
Belgium----------	2,090	Total----------	16,878

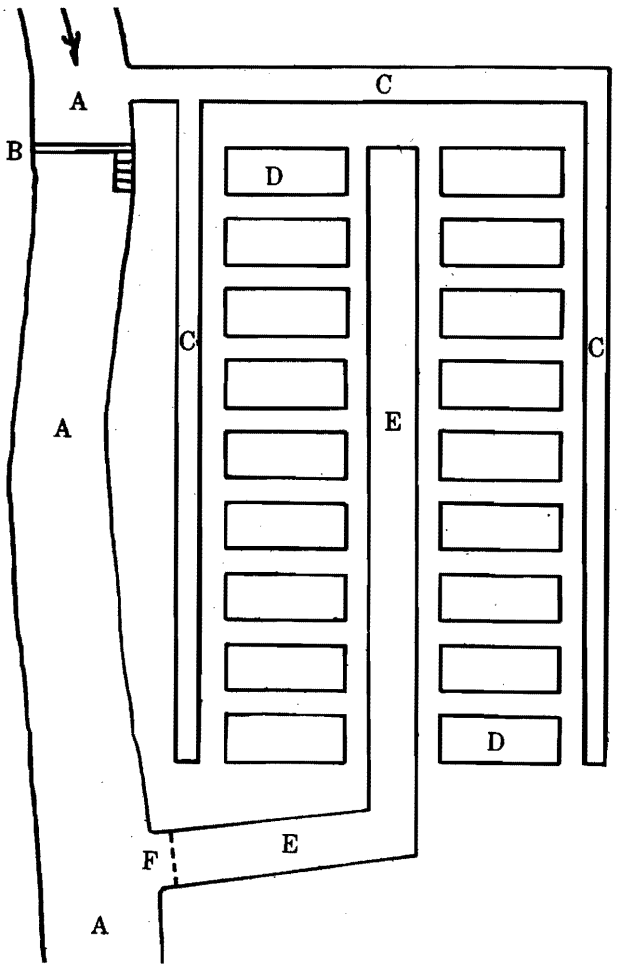

FIGURE 1.-- Sketch of pond arrangement.
A = River.
B = Dam with fish ladder for wildfish.
C = Inlet channels.
D = Ponds.
E = Outlet channel.
F = Fish screen.

any trout diet composed of manufactured ingredients such as fish meal, dried skim milk, and liver meal. Further, fresh fish is easy to grind and easy to broadcast on the ponds, and the trout may be fed all they can eat except when the water is warmer than 20° C. (68° F.). Generally, 5 to 7 pounds of fresh fish will be used to produce 1 pound of trout. About 48,000 metric tons (105,600,000 pounds) of fish were used for trout feed in 1962. The fishes used were mostly herring and sand eels and--to a smaller degree--whiting, sperling, and a few other salt-water species.

In November the fry will have grown to a size between 8 and 15 centimeters (3 to 6 inches). In the succeeding May or June, the fastest growing trout will have reached a marketable size. The majority of the trout, however, will not be big enough for marketing before they are 1.5 years old, and some will be 2 years old before they are marketable. The trout are generally sold in sizes between 160 and 260 grams (6 to 9 ounces), depending on what size of fish the consumers in the various countries prefer. For overseas transportation, the trout are frozen; but trout for the European market are iced or transported alive in tanks by rail or truck. As a rule, trout sold alive are small, frozen trout are middle-sized, and iced trout are rather large. In Sweden we sell iced trout weighing as much as 1 pound apiece.

Generally the Danish trout farmer keeps a dense population of trout in his ponds, and he will try to force his fish the preparation of diets and storage of feed. All he has to add to the feed is a little vitamin B_1 (thiaminhydrochloride) in a water solution if he has used herring for a long period, as herring contain an enzyme (thiaminase) which destroys vitamin B_1.

The salt-water fish used to feed the trout is not cheap, costing about 30 øre per kilogram (2 cents per pound); but still I think it is cheaper than

TABLE 3.--Production of eggs and fry: Rainbow and brown trout by number for the hatching season 1960-61

[In thousands]

Item	Rainbow trout	Brown trout
Green eggs used	458,444	192,125
Eggs dead before the eyed stage	80,891	14,656
Eyed eggs exported	83,775	131,369
Eyed eggs used in Denmark	293,778	46,100
Fry hatched in Denmark	287,903	45,639

