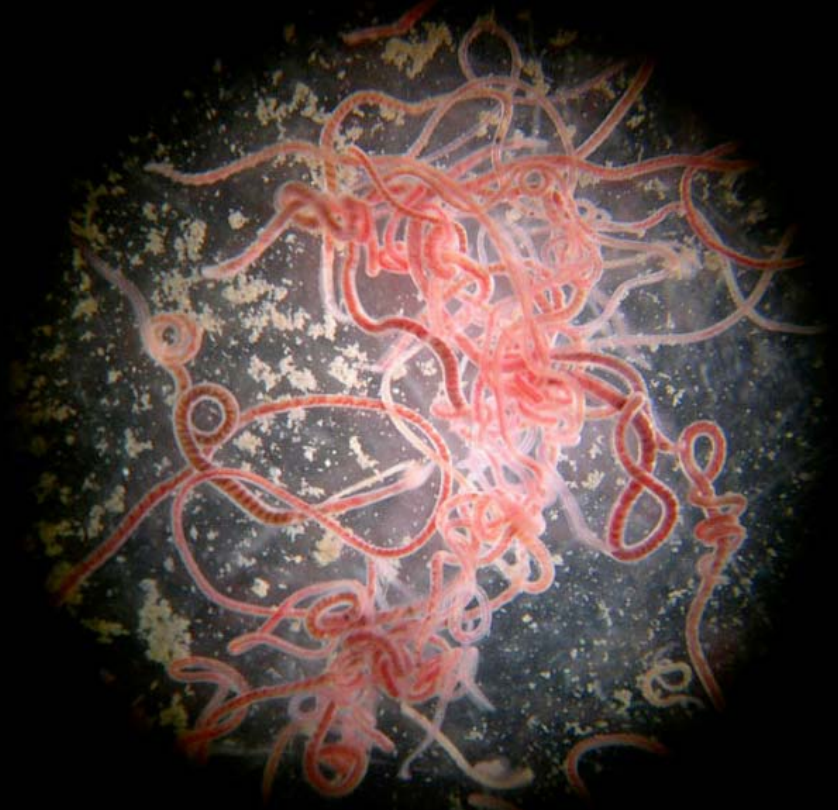


WHIRLING DISEASE RESEARCH FOCUSES OFTEN ON THE VARIABILITY IN SUSCEPTIBILITY AMONG TUBIFEX TUBIFEX, THE ALTERNATE HOST OF THE PARASITE (PHOTO COURTESY OF LEAH STEINBACH ELWELL)

DEVELOPMENTS IN WHIRLING DISEASE RESEARCH THROUGH THE NATIONAL SYMPOSIUM

BY KAJSA STROMBERG, (WHIRLING DISEASE INITIATIVE, MONTANA WATER CENTER, USA)

When the first national Whirling Disease Symposium was held in 1995, there was a great sense of urgency among coldwater fisheries managers, aquaculturalists and a concerned public.

Whirling disease, caused by the myxozoan parasite *Myxobolus cerebralis,* had recently emerged as a major threat to wild trout in the United States. Since that time, intensive research has increased knowledge about the parasite, its two hosts and the potential for managing the disease.

Although investigations about the complicated disease seem to raise more questions for every one that is answered, research results presented at the 12th annual symposium have yielded new information that can be put into practice on the ground.

The first detection of *M cerebralis* in the United States occurred in Pennsylvania in 1956 (Hoffman 1962). The parasite was also detected at nearly the same time in California. Researchers suspect the parasite was introduced from Europe, where it is native, in a shipment of infected frozen trout (Bartholomew and Reno 2002). The parasite soon became widely distributed as a result of inadvertent stocking of infected fish and the use of infected fish for food in hatcheries.

Low levels of infection in wild fish and a lack of visible signs of disease allowed the parasite to spread largely unnoticed. By 1970, the parasite had been detected in 10 states. By 1990, it had spread to an additional seven states, from the eastern to the western coast of the country. Currently, the parasite has been reported in 23 states.

