FISH HEALTH IN THE TAILWATERS OF BUFORD DAM, GEORGIA

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Abstract: Eight species of bacteria, 8 genera of parasites, and 1 species of virus were found infecting rainbow trout (*Salmo gairdneri*), brown trout (*S. trutta*), brook trout (*Salvelinus fontinalis*) and yellow perch (*Perca flavescens*) from 2 locations in the Chattahoochee River below Buford Dam. There were no clinical signs of diseases caused by these potentially pathogenic organisms. Microscopic lesions were present in some of the fish, and the gill was the organ most often affected. These lesions were probably caused by a chemical in the water, but it was not possible to identify the chemical with the results of this study. There were fewer lesions in the fish collected at the downstream station compared to the fish collected near the dam, possibly a result of higher dissolved oxygen concentrations downstream. Lesions were more common following increases in iron and manganese concentrations in the water, but additional water quality data and information on fish diseases in the Buford Dam tailwaters must be obtained before reasons for the poor fish health can be determined.

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 33:535-548

Extensive mortalities of trout began during September 1976 at the Lake Lanier Hatchery operated by the Georgia Department of Natural Resources. The water source of this hatchery is the Chattahoochee River, 2.5 km below Buford Dam, Georgia. The mortalities were attributed to manganese and humic material in the hatchery water supply (Noell and Oglesby 1977, Oglesby et al. 1978). The river water is aerated before use in the hatchery to increase the dissolved oxygen level since hypolimnetic water is discharged from the reservoir.

Fish in Buford Dam tailwaters are exposed to manganese, iron, natural organic material, low dissolved oxygen, and perhaps other substances which could cause suboptimal fish health. Toxic substances often cause changes in tissues and cells which can be seen by examining the whole fish or by microscopic examination. Poisons also cause stress that results in physiological changes in the fish and increase susceptibility to infectious diseases caused by viruses, bacteria, or parasites (Wedemeyer et al. 1976).

Low dissolved oxygen concentration in the water can cause lesions in fish tissues (Plumb et al. 1976, Scott 1977). Lesions occur even though the fish are able to survive the hypoxic condition. Low oxygen concentration also increases susceptibility to bacterial infection (Walters 1978).

Rainbow trout, brown trout, brook trout, and yellow perch from 2 locations in the Chattahoochee River below Buford Dam were examined for evidence of viral, bacterial, or parasitic infection. Selected organs were examined histologically to evaluate the severity of any infectious diseases and to determine if toxic chemicals or other water quality characteristics were causing damage to the fish. Direct identification of a poison is seldom possible with the techniques used in this study because of similarities in lesions produced by various chemicals and because of the small amount of information available concerning lesions in fish caused by poisons under natural conditions. A change in the health of fish that corresponds to changes in the concentration of a chemical is evidence that the disease is caused or influenced by that chemical.

This study was supported by a contract with the U.S. Army Corps of Engineers and by the Southeastern Cooperative Fish Disease Project. The University of Georgia Cooperative Fisheries Unit collected and shipped the fish specimens. Georgia Department of Natural Resources provided water quality data. Technical support included identification of bacteria by J. Hawke, isolation of virus by P. Bowser, and

assistance with examinations of fish and histological preparation by T. Schwedler, H. McIntyre, and D. Jezek. J.A. Plumb and W.A. Rogers gave advice concerning all aspects of this study and read the manuscript.

MATERIALS AND METHODS

Fish were collected by electrofishing from 4 stations on the Chattahoochee River by the University of Georgia Cooperative Fisheries Unit (CFU). Fish were examined from 2 stations, the upstream station (station 1) just below the Buford Dam and the downstream station (station 4) at the mouth of Suwanee Creek (19 km below the dam). An attempt was made to collect 4 rainbow trout, 4 brook trout, 4 brown trout, and 4 yellow perch at each station biweekly from 24 August 1977 to 7 December 1977. Samples of trout from a hatchery using spring water were also examined for controls. In some cases the desired number of fish could not be collected from the river (Tables 1 and 2). Total lengths of the fish ranged from 93 to 405 mm.

TABLE 1. Pathogens found in fish from the Chatahoochee River - Station 1.

