SALMINCOLA IN COLORADO

(*Salmincola sp.*) Biosheet

Carolyn Gunn, DVM
Aquatic Veterinarian
CPW Aquatic Animal Health Lab

Description:

Salmincola is a crustacean in the Subclass Copepoda which parasitizes salmonids in both free-ranging and hatchery populations in Colorado. They are often called by the common name of gill lice. *Salmincola* is an obligate parasite of fish with no intermediate hosts, but with several stages of development occurring off of the host. The species found in Colorado has not been delineated, with the exception of the population at Crystal River State Fish Hatchery, Poudre River State Fish Hatchery, and Catamount Reservoir (*S. californiensis*). We are currently pursuing identification of species found within the state through the use of DNA studies.

S. californiensis is native to the western United States, but has spread via fish transfers as far east as New Jersey. It has been documented to infest rainbow trout (*Oncorhynchus mykiss*), Chinook salmon (*O. tshawytscha*), lake trout (*Salvelinus namaycush*), Kokanee salmon (*O. nerka*), and cutthroat trout (*O. clarki*) (Hoffman 1999).

Salmincola edwardsii is holarctic in distribution and affects primarily fish in the genus *Salvelinus*, but can infect and has been reported from *O. clarki, O. mykiss, O. nerka*, mountain whitefish (*Prosopium williamsoni*), arctic char (*Salvelinus alpinus*), Dolly Varden (*S. malma*), lake trout, and arctic grayling (*Thymallus arcticus*) (Hoffman 1999).

Salmincola sp. infections of fish are not to be confused with *Nanophytes salmincola.* The latter is a parasitic fluke with a snail being the first intermediate host, salmonid fish being the second intermediate host, and canids, felids, mustelids, bear, and humans as the definitive or final host.

Range in Colorado: Within the CPW State Hatchery system, gill lice were found at Chalk Cliffs State Fish Hatchery in the late 1990s and at the Poudre State Fish Hatchery in 1995 and 2007, and in the Crystal River Hatchery in 2009 and 2012. It has also been found in broodstock fish at several private aquaculture facilities in the state. In free-ranging fish, it has been documented in the Blue River (between Dillon dam and Green Mountain Reservoir, and in the Blue to its confluence with the Colorado River, and downstream to Radium), Rio Grande, Yampa, and Arkansas Rivers; in the South Platte drainages near Jefferson and Evergreen; and the North Fork of the Cache la Poudre River (Walker, 1995). It has been found in the North Fork of the South Platte River and in Eleven Mile, Green Mountain and Gross Reservoirs (Walker, pers. comm.). It is known to have occurred in Woody Creek and the Upper Roaring Fork for 20 years (Walker, pers. comm.). Samples were recently collected from the Colorado River at New Castle. It has also been found in Cheesman Reservoir in kokanee during the spawn (Johnson, pers. comm.), Pinewood and Flatiron Reservoirs (Ingram, pers. comm.) and Williams Fork Reservoir (Ewert, pers. comm.). It was identified in Catamount Reservoir in and in Spinney Mountain Reservoir in 2010 and Stagecoach Reservoir in 2012 (Atkinson, pers. comm.). Specimens collected in 2012 from the Big Thompson River between Estes Park and the base of the canyon in Loveland were heavily infested (Swiggle and Walker, pers. comm.).

Known hosts in Colorado:

In Colorado, *Salmincola* sp. has been found on kokanee salmon and rainbow trout. Although not reported, other fish within the state are susceptible, including those listed above that occur in the state.

Life Cycle:

See attached illustration for *S. californiensis*. Historically, the infective swimming stages were thought to die after about two days without finding a host, but for *S. edwardsii it* was discovered that swimming/infectivity was temperature dependent: at 8°C (46.4°F), the copepodids stopped swimming at day 17; for 12, 16 and 20°C (53.6, 60.8, and 68.0°F), maximum swimming durations were 12, 8 and 5 days, respectively. Onset of egg sac hatching was directly related to increasing water temperatures (Conley and Curtis 1993). It is unknown whether this is true for *S. californiensis* or not.

Epizootiology:

The females, which are very evident to the naked eye, bear two clutches of eggs from each of two egg sacs, and then die (Kabata and Cousens 1973). The entire life cycle can take about 2.5 months, depending on various factors such as water temperature.

Presence and activity of the parasites on gill tissues cause thickening of the upper quarter of the primary lamellae, reduction in length of secondary lamellae, and deformation of the primary lamellar support cartilages (Roberts et al. 2004). In response to the infestation, heavily infected fish develop a tenacious mucoid mass of fibrin and cellular debris on the gill lamellae. In combination with parasite tissues over the gill surface, respiratory function is severely reduced (Roberts 2001) by inhibiting oxygen uptake and gas exchange at the gill lamellae/water surface interface. The problems are exacerbated by high water temperatures and low dissolved oxygen levels. Damaged tissue at the attachment site is also susceptible to invasion by opportunistic bacteria and fungi and fish weakened by heavy infestations may be more likely to succumb to environmental, nutritional or pathogenic diseases.