However, despite this widespread distribution, prior to 1994 observations of clinical whirling disease were largely limited to aquaculture facilities, and population-level impacts were not documented in the wild.

IMPACT OF WHIRLING DISEASE

In the years following its introduction, impacts of whirling disease on public and private aquaculture enterprises were severe, in part as a result of fish health regulations imposed to control the further spread of the parasite.

During that time, the detection of the parasite could signal the destruction of infected trout stocks, expensive renovations and even the closure of facilities. Millions of fish were destroyed and the economic costs were high. Regulations attempted to keep pace with the spread of the parasite, restricting the transfer of fish and fish parts.

However, the parasite continued to spread through inadvertent introductions and *M cerebralis* was detected in an increasing number of waters. The consequences of *M cerebralis* for aquaculture in the United States continue to be severe in many cases.

For example, in the state of Utah, the total value of trout sales in Utah was reduced nearly 29 percent during 2005. This is largely attributed to whirling disease, since six private hatcheries went out of business in 2005 due to detection of the parasite, according to the Utah Department of Agriculture and Food.

The first observations of the effect of whirling disease on wild fish populations occurred in the early 1990s in Colorado and Montana. Biologists observed declines in wild rainbow trout, and by 1994 whirling disease was identified as the primary cause. Reductions in recruitment of 90 to 100 percent were observed in the worst cases, and biologists, managers, and anglers became very concerned.

The parasite was already widespread, and its distribution continued to increase. In addition, it was well known that

DEVELOPMENTS IN WHIRLING DISEASE RESEARCH THROUGH THE NATIONAL SYMPOSIUM

management and eradication in aquaculture facilities was highly difficult and expensive. Concerns were raised that *M cerebralis* might decimate wild trout and salmon populations throughout North America and run producers out of business.

THE NEED FOR FURTHER RESEARCH

In this atmosphere of urgency and concern, the first national Whirling Disease Symposium was held in Denver, Colorado in 1995. This annual event, organised by the Whirling Disease Foundation, is the main gathering for whirling disease-related scientific research.

Scientists from a wide spectrum of scientific fields, including pathology, parasitology, fish ecology and genetics, attend the meeting each year. It provides a forum to share the latest research developments and management lessons, and facilitates cooperation and strategic planning.

This year marked the 12th annual Whirling Disease Symposium, and it is evident that research has become increasingly sophisticated and that the cooperative research programmes have matured. There is no single solution to the problems of whirling disease, and it's clear that a variety of approaches will be required.

As the scientific community struggles to provide the answers needed by managers and policy-makers, research focus areas continue to shift. The primary drivers of research related to whirling disease are the Whirling Disease Foundation and the Whirling Disease Initiative, each with their own priorities and strategies, but complementary and cooperative.

In the beginning, during the 1990s, research was mainly focused on basic questions of biology, ecology, diagnostics and treatment. Research revealed more information about the parasite's complicated life cycle, and deepened our understanding of the factors that influence whether the parasite becomes established in a locale, and causes infection and mortality. Research has also provided tools for detecting the parasite at very low levels in fish and in the wild.

This achievement has resulted in a regulatory programme that is much more efficient at preventing further parasite spread as a result of inadvertent movements of infected fish, and also in providing better information on where the parasite life cycle had become established. As this information was obtained, attention shifted to the study of management applications of these results and large-scale, watershed level investigations that would provide more insight on how the parasite spreads and under what conditions it results in disease.

THE 2006 WHIRLING DISEASE SYMPOSIUM

Research presented during the 2006 symposium focused on where *M cerebralis* infection occurs and why, particularly emphasising aspects of resistance and susceptibility of the parasite's two hosts: salmonid fishes and *Tubifex tubifex* worms.

One series of investigations examined the relationships between land use, habitat characteristics, *T tubifex* genotype and the prevalence of *M cerebralis*. There are multiple, distinct genetic lineages of *T tubifex* (Beauchamp et al 2002).