Date	Fish Species[1]	Number Examined[2]	Parasites[3]	Bacteria[3]	Viruses
24 Aug 77	RBT	2	*Scyphidia* (2)		
			Gyrodactylus (2)	*Aeromonas hydrophila* (1)	
24 Aug 77	BNT	2	*Gyrodactylus* (1)	*Enterobacter* sp (1)	
24 Aug 77	BKT	2		*Pseudomonas* sp. (1)	
24 Aug 77	YP	2	*Glossatella* (2)	*Micrococcus* sp. (1)	
				Pseudomonas sp. (1)	
31 Aug 77	RBT	3	*Trichodina* (1)		
31 Aug 77	BNT	2	*Gyrodactylus* (1)		
31 Aug 77	BKT	2	*Gyrodactylus* (1)		
			Scyphidia (1)	*Salmonella* sp. (1)	
31 Aug 77	YP	3	*Glossatella* (3)		
			Gyrodactylus (1)	*Pseudomonas fluorescens* (1)	
			Trichodina (1)		
			Trichophrya (1)		
14 Sep 77	RBT	2	*Gyrodactylus* (1)		IPN
14 Sep 77	BNT	2		*Flexibacter columnaris* (1)	
14 Sep 77	BKT	2	*Gyrodactylus* (1)		
			Glossatella (1)		
			Scyphidia (1)		
14 Sep 77	YP	2	*Glossatella* (2)		
28 Sep 77	RBT	2	*Gyrodactylus* (2)		
28 Sep 77	BNT	Histological	examination only		
28 Sep 77	BKT	2	*Epistylis* (1)		
			Scyphidia (1)		
			Trichodina (1)		
28 Sep 77	YP	2	*Glossatella* (2)		
			Gyrodactylus (2)		
			Trichophrya (1)		
12 Oct 77	RBT	2	*Gyrodactylus* (1)		
			Glossatella (1)		

Table 1. (cont.)

12 Oct 77	BNT	2	*Glossatella* (1)		
			Gyrodactylus (1)		
			Trichodina (1)		
12 Oct 77	BKT	2	*Epistylis* (1)		IPN
12 Oct 77	YP	2	*Glossatella* (2)		
			Gyrodactylus (1)		
26 Oct 77	BNT	2			
26 Oct 77	YP	1	*Glossatella* (1)	*Aeromonas hydrophila* (1)	
9 Nov 77	RBT	1	*Costia* (1)		
9 Nov 77	BNT	Histological	examination only		
9 Nov 77	BKT	2	*Glossatella* (2)		
21 Nov 77	RBT	1	*Epistylis* (1)		
21 Nov 77	BNT	3			
21 Nov 77	BKT	Histological	examination only		
21 Nov 77	YP	2	*Glossatella* (2)	*Enterobacter* sp. (1)	
6 Dec 77	RBT	1			
6 Dec 77	BNT	2	*Trichodina* (1)		
			Glossatella (1)		
6 Dec 77	BKT	2	*Glossatella* (1)		
6 Dec 77	YP	2	Glossatella (2)		
			Costia (1)		

[1]RBT = Rainbow trout
BNT = Brown trout
BKT = Brook trout
YP = Yellow perch
[2]Number of fish examined for pathogens. For most samples, an equal number were examined histologically.
[3]Number of fish with pathogen in parenthesis

Fish were shipped from the collecting site to Auburn, AL by the CFU. For each shipment, one-half of the fish of each species were shipped alive and reached Auburn within 24 hours of collection. The other fish were dissected at the Lake Lanier Hatchery; and liver, head kidney, trunk kidney, spleen, and a gill were fixed in Bouin's solution (Humason 1967). It was necessary to fix the organs used for histological examination at the hatchery because it is not known what changes in the tissue occur during shipping and because some of the fish die while being transported.

The live fish were examined for clinical signs of disease. The gills and skin were examined with a microscope for parasites or myxobacteria. The body cavity was then opened aseptically, and liver and kidney tissues were streaked on trypticase soy agar to detect systemic bacterial infections. The internal organs were examined for signs of disease or the presence of parasites. A Gram-stained kidney smear from each trout was examined for the presence of bacteria, especially *Corynebacterium salmoninus*, that are difficult to isolate on bacterial media. Trout were examined for viruses by grinding kidney tissue, filtering it with a 0.45 μm filter and placing the filtrate in RTG2 cell cultures. All of the trout of one species in each collection were pooled for the viral examination.

Tissues fixed in Bouin's solution were embedded in paraffin, sectioned, and stained with hematoxylin and eosin. The slides were examined for lesions that could have resulted from an infectious disease, a poison, or low oxygen concentration; and for parasites or bacteria that were not present in the fish shipped alive.

TABLE 2. Pathogens found in fish from the Chattahoochee River - Station 4.