In the literature, it is often stated that larger, older fish are capable of having heavy infections, possibly due to their continued exposure to the copepods for a longer period of time than younger fish. In some studies, size, rather than age, has been an indicator for heavy infestations. Environmental conditions, such as low flows and high water temperatures have also been implicated in heavy infestations (Horton and Staigmiller 2005). Habitat use patterns have also been implicated in differing infection rates among fish species. The infective stage of one species of *Salmincola* was shown to swim up into the water column and attach to a host when stimulated by shadows or shock waves from passing objects, thereby causing species that use upper portions of the water column to develop heavier infections (Barndt and Stone 2003).

Prevention, control and treatment:

The adult females have an impermeable cuticle rendering them quite resistant to common chemical agents, but larval stages can be killed with some chemical treatments. However, since infective stages continue to be produced, repeated and frequent chemical treatments would be needed to control numbers of infective larvae. Severity of infestation may be decreased by this method.

Prevention: Secure water sources, prevention of introduction of infected fish, and eliminating bird and animal vectors are all first-line prevention measures.

Control: Increased flows to flush free-swimming stages from the fish's environment are often recommended for partial control. Free-swimming stages can be killed by using 166-250mg/L formalin for one hour (Kabata 1970), or by using sodium chloride at 20,000mg/L (duration not given) (Hoffman and Meyer 1974), or with magnesium sulfate immersion at 30,000mg/L plus 7,000mg/L sodium chloride for 5-10 minutes (CVM 2007) Since the adult copepod may remain alive on a fish for 2 months or more, producing two broods/female during that time, treatments to kill free swimming stages are variably effective. Biological control by holding brook trout upstream of rainbow trout effectively removed copepodid larvae from the water and reduced *S. californiensis* infestation in rainbow trout by more than 89% (Modin and Veek 2002). Anecdotal evidence exists that holding Snake River cutthroats upstream of fish achieves the same result, but this has not been proven. A hatchery within the California Department of Fish and Game was treated with 2% NaCl for 24 hours, and they claimed this treatment was successful (Cox, pers. comm.).

Treatment: Currently in the United States there are no Food and Drug Administration-approved drugs available for eliminating *Salmincola sp.* in food fish. Emamectin benzoate (SLICE™) is a pesticide for control of parasitic copepods, but has only been approved in countries other than the US. In 2010, treatment authority was granted to the Investigational New Animal Drug (INAD) Program of the Federal Drug Administration's Center for Veterinary Medicine for use of SLICE™ to control mortality caused by external parasites (copepods) in a variety of freshwater fish species and has been used successfully at one state hatchery. Emamectin benzoate belongs to the avermectin class of chemicals (ivermectins), which are derived from the bacterium *Streptomyces avermitilis*. It kills by interfering with the animal's nervous system.

A 2% NaCl bath for 24 hours used at a production facility was deemed a successful treatment of *Salmincola* (W. T. Cox, California Department of Game and Fish, personal communication).

Of the parasitic copepods *Argulus, Lernaea, Ergasilus*, and *Salmincola*, the latter are reportedly most resistant to chemical treatment. Organophosphates, such as trichlorfon (Dylox® and Masoten®) and growth regulators such as diflubenzuron (Dimilin®) may be effective, but are not approved for use in fish.

Field collection: If a fish is suspected of having gill lice in the mouth, opercular cavity, on the gills, or on other parts of the body such as fin bases, an attempt should be made to collect the entire organism for identification. The adult female attaches to underlying cartilaginous or bony tissue via an attachment organ (bulla), and this structure is important in identifying the parasite species. The bulla is easily destroyed or left behind in the tissues if the gill lice are pulled from the tissues. Therefore, collection of a whole gill arch containing gill lice or removal of a segment of tissue at the attachment point and placing in 70-90% ethanol or isopropyl alcohol will preserve structures for identification. Submit samples to Carolyn Gunn, DVM, P.O. Box 791, 205 South 7th Street, Dolores, CO 81323.

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LIFE CYCLE OF *SALMINCOLA CALIFORNIENSIS*

Eggs hatch after 28-32 days

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Adult female fused to fish for duration of parasite's life. Grows and may have male attached. Each of two vaginal pores receives sperm packet from male. She can produce two broods.

Copepodid stage – active swimmers. Move over surface of fish seeking suitable implantation site and then anchors to host. Molts.

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4th Chalimus female stage. May last 2 weeks. Finds a final attachment site.

1st chalimus stage – lasts about 12 hours

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2nd chalimus stage – lasts about 12 hours

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Adult male – detaches from host and wanders in quest of a female. Becomes attached to genital region of female

3rd chalimus stage – point at which males and females become differentiated. Male stage lasts about 24 hours; female stage lasts about 48 hours

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4th chalimus male stage – lasts about 40 hours; molts into young adult male

Adult female and attachment to gill filament – C. Gunn photo