Lineages are determined by mitochondrial DNA (mt 16S) sequences that indicate genetic relationships, but are not necessarily indicators of specific resistance or susceptibility to the parasite. However, there is some indication that genetic differences may reflect variations among *T tubifex* worm populations with regard to their ability to support the parasite and produce the triactinomyxon life stage.

This variability between lineages may therefore be an important factor in determining infection rates among fish (Baxa et al 2006). This recent discovery has generated considerable interest in the implications for management of *M cerebralis*. Future studies are planned to investigate the mechanisms for resistance in *T tubifex* and how this information can be applied.

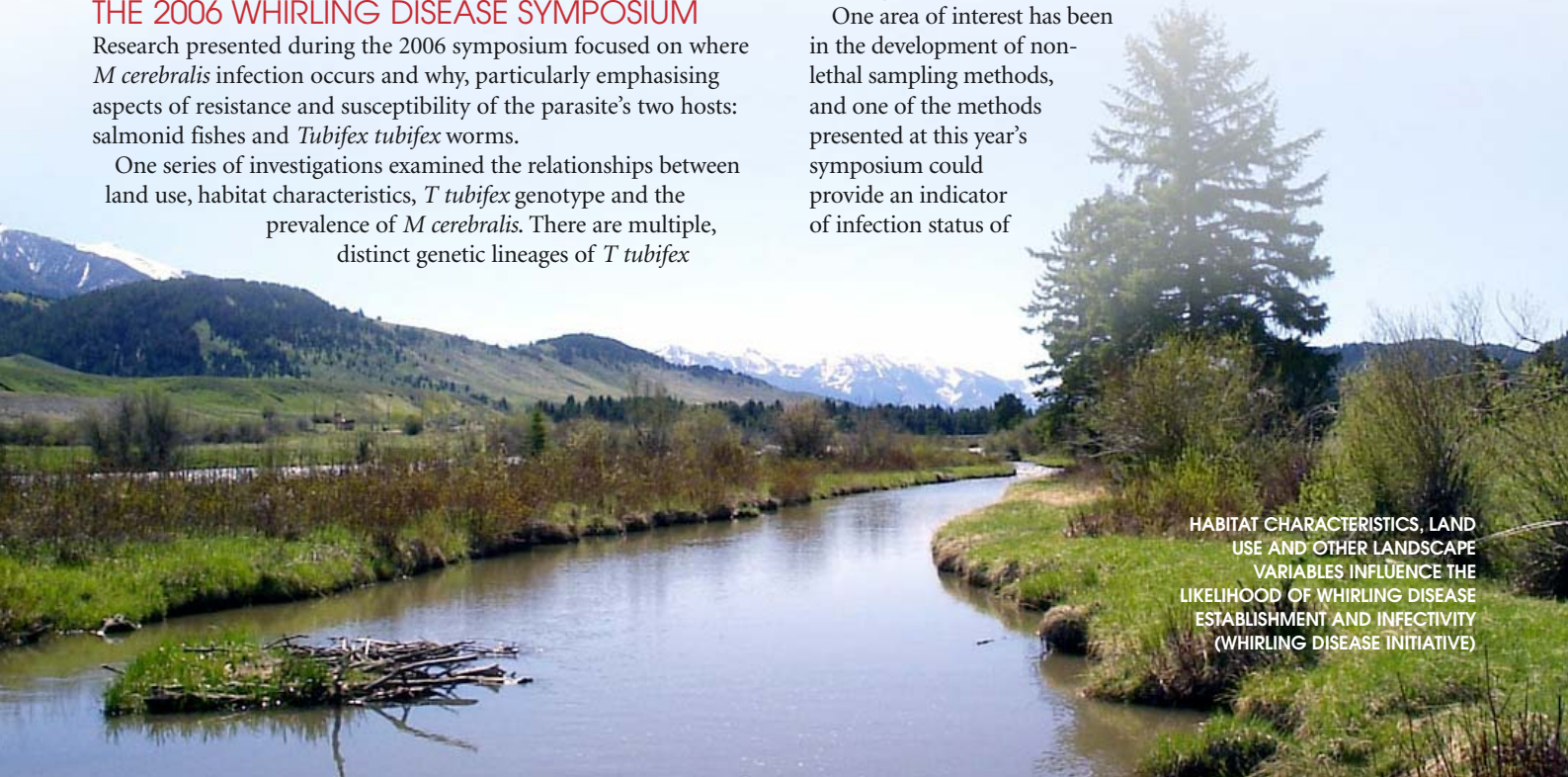
Studies regarding the salmonid host also focused on resistance to *M cerebralis* infection. Naturally occurring resistance is being investigated on the Madison River, Montana, where researchers hypothesise that selective processes are yielding a surviving population of fish that is more resistant to *M cerebralis* infection (Vincent 2006). Despite a high parasite concentration, the severity of infection in young rainbow trout in the Madison River in 2004 and 2005 is much lower than during the 1990s. However, many of these fish are not surviving to reproductive age due to factors still unclear. Research is continuing to evaluate the possibility of a developing resistance and what implications it may have for management.