Date	Fish Species[1]	Number Examined[2]	Parasites[3]	Bacteria[3]	Viruses
27 Aug 77	RBT	1		*Aeromonas hydrophila* (1)	
				Providentia sp. (1)	
27 Aug 77	BNT	2			
27 Aug 77	BKT	2			
27 Aug 77	YP	2		*Micrococcus* sp. (1)	
2 Sep 77	RBT	2	*Scyphidia* (2)		
			Gyrodactylus (1)		
2 Sep 77	BNT	2			
2 Sep 77	BKT	1	*Gyrodactylus* (1)		
			Scyphidia (1)		
2 Sep 77	YP	2	*Trichophrya* (1)		
			Gyrodactylus (1)		
16 Sep 77	RBT	1	*Gyrodactylus* (1)		
16 Sep 77	BNT	2			
16 Sep 77	BKT	1	*Epistylis* (1)		
			Trichodina (1)		
16 Sep 77	YP	2	*Trichophrya* (1)		
30 Sep 77	RBT	2	*Gyrodactylus* (1)		
30 Sep 77	BNT	2	*Gyrodactylus* (2)	*Aeromonas hydrophila* (1)	
			Ichthyophthirius (1)	*Enterobacter* sp. (1)	
30 Sep 77	BKT	1	*Gyrodactylus* (1)		
30 Sep 77	YP	2	*Glossatella* (2)		
			Gyrodactylus (2)		
			Trichophrya (1)		
28 Oct 77	BNT	2			
28 Oct 77	YP	2	*Trichophrya* (2)		
			Glossatella (1)		
			Gyrodactylus (1)		
11 Nov 77	RBT	1			
11 Nov 77	BNT	1			
11 Nov 77	YP	2	*Trichodina* (1)		
			Glossatella (2)		
23 Nov 77	YP	2	*Trichophrya* (2)		
			Glossatella (2)	*Pseudomonas* sp. (1)	
			Trichodina (1)		
7 Dec 77	RBT	2	*Trichophrya* (1)		
7 Dec 77	BNT	1	*Trichophrya* (1)		
7 Dec 77	YP	2	*Trichophrya* (1)		

[1]RBT = Rainbow trout
BNT = Brown trout
BKT = Brook trout
YP = Yellow perch
[2]Number of fish examined for pathogens. For most samples, an equal number were examined histologically.
[3]Number of fish with pathogen in parentheses.

Data on water temperature, dissolved oxygen, pH, oxidation-reduction potential, total organic carbon, color, turbidity, alkalinity, total suspended solids, total manganese, total iron, ionized iron, and conductivity were provided for station 1 and a site 5 km upstream from station 4 by the Georgia Department of Natural Resources. Collection of water data was within 2 days of fish collections.

RESULTS

Infectious diseases

Eight genera of parasites were found (Tables 1 and 2). The number of parasites per fish was low with the exception of heavy infestations of the protozoan *Glossatella* (= *Apiosoma*) on yellow perch from some collections. A histological examination of yellow perch infested with *Glossatella* did not reveal any lesions resulting from this parasite (Fig. 1).

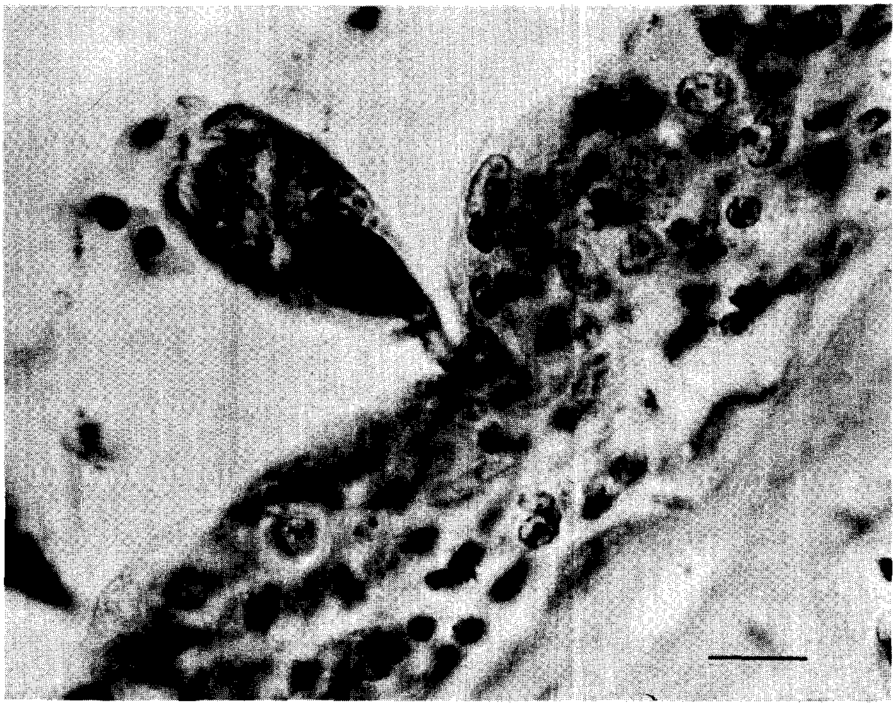

Fig. 1. Section of *Glossatella* on a yellow perch gill. Bar=10 μm.

