# MORTALITY OF YOUNG-OF-THE-YEAR RAINBOW SMELT (Osmerus mordax) IN LAKE ERIE ASSOCIATED WITH THE OCCURRENCE OF Glugea hertwigi 1

Author: NEPSZY, STEPHEN J.

Source: Journal of Wildlife Diseases, 14(2) : 233-239

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-14.2.233

# MORTALITY OF YOUNG-OF-THE-YEAR RAINBOW SMELT *(Osmerus mordax)* IN LAKE ERIE ASSOCIATED WITH THE OCCURRENCE OF *Glugea hertwigi* [1]

STEPHEN J. NEPSZY, Fisheries Research Station, Ontario Ministry of Natural Resources, R.R. 1, Wheatley, Ontario NOP 2PO

JOAN BUDD, Department of Pathology, Ontario Veterinary College, University of Guelph, Guelph, Ontario NIG 2W1

ALEX O. DECHTIAR, Fish and Wildlife Research Branch, Ontario Ministry of Natural Resources, Maple, Ontario LOJ 1EO

*Abstract:* An extensive mortality of young-of-the-year rainbow smelt ***(Osmerus mordax)*** occurred in Lake Erie during the fall of 1969. Dead and dying smelt were observed along the north shore from west of Long Point in the central basin to Port Maitland in the eastern basin. No other fish species was involved. ***Glugea hertwigi***, a microsporidan parasite, was observed in 90% of the distressed smelt examined, and is believed to have been a major contributing factor to the mortality.

## INTRODUCTION

The first reported mortality of rainbow smelt *(Osmerus mordax)* in North America attributed to *Glugea hertwigi* occurred in New Hampshire.[10] Subsequent mortalities, associated with a high prevalence of this parasite, have been reported in young-of-the-year smelt[14] and in adult smelt[6] in Quebec. Similar situations involving stint *(Osmerus eperlanus* m. *spirinchus)* have occurred in the U.S.S.R.[1,18]

The prevalence of cysts of *G. hertwigi* in rainbow smelt of all ages has been monitored in Lake Erie since the parasite was first observed in 1960.[4] Some mortality of adult rainbow smelt occurs in Lake Erie each spring and has generally been attributed to post-spawning exhaustion. However, a high prevalence of *G. hertwigi* cysts is believed to have contributed to an unusually high mortality of adult smelt in May, 1971.[17]

This paper describes a mortality of young-of-the-year rainbow smelt that was first noted in September, 1969 off Port Glasgow in central Lake Erie and subsequently extended to Port Maitland in the eastern basin (Fig. 1).

## MATERIALS AND METHODS

The geographic extent of the mortality (Fig. 1) was determined by examining the beach area and the immediate offshore waters for any signs of dead or dying smelt. Underwater diving was done only in the Port Dover area to observe dead young-of-the-year smelt on the lake bottom.

A total of 1150 young-of-the-year rainbow smelt involved in this mortality were examined. Dead fish were collected from the beach area, while live and distressed fish were captured with a beach seine. A sample of 50 fresh fish was sent, packed in ice, to the Department of Microbiology, University of Guelph for bacteriologic examination. Three representative samples, each consisting of nine infected fish from collections made on different days, were fixed in 10% formalin and submitted to the Section of Wildlife Pathology, Ontario Veterinary College, for

[1] Contribution No. 77-1 of the Ontario Ministry of Natural Resources Fish and Wildlife Research Branch, Maple, Ontario.