Another life of research on resistant trout focuses on a domestic strain of rainbow trout known as the Hofer strain developed in Germany. These fish have been identified as having a high degree of resistance to whirling disease (Hedrick et al 2003). Crosses between this domestic strain and naturalised strains, like the Colorado River rainbow trout, are being evaluated for potential stocking into parasite-positive waters (Schisler et al 2006).

Pilot introductions have taken place in the Gunnison River, Colorado and survival will be carefully tracked and evaluated. These fish may provide managers with a sportfish that will survive in waters where infection levels are high. Additional studies investigated the mechanisms of resistance, evaluating the physical processes involved and genetic analyses.

Advances in *M cerebralis* diagnostics have been helpful for researchers, and have provided managers with highly sensitive tools for detecting low parasite levels in fish. However, the increasingly diverse questions being asked have presented challenges that require development of a new tool.

One area of interest has been in the development of non-lethal sampling methods, and one of the methods presented at this year's symposium could provide an indicator of infection status of



HABITAT CHARACTERISTICS, LAND USE AND OTHER LANDSCAPE VARIABLES INFLUENCE THE LIKELIHOOD OF WHIRLING DISEASE ESTABLISHMENT AND INFECTIVITY (WHIRLING DISEASE INITIATIVE)

a fish population by measuring antibody levels (Adkinson et al 2006).

Other researchers are investigating methods to identify the parasite in soil and fecal material through molecular techniques that have already proved successful for detection in fish and water (Gates and Guy 2006, Steinbach Elwell et al 2006).

Risk assessments, habitat studies and manipulations continued to be vital research areas in 2006. Hatchery operations were in the spotlight, with a case study from Utah's Springville fish hatchery, where composting provided a valuable disposal option for infected fish (Cavender and Wilson 2006).

LOOKING TO THE FUTURE

Whirling disease is nothing if not complicated. With multiple hosts and parasitic forms, *Myxobolus cerebralis* has introduced new complexities to the management of salmonids in the wild and in hatcheries. Since the parasite first appeared in the United States in 1956, research has advanced significantly, yet the parasite and the disease it causes continues to spread. Each year we add a few more pieces to the puzzle and solve a few more questions.

As time goes by, the perspectives shift. What once was commonly viewed with panic is now more often viewed with resignation. What once was considered solely a fish health issue is increasingly considered in a context with other aquatic nuisance species, gaining attention broadly on a national scale collectively as a major emerging threat.

The full impact of whirling disease in the US may not yet have been observed, nor have all the questions been answered. Meanwhile, through an unprecedented collaboration of scientists, fishery managers, biologists and aquaculturalists, we continue to increase our understanding of the disease biology and develop measures for control and management.

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NEW DIAGNOSTIC TECHNIQUES ARE IMPROVING THE DETECTION OF M CEREBRALIS IN AQUACULTURE AND WILD SETTINGS (WHIRLING DISEASE INITIATIVE)