Eight species of bacteria were isolated (Tables 1 and 2), but only 3, *Aeromonas hydrophila*, *Pseudomonas fluorescens*, and *Flexibactor columnaris*, are known to cause fish diseases (Wolke 1975). None of the fish had clinical or histological signs of bacterial diseases. Two bacterial pathogens, *Aeromonas salmonicida* and *Corynebacterium salmoninus*, that caused mortalities in Lake Lanier Hatchery during this time period (Grizzle, unpublished data) were not isolated from any of the fish from the Chattahoochee River.

Infectious pancreatic necrosis (IPN) virus was found in rainbow and brook trout from station 1 (Table 1), but the fish did not have any clinical or histological signs of IPN.

Histological examination - station 1

Microscopic lesions were found in the gill, liver, trunk kidney, and spleen. Gills had hypertrophy and hyperplasia of the lamellar epithelium (Fig. 2,3, and 4), edema in lamellae (Fig. 5), and lamellar aneurisms (Fig. 6).. Hypertrophy and hyperplasia of the lamellar epithelium were also found in control rainbow trout, but the lesions were more severe in trout from the river. Lesions found in the trunk kidney were congestion, vacuolation of tubular epithelium, necrosis of tubular epithelium (Fig. 7) and dilation of the tubular lumens. Liver lesions were necrosis (Fig. 8), edema, congestion (Fig. 9) and fatty change (Fig. 9). The only lesion found in the spleen was congestion.

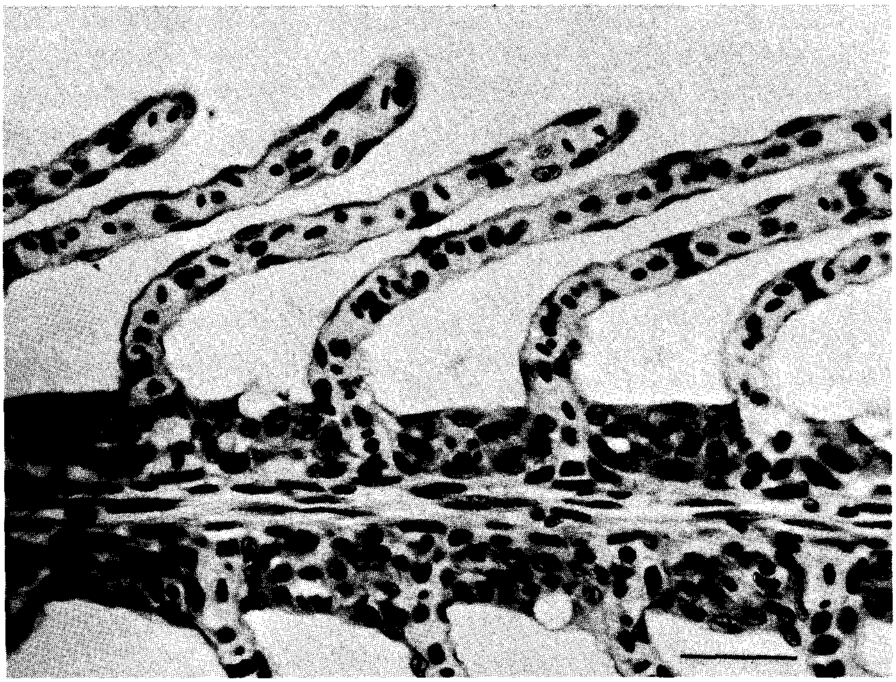

Fig. 2. Rainbow trout gill without lesions. Bar=30 μm.

The three species of trout had similar types of lesions in the organs examined. The lesions were more common and severe in the rainbow and brook trout collected on 12 October and 9 November than in these species collected at other times. Of the trout species, brook trout had the fewest lesions. Yellow perch had fewer lesions that any of the trout species. Hypertrophy and hyperplasia of the lamellar epithelium, kidney necrosis, and liver edema and congestion were not found in yellow perch.