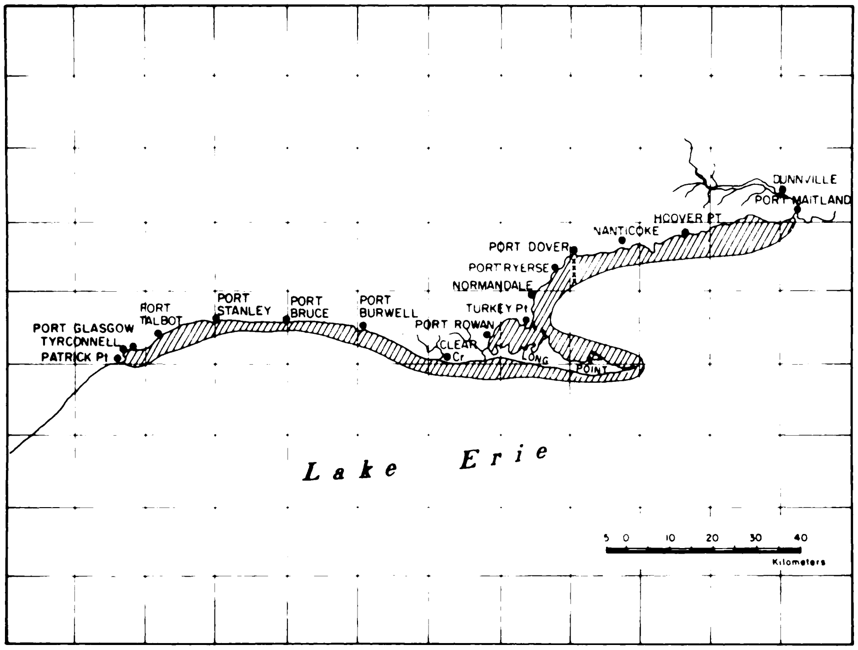


FIGURE 1. Geographic extent of observed mortality of young-of-the-year rainbow smelt in Lake Erie (hatched area) and water sampling sites (X) in Long Point Bay.

histopathologic examination. Three or four whole fish from each submission were embedded in paraffin, serially sectioned on a sagittal plane and stained with hematoxylin and eosin or Giemsa's stain.

Water samples were obtained in October and analysed by the Ontario Ministry of the Environment from locations at Port Dover: a) two surface sites near the beach where dead and distressed smelt were observed; b) two bottom sites on a transect from shore to a distance of 4.2 km offshore (Fig. 1).

## RESULTS AND DISCUSSION

### Observations on Current Mortality and Histopathology of Smelt

Examinations for ecto- and endoparasites and external and internal lesions were performed on each specimen collected. The fish ranged from 29 to 90.5 mm in total length and 90% contained the whitish, spherical cysts of *G. hertwigi*. These cysts were localized predominantly at the posterior portion of the abdomen although a few were present in the muscle tissue. Several larger cysts (>2 mm) and multiple smaller ones occupied a large portion of the body cavity and occluded the posterior portion of the intestine (Fig. 2). No other parasites were evident during these gross examinations.

Although there was variation between fish in the size and number of cysts or "xenomas",[21] in all fish examined histologically, the mass resulting from multiple, closely associated xenomas occupied much of the abdomen, displacing and causing distortion of various organs. In some fish the parenchyma of the liver

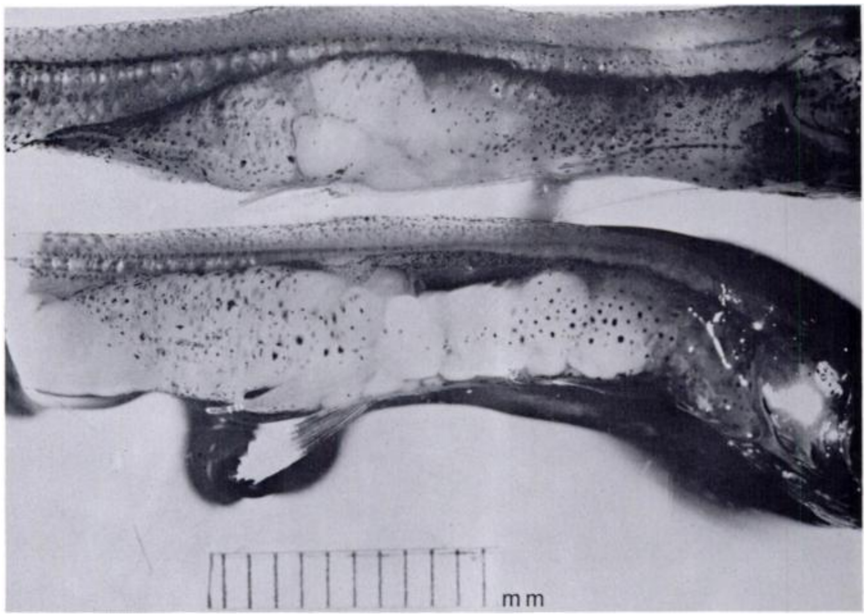


**FIGURE 2. Body cavity of young-of-the-year rainbow smelt showing cysts of *Glugea hertwigi* causing apparent blockage of intestine.**

had a scalloped outline due to the presence of adjacent cysts, but there was no evidence of degenerate hepatocytes. Blood vessels of the liver and spleen were congested. In the pancreas there was slight hyperplasia of acinar cells and occasional acinar cells were vacuolated, but the remainder of the pancreatic tissue was normal. In others the normal shape of the kidney was disrupted to the extent that glomeruli and tubules were seen ventral to and occupying spaces between dorsally located xenomas. In all fish examined, the intestine had greatest evidence of change, especially the posterior portions. Large xenomas and numbers of smaller ones, apparently originating in the connective tissue of the submucosa, appeared to displace the muscular wall of the intestine. The epithelium of the mucosal surface was visible only intermittently in any one section in spaces between xenomas (Fig. 3). Areas of the mucosa adjacent to large