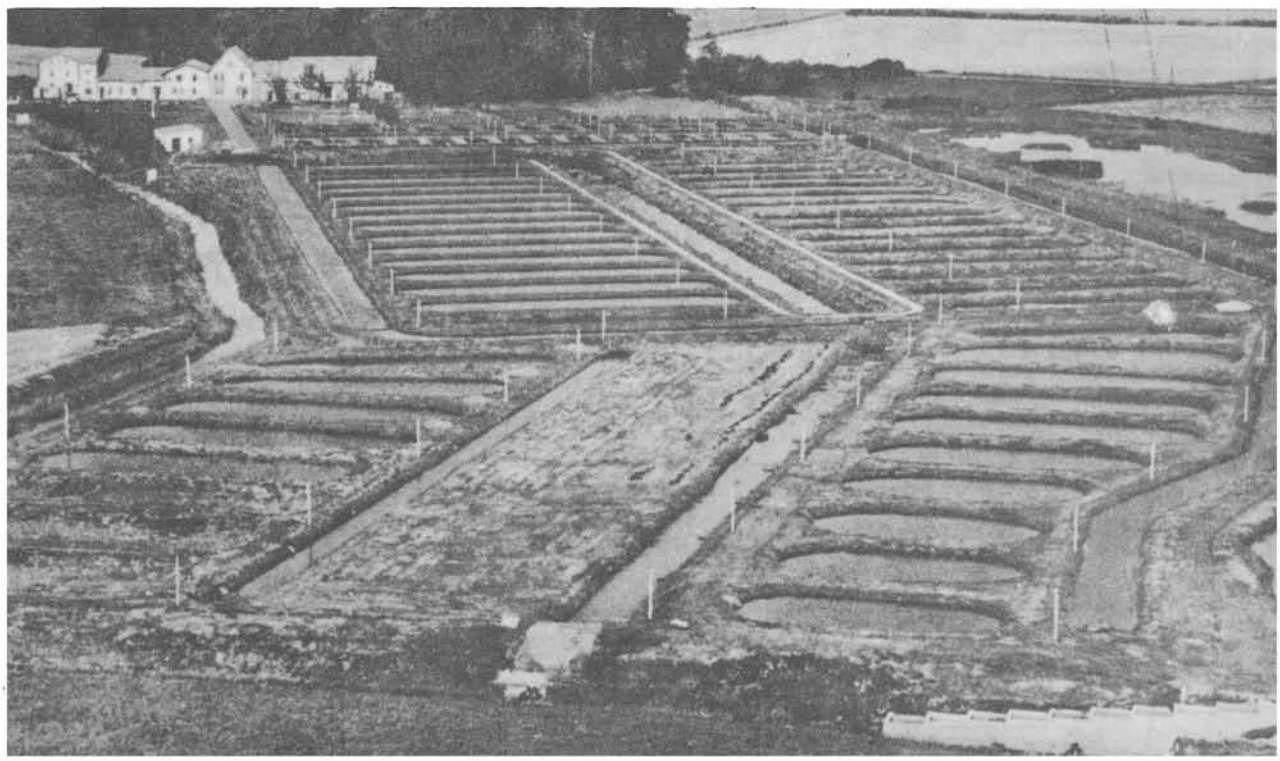

FIGURE 2.--Aerial view of the Danish Trout Research Station in Brøns.

to eat as much as possible in order to make the production per pond and per worker as big as possible. I believe it to be normal for three workers to produce about 100,000 pounds of trout per year if the trout farm is only producing marketable trout and buys the fingerlings from small hatcheries. I think this could be considered a rather high production per worker. Probably the reasons for it are our excellent feed and our rather big ponds, where the population density is never so high as in concrete tanks.

Parasites and diseases of trout constitute an important problem for trout farmers all over the world. In Denmark, trout farmers have met the problem by establishing a trout research station. About 8 years ago some trout farmers formed a partnership to start research on trout; they established a trout farm and a laboratory and engaged a biologist. In the beginning the farmers paid all the costs, but later the Government agreed to pay the wages of the scientific staff. At present most of the Danish trout farmers have joined the partnership. Two biologists are employed at the research station, which consists of 79 ponds, concrete tanks, aquaria, and laboratories. (See figure 2.)

Being one of the biologists, I am inclined to find that the trout farmers spent their money with great wisdom when they founded a research station. I think they have gotten their money back many times by having trout diseases diagnosed and controlled. Now a member of the trout-farmer partnership can call the research station at any time and a few hours later a biologist will turn up at the farmer's trout ponds and, as far as possible, tell him what is the matter with the trout and how he can control the disease.

Below I have listed the conditions which biologists have diagnosed in 1962:

Gyrodactylus	2
Eye fluke (Diplostomum)	1
Costia	6
Chilodon	1

Lentospora cerebralis	1
Octomitus	24
Furunculosis	15
Fin rot	5
Gill disease	2
Egtved-syge (a virus disease)	23
Fungus disease (Saprolegnia)	1
Deficiency of vitamin B_1	1
Poor water quality	11
Cause of death not evident	5

The following comments on the list should be noted:

Gyrodactylus has not occurred very often in Danish trout farms. The two cases mentioned involved brown trout.