Histological examination - station 4

The microscopic lesions in fish from station 4 were of the same types as in fish from station 1 except that the vacuolation of kidney-tubule epithelium and liver congestion were not present at station 4. Additional lesions found at station 4 were edema and hemorrhage in the trunk kidney and separation of the gill-lamella epithelium from the pillar cells. Brown trout collected from station 4 had fewer lesions than those from station 1. There was an inadequate number of yellow perch and brook trout for a comparison

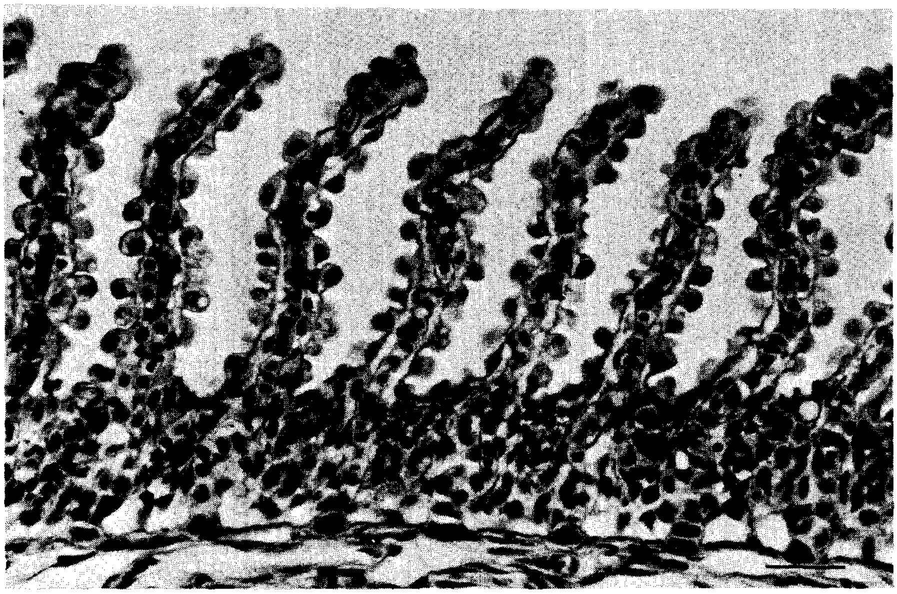

Fig. 3. Hypertrophy of the gill-lamella epithelium of a rainbow trout collected at station 1 on 9 November 1977. Bar=30 μm.

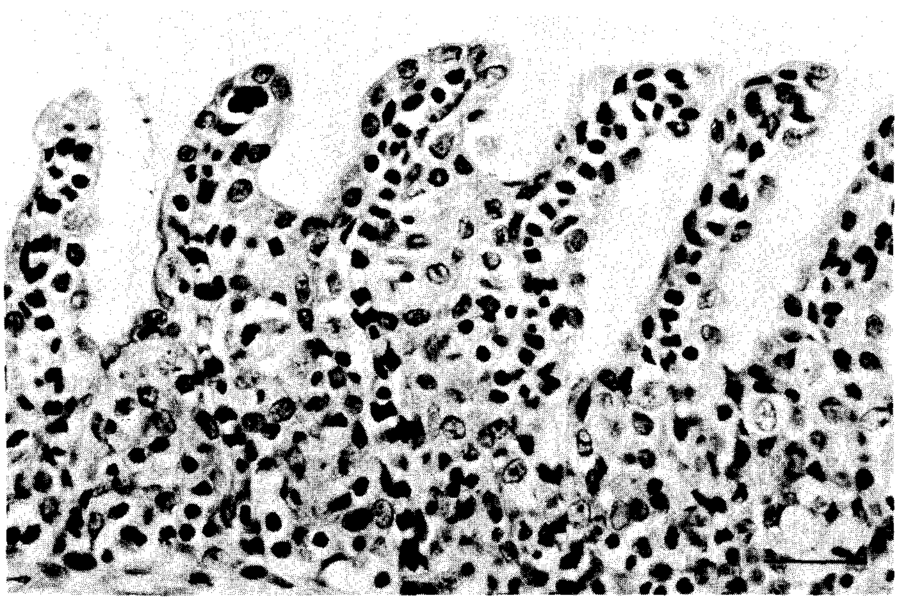

Fig. 4. Hyperplasia of the gill-lamella epithelium of a brown trout collected at station 1 on 12 October 1977. Bar=30 μm.

Fig. 5. Edema in gill lamellae of a rainbow trout collected at station 1 on 14 September 1977. Bar=30 μm.

Fig. 6. Aneurisms in gill lamellae of a brown trout collected at station 1 on 24 August 1977. Bar=50 μm.