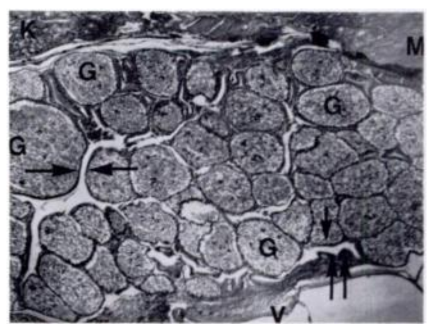


FIGURE 3. Sagittal section of the posterior of the coelomic cavity. Large numbers of *Glugea* cysts or "xenomas" fill the space causing distortion of the intestine. The mucosa of the intestine is recognizable between some cysts. G - *Glugea* cysts; K - kidney; M - dorsal muscle; V - ventral surface of body; double arrows-columnar epithelium in the lumen of intestine; single arrow - flattened mucosa adjacent to cysts. ×40.

xenomas consisted of low columnar or, in some cases, a single layer of low cuboidal cells, with occasional goblet cells present (Fig. 4). The normal fingerlike villi with columnar cells projecting into the lumen were absent. In some areas villi were normal on the opposite side where xenomas were not present.

Where space occurred between cysts there was proliferation of connective tissue and slight infiltration of leukocytes. No xenomas were seen within epithelial cells in the lumen of the intestine, or within the parenchyma of other organs. Cells in the connective tissue of the mesentery were probably the origin of the xenomas, as these masses of hypertrophied cells appeared to occupy the coelomic cavity and, with the exception of those associated with the posterior part of the gastrointestinal tract, were not within the organs affected.

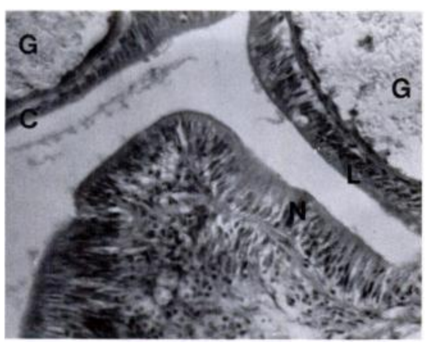


**FIGURE 4. Higher magnification to illustrate effect of *Glugea* cysts (G) on the intestinal mucosa. C - low cuboidal epithelium; L - low columnar epithelium; N - normal columnar epithelium. ×400.**

## Causes of Mortality

Possible causes for this mortality were: (a) organic and/or inorganic pollution, (b) water temperature change, (c) decreased dissolved oxygen, (d) presence of highly virulent bacteria, fungi or parasites.

*Pollution*

During the past half century, organic and inorganic pollution has contributed to many changes in the environment and biota of Lake Erie.[12] Fish may be affected by the following types of pollution: (a) siltation, (b) nutrient and organic matter and (c) industrial wastes.

Gross and microscopical examination of rainbow smelt did not reveal signs which could be attributed to pollution. We believe that organic or inorganic pollution was not a factor responsible for this mortality because (a) only rainbow smelt were affected, (b) mortality was confined to young-of-the-year fish and (c) rainbow smelt in western Lake Erie, where pollution is greater,[12] were unaffected.

*Temperature*

Temperature influences the metabolic rates of fish as well as their behaviour and distribution.[9] Surface water temperature in the Port Dover beach area on 3 October 1969 was 16 C; offshore bottom temperature was 12 C. Temperature for the same area during the first half of October ranged from 14.7 to 16 7 C.

During the same period and in the same area in 1968 and 1970, when no mortalities of young-of-the-year smelt or other fish occurred, the water temperature ranged from 13.6 to 19.4 C and 15 to 16.7 C respectively. These ranges are well within the temperature tolerance of this life stage of rainbow smelt[8] (Nepszy, unpubl.). Therefore, temperature alone cannot be considered a direct cause for this mortality.

*Dissolved Oxygen*

Reduced levels of available oxygen affect physiological, behavioural and biochemical processes in fish and very low levels can cause mortalities.[3,9]

Dissolved oxygen regimes differ in the three basins of Lake Erie. The western basin is well oxygenated, high in nutrient matter, and usually does not stratify except during periods of prolonged hot, calm weather. The eastern basin stratifies, but is low in organic content and critically low concentrations of dissolved oxygen have not been reported; although concentrations of less than 30% saturation recently have been reported in the hypolimnion.[2] While stratification in the central basin occurs regularly during the summer, low oxygen concentrations in the hypolimnion have been detected over the past three decades. The shift to anoxia in the hypolimnion during late summer and fall is gradual[2] and healthy rainbow smelt normally can avoid the area and seek more suitable habitat.