Eye fluke was formerly rather common; but now most trout farms have wire over the ponds, so most of the gulls are kept away. Further, the snails are killed with chemicals (for example, quicklime) every time a pond is drained. Attempts to control the fluke by breaking its life cycle have been rather successful.

Costia seldom causes mortality in ponds, but violent attacks on fry are often seen in concrete tanks. When the trout farmers began to use concrete tanks a few years ago, Costia soon became a great problem. Now most trout farmers have learned to give prophylactic treatments with formalin and the problem is solved.

Chilodon, Trichodina, and Ichthyophthirius. Besides Costia, we have a number of external protozoan parasites which are well known in the United States. We find Chilodon, Trichodina, and Ichthyophthirius; but most often we find them with Costia. They are, like Costia, killed with formalin. We cannot control Ichthyophthirius in ponds. but it seldom causes great mortality.

Lentospora cerebralis is a sporozoan which attacks the balance organs of the fry before the skeleton is ossified, and causes the whirling disease. I believe it is infrequent in North America, but in Europe it has been one of the most fatal parasites. Now we meet the problem in two ways: In ponds which can be drained absolutely dry, the parasite is killed with calcium cyanide. As much as 1 kilogram of calcium cyanide per square meter (1.84 pounds per square yard) is distributed on the pond bottom and dams. If, however, a little water seeps through the pond bottom, disinfection is not possible: then we keep the fry in concrete tanks until the skeleton is well ossified; i.e., when they are more than 5 centimeters (2 inches) long. At that size the parasites do not cause serious symptoms, and the fry can now live in infected ponds without being damaged. The prophylaxis is effective only if the water intake to ponds and tanks is not infected with spores of Lentospora.

Octomitus is a popular parasite among biologists. It is, as a rule, easy to detect, and treatment with calomel is normally very effective. This gives the trout farmer an opportunity to observe the skill of the biologist.

Furunculosis. All cases of internal bacterial diseases are gathered under this designation. We do not culture the bacteria to make sure that it is Aeromonas salmonicida, for we have at our disposal only one cheap medicine against bacterial diseases; namely, sulfamerazine. It is fortunate that sulfamerazine has proved effective, whether the disease is furunculosis or some other internal bacterial disease.

Fin rot is often found in concrete tanks, especially if they are not shaded from the sun. Now and then fin rot causes heavy mortality. So far we have found no effective treatment.

Bacterial gill disease is seldom seen in Denmark. We have treated it with copper sulfate, but the results are questionable.

Egtved-syge is the most serious trout disease in Europe. The most conspicuous symptoms of this virus disease are anemia and hemorrhages in organs and muscles. The disease may sometimes kill more than 50 percent of the fingerlings during one winter. Till now no treatment has been successful. Last year the virus was propagated in monolayer cell culture, and experiments on immunizing the trout and attempts to breed resistant strains have been planned. In 1962 the number of cases of virus disease exceeded 23, but

most trout farmers can diagnose the disease themselves and generally do not invite the biologists to join the mourners.

Fungus disease is no longer a problem, as the trout farmers are experienced in routine treatment of fry with malachite green.

Deficiency of vitamin B_1 is not common because now the trout farmers routinely add thiaminhydrochloride to the trout feed when it consists mainly of herring.

Poor water quality, in most cases, results from a high iron content in the water, which may suffocate the fish by covering the gills with iron compounds. Deficiency of oxygen, resulting from repeated use of water and overstocking, also occurs. In a crowded country with intensive farming, such as Denmark, pollution (from ensilage and liquid manure, for example) is a frequent occurrence.

As has been seen, the Danish trout farmer, like his U.S. counterpart, has a lot of problems. The Danish farmer's trout will not suffer from pancreas necrosis or columnaris disease, but they may get the European virus disease or whirling disease. The Danish trout farmer utilizes the biologists very effectively, however, because most of the trout farms are not far from the experimental station. Possibly this does not apply to the U. S. trout farmer, though much more funds and work are expended in North America to solve trout-culture problems, and, indeed, the biologists of North America have had admirable success in the improvement of fish culture.

The "secrets" of Denmark's ability to compete in trout farming might be summarized as follows:

1. Earthen ponds are rather cheap to establish and may contain a large water volume. Though we keep a dense population of trout in the ponds, they never become so overcrowded as concrete tanks.

2. Fresh fish is used for feeding. It is relatively cheap and constitutes an excellent trout feed.

3. Distances are short, and the roads are excellent. Therefore, the transport of feed to the farms and of trout to the exporters is not very expensive, and the biologists can reach the trout farms quickly if disease appears. In fact, we have more than 500 trout farms within an area of 25,000 square kilometers (9,650 square miles).

4. The great water volume of the trout farms and the excellent feed make possible a high trout production per worker.

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