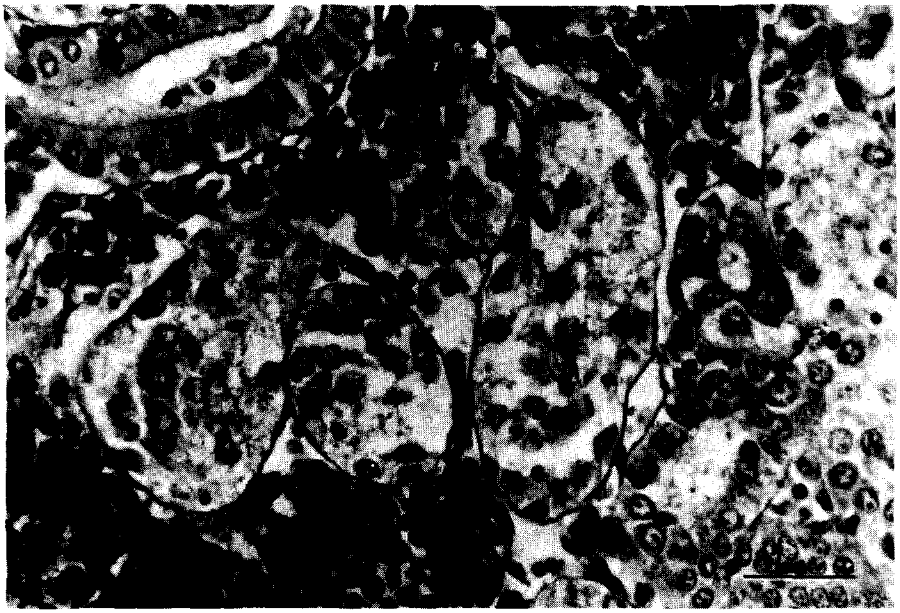

Fig. 7. Necrosis of kidney-tubule epithelium in a rainbow trout collected at station 1 on 9 November 1977. Bar=30 μm.

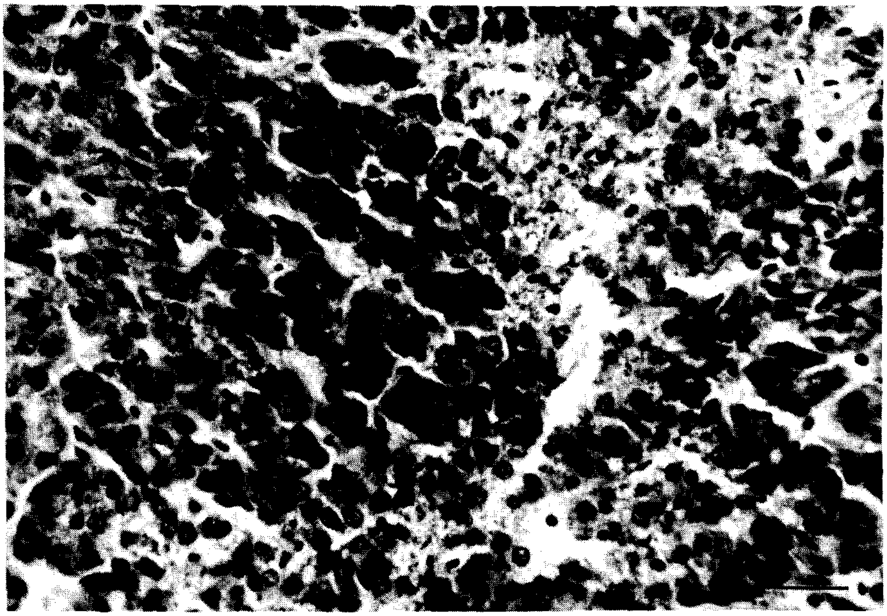

Fig. 8. Necrosis of brook trout liver collected at station 1 on 6 December 1977. Bar=30 μm.

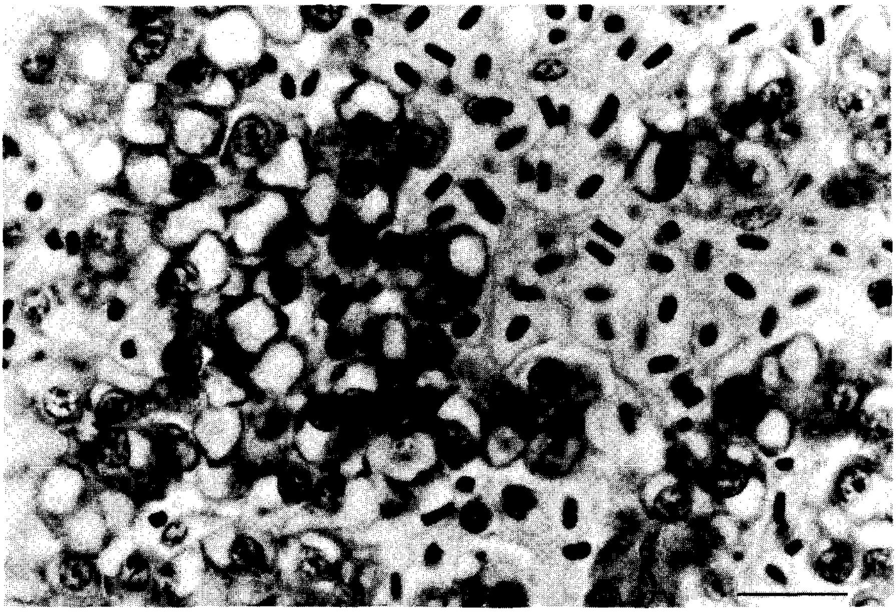

Fig. 9. Fatty change and congestion of rainbow trout liver collected at station 1 on 9 November 1977. Bar=20 μm.