Water samples from the Port Dover area had dissolved oxygen levels of 9 ppm. Although the first occurrence of mortality was in the central basin where oxygen levels may have been low (but were not determined), the presence of dead fish and high oxygen levels in the eastern basin does not suggest that lack of oxygen was a direct cause.

**Bacteria, Fungi and Parasites**

Common saprophytic water bacteria such as *Aeromonas hydrophila, Pseudomonas* spp. and Cytophagaceae may become pathogenic, causing disease and death when fish are under stress from specific environmental conditions.[20]

Bacteriological examination of young-of-the-year smelt failed to reveal any bacteria which may have been the primary cause of mortality (Dr. L.A. McDermott, pers. comm.). There was also no evidence of fungal infection.

Microsporidans are known to infect a variety of North American fish, including rainbow smelt.[7,11] Haley[10] reported 23.3% infection with *G. hertwigi* in American smelt from the Great Bay region of New Hampshire. He discussed pathogenesis, suggesting that initial infection was probably by the oral route and that auto-infection may be the basis of heavy infections.

Spawning rainbow smelt in Lake Erie during 1969 were predominantly the two-year-old-fish of the strong 1967 year-class. The prevalence of *G. hertwigi* cysts in this age class reached 79.9% during the April-June period.[16] Index fishing data for young-of-the-year smelt in 1969 showed the presence of a strong year-class, relatively stronger than previous or subsequent years.[13] Therefore, it seems probable that, with the high prevalence of *G. hertwigi* in the spawning stock and the subsequent abundance of young-of-the-year fish, circumstances were favorable for the rapid spread of the disease. Since development of *G. hertwigi* may not be dependent upon an intermediate host, it is believed that transmission may be via direct ingestion of spores by the fry once they begin feeding independently.[19]

Data from previous sampling of young-of-the-year rainbow smelt in Lake Erie support the observations of Delisle[5] that increased development of cysts occurs on an annual cycle, with initial development evident in early summer and maximum numbers occurring in August and September. Increase in size of the cysts, together with the number of cysts is related to the greater growth period during this time;[5] and we feel that increased water temperatures (23.6 C in August and 23.3 C in September) also favoured cyst growth. The marked effect of high temperatures on the increased prevalence of *Glugea stephani* cysts in plaice, *Pleuronectes platessa*, has been demonstrated experimentally.[15]

Considering the intensity of infection with *G. hertwigi* cysts and the histopathologic changes observed in the smelt examined, we conclude that the presence of the parasite was the major factor contributing to this mortality.

Although favourable water temperature may have contributed to rapid parasite multiplication, we have eliminated other factors such as pollution, insufficient dissolved oxygen and pathogenic bacteria, fungi or other parasites as primary causes. The direct evidence strongly suggests that mortality resulted from mechanical damage to internal organs. The flattened epithelium and thinning of the intestinal wall are indications of the effect of adaptation to the presence of cysts. Under ideal conditions these fish probably could survive for a time while developing organs were accommodating to the space-occupying parasitic cysts, but physiological stress may make demands to which the fish are unable to adjust.

Death probably resulted from a combination of factors, including changes in the gravity centre of the fish, thus affecting swimming ability, malformation of organs resulting in physiological stress, and probable intestinal occlusion, resulting in starvation or absorption of toxic waste products. Our conclusions corroborate the opinions of Haley[10] and Legault and Delisle[14] concerning mass mortalities of rainbow smelt from other locations.

## Acknowledgements

We thank A.H. Lawrie and J.H. Leach (Ont. Ministry of Natural Resources) and R. Lester (Dept. of Pathology, Ont. Veterinary College, Univ. of Guelph) for critically reviewing the manuscript. Histopathologic studies were supported in part by the Ontario Ministry of Agriculture and Food. Underwater observations were kindly provided by J.L. Misner. We acknowledge the assistance of J. Murphy with fish necropsy and J. Robinson for some of the photography.