between stations, and there were no obvious differences in the severity or number of lesions in rainbow trout from the 2 stations.

DISCUSSION

Infectious diseases

Bacterial, viral, and parasitic infections did not appear to be a health problem in the fish examined. Organisms capable of causing diseases were found in the fish, but clinical signs of disease and the types of histological lesions that are associated with the diseases caused by these organisms were not present. It is possible that some fishes in the study area did have infectious diseases, but these fish were not collected. Larger sample sizes would be better for determining if any fish are being harmed by infectious diseases.

Histological lesions

Histological lesions were found in the gill, liver, spleen, and trunk kidney but not in the head kidney. These lesions could have been caused by various toxic chemicals, but almost no study has been devoted to the effects of chronic exposure of fish to poisons under natural conditions. The lack of information concerning toxic effects under natural conditions makes it impossible to determine the chemical associated with the lesions found in this study.

Most histological lesions were in the gills. Hypertrophy and hyperplasia of the lamellar epithelium and lamellar aneurisms occur after exposure to some chemicals such as ammonia (Burrows 1964, Smith and Piper 1975), pesticides (Walsh and Ribelin 1975), copper (Baker 1969), and in conditions of low dissolved oxygen in the water (Scott 1977). Some of the control fish examined also had hypertrophy and hyperplasia of the lamellar epithelium, although trout from station 1 had more sever lesions than any of the hatchery fish.

Copper and zinc have been reported to cause a separation of the epithelium from the gill lamellae (Baker 1968, Matthiessen and Brafield 1973). This type of lesion resulted after an acute exposure and might not occur after a chronic exposure. A separation of the epithelium from the gill lamellae was found in 2 yellow perch from station 4 but was not found in trout.

The types of lesions in internal organs found in this study can result from the direct effects of a poison but can also result from tissue hypoxia. Other investigations have found that gill lesions that interfered with the entry of oxygen into the blood resulted from zinc (Burton et al. 1972) and high temperature (Rombough and Garside 1977) thus causing tissue hypoxia throughout the body. Tissue hypoxia can result in histological lesions in many organs (Plumb et al. 1976, Scott 1977) and causes adverse effects on growth, reproduction, activity or other physiological functions (Wedemeyer et al. 1976).

Species differences

Histological lesions of the gills were different between the trout species and the yellow perch. Hyperplasia and hypertrophy of the lamellar epithelium, frequently found on trout gills, were absent from all of the yellow perch examined. In some yellow perch the lamellar epithelium was separated from the pillar cells, but the resulting space did not contain the eosinophilic material usually present in edema. This separation could be an early stage in the sloughing of the epithelium from the lamellae.

Fewer lesions were found in the yellow perch collected at station 1 than in trout from station 1 which probably indicates that the conditions at station 1 are more detrimental to the trout than to the yellow perch. A comparison of the lesions found in the trout collected at station 1 indicates that the brook trout are less affected than the other trout species. This is especially noticeable when the gill lesions found in brook trout are compared to gill lesions of rainbow and brown trout.

Differences between stations

The brown trout collected at station 4 had fewer lesions than those from station 1 indicating an improvement in the conditions at station 4 compared to station 1. There was more dissolved oxygen at station 4 than at station 1 (Fig. 10) and this was the only water quality characteristic measured that was consistently better at station 4 than at station 1. The greater number of lesions found in brown trout at station 1 than at station 4 could be a result of the difference in dissolved oxygen. The station 1 oxygen concentration at both low flow and high flow was usually below the 5.0 mg/liter level regarded as a minimum level suitable for salmonids (Amlacher 1970, Wedemeyer et al. 1976). Station 4 oxygen concentrations were near or above 5.0 mg/liter. Since many lesions were found in fish from station 4 the additional oxygen did not completely alleviate the toxic nature of the water.

Variation between collection dates

Histological lesions were more numerous in rainbow and brook trout collected at station 1 on 12 October and 9 November than in these species collected at other times. During the 2- or 3-week period prior to 12 October there was an increase in concentrations of total iron, ionized iron, and manganese during both high and low flow (Fig. 11). These dates also correspond to a period when dissolved oxygen concentration during low flow was 0.7 to 1.2 mg/liter. These water quality data indicate poor conditions for the survival of trout since 2.0 mg/liter dissolved oxygen is reported to cause the rapid death of trout (Amlacher 1970). Decker and Menendey (1974) report that 0.48 mg/liter of ionized iron is the 96-hr LD_{50} at pH 6.0 for brook trout. The ionized iron concentration at station 1 during low flow reached 0.48 mg/liter on 7 September and during high flow reached 0.41 mg/liter on 5 October.

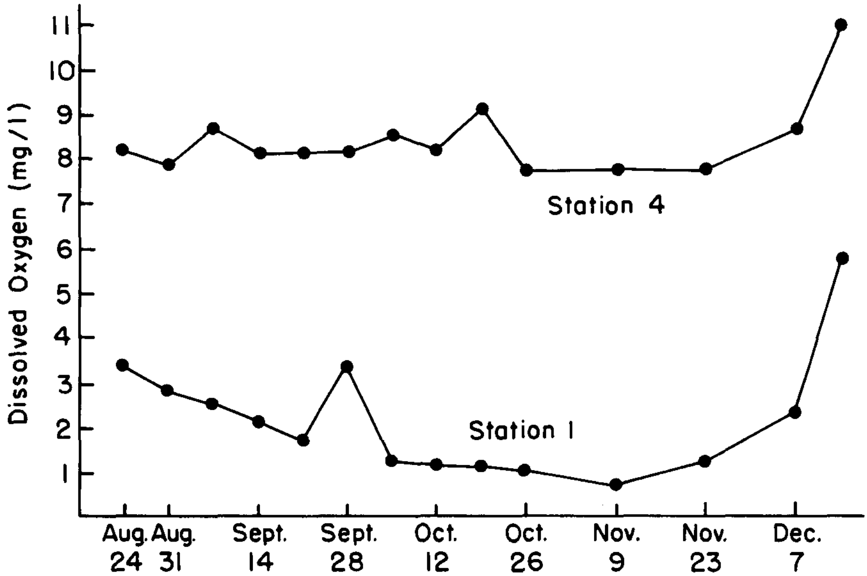

Fig. 10. Dissolved oxygen concentrations below Buford dam during periods of low water, 1977. (Data provided by the Georgia Department of Natural Resources).

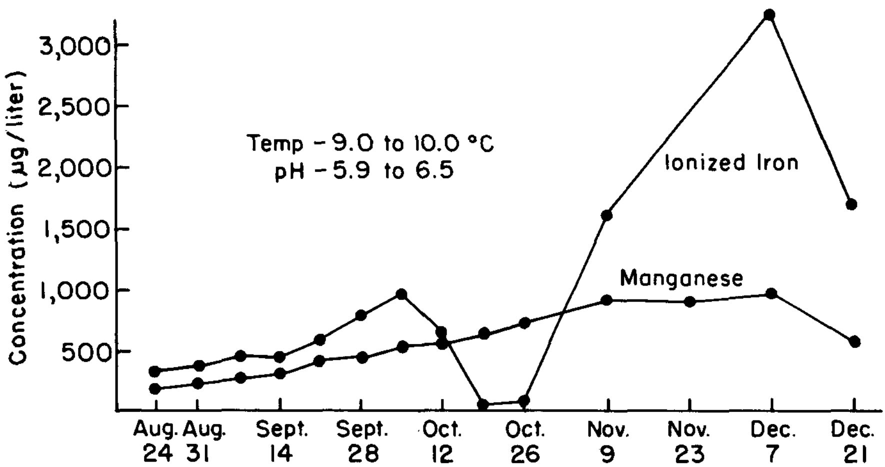

Fig. 11. Concentrations of manganese and ionized iron at station 1 during periods of low water, 1977. (Data provided by the Georgia Department of Natural Resources).

Insufficient research has been done to determine the importance of some of the water sample data provided by the Georgia Department of Natural Resources. Toxicity information is not available for manganese in conditions similar to those in the study area. The effects of oxidation-reduction potential, total organic carbon, color, turbidity, total suspended solids, and volatile suspended solids under conditions present in the study area are not known. The low alkalinity level would increase the toxicity of heavy metals that might be present (Lee 1973), but the concentrations of total organic carbon indicate that the organic matter present would decrease heavy metal toxicity (Brown et al. 1974). The interaction between alkalinity, organic matter, and heavy metals will make future interpretations of heavy metal concentration difficult unless bioassay data are obtained using water from the study area.

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