## LITERATURE CITED

1. BOGDANOVA, E.A. 1957. The myxosporidian, *Glugea hertwigi* Weissenberg, in the stint *(Osmerus eperlanus* m. *spirinchus)* from Lake Yulya-Yarvi. Bull. All-Union Sci. Res. Inst. Freshwater Fish. 42: 328 (Transl. by U.S. Dept. of Comm., Off. of Tech. Serv., 1961).
2. BURNS, N.M. 1976. Temperature, oxygen and nutrient distribution patterns in Lake Erie 1970. J. Fish. Res. Board Can. 33: 485-511.
3. DAVIS, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species; a review. J. Fish. Res. Board Can. 32: 2295-2332.
4. DECHTIAR, A.O. 1965. Preliminary observations on *Glugea hertwigi* Weissenberg, 1911 (Microsporidia: Glugeidae) in American smelt, *Osmerus mordax* (Mitchill) from Lake Erie. Can. Fish. Cult. 34: 35-38.
5. DELISLE, C. 1969. Bimonthly progress of a non-lethal infection by *Glugea hertwigi* in young-of-the-year smelt, *(Osmerus eperlanus mordax.)* Can. J. Zool. 47: 871-876.
6. ——— 1972. Variations mensuelles de *Glugea hertwigi* (Sporozoa: Microsporida) chez différents tissus et organes de l'éperlan adulte dulcicole et conséquences de cette infection sur une mortalité massive annuelle de ce poisson. Can. J. Zool. 50: 1589-1600.
7. FANTHAM, H.B., A. PORTER and L.R. RICHARDSON. 1941. Some microsporidians found in certain fishes and insects in Eastern Canada. Parasitology 33: 186-208.
8. FERGUSON, R.G. 1965. Bathymetric distribution of American smelt *(Osmerus mordax)* in Lake Erie. Great Lakes Res. Div. Univ. Mich. Publ. 13: 46-60.
9. FRY, F.E.J. 1957. The aquatic respiration of fish. p. 1-63. In: *The Physiology of Fishes.* M.E. Brown, ed. Vol. 1. Academic Press Inc. New York. N.Y.

10. HALEY, A.J. 1954. Microsporidian parasite, *Glugea hertwigi*, in American smelt from the Great Bay region, New Hampshire. Trans. Am. Fish. Soc. 83: 84-90.

11. HOFFMAN, G.L. 1967. *Parasites of North American Freshwater Fishes*. Univ. Calif. Press, Berkeley, Calif. 486 p.

12. INTERNATIONAL JOINT COMMISSION. 1969. Report of the International Joint Commission, United States and Canada on the Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River Lake Erie 2: 316 p.

13. LEACH, J.H. and S.J. NEPSZY. 1976. The fish community in Lake Erie. J. Fish. Res. Board Can. 33: 622-638.

14. LEGAULT, R.O. and C. DELISLE. 1967. Acute infection by *Glugea hertwigi* Weissenberg in young-of-the-year rainbow smelt, *Osmerus eperlanus mordox* (Mitchill). Can. J. Zool. 45: 1291-1292.

15. McVICAR, A.H. 1975. Infection of plaice *Pleuronectes platessa* L. with *Glugea (Nosema) stephani* (Hagenmuller, 1899) (Protozoa: Microsporidia) in a fish farm and under experimental conditions. J. Fish. Biol. 7: 611-619.

16. NEPSZY, S.J. 1970. Research Review 69. Ann Rept. Fish Sect. Res. Branch, Ont. Dept. Lands and Forests, 1970: 15-18.

17. ——— and A.O. DECHTIAR. 1972. Occurrence of *Glugea hertwigi* in Lake Erie rainbow smelt *(Osmerus mordax)* and associated mortality of adult smelt. J. Fish. Res. Board Can. 29: 1639-1641.

18. PETRUSHEVSKI, G.K. and S.S. SHULMAN. 1970. The parasitic diseases of fishes in the natural waters of the USSR. p. 299-319. In: *Parasitology of Fishes*. Dogiel, V.A., G.K. Petrushevski and Yu I. Polyanski eds. T.F.H. (Great Britain) Ltd. 384 p.

19. PUTZ, R.E. 1969. Parasites of fresh water fishes: II Protozoa. 1. Microsporidea of fish. U.S. Dept. Interior, Fish Wildlife Serv., Bur. Sport Fish. Wildlife, FDL-571: 1-4.

20. SNIESZKO, S.F. 1974. The effects of environmental stress on outbreaks of infectious diseases of fishes. J. Fish. Biol. 6: 197-208.

21. WEISSENBERG, R. 1968. Intracellular development of the microsporidian *Glugea anomala* Moniex in hypertrophying migratory cells of the fish *Gasterosteus aculeatus* L., an example of the formation of "xenoma" tumours. J. Protozool. 15: 44-57.

*Received for publication 22 February 1977*