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Marcy Kamerath
University of Nevada, Reno, mkamerath@cabnr.unr.edu

B. C. Allen
Tahoe Environmental Research Center, University of California–Davis, Incline Village, Nevada, bcallen@ucdavis.edu

S. Chandra
University of Nevada, Reno, sudeep@cabnr.unr.edu

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FIRST DOCUMENTATION OF *SALMINCOLA CALIFORNIENSIS* IN LAKE TAHOE, CA–NV, USA

Marcy Kamerath[1,3], B.C. Allen[2], and S. Chandra[1]

ABSTRACT.—*Salmincola californiensis* is a parasitic copepod in the Lernaeopodidae family that commonly parasitizes salmonid fishes (*Oncorhynchus* spp.) by attaching near the fins and on gill filaments. Historically their distribution was limited to streams that emptied into the Pacific Ocean. During the summer of 2006, several rainbow trout (*Oncorhynchus mykiss*) captured in Lake Tahoe were infested with *S. californiensis.* This is the first known record of *S. californiensis* in Lake Tahoe.

Key words: parasitic copepods, Salmincola californiensis, *fish parasitism, Lake Tahoe, salmonids, salmonid stocking.*

Salmincola californiensis (Dana 1852) is a parasitic copepod belonging to the Lernaeopodidae family, also referred to as the gill maggot (Piasecki et al. 2004). It has 6 stages in its life cycle, with 1 mobile stage in females and 2 in males. Adult females can attach at the base of fins or on gill filaments, forming a bulla from frontal appendages that serve as an anchor (Kabata and Cousens 1973). *Salmincola californiensis* primarily infects salmonid fishes (*Oncorhynchus* spp.), and historically it infected fish in streams emptying into the Pacific Ocean (Piasecki et al. 2004). Hoffman (1984) and Sutherland and Wittrock (1985) documented *S. californiensis* expansion east of the Rocky Mountains and as far east as New Jersey. Haderlie (1953) examined over 2000 fish specimens for parasites and documented 3 types of parasitic copepods in Northern California. He did not detect *S. californiensis* but found a close relative, *S. edwardsii,* on a rainbow trout from the Eel River north of Clear Lake, west of the Sierra Nevada range and the Lake Tahoe Basin. *Lernea carassii* and *Ergasilus* spp. were the other 2 species of parasitic copepods found in Northern California in 1953. In 1959 one unidentified *Salmincola* species was found on a rainbow trout dorsal fin on the east shore of Lake Tahoe near Glenbrook Bay. This appearance occurred shortly after an accidental introduction in Incline Lake north of Lake Tahoe, but no other specimens appeared (Almo J. Cordone, Fisheries Biologist [retired], California Department of Fish and Game, Sacramento, CA, personal communication).

Salmincola californiensis distribution has since expanded to inland waters in California. The species is presently documented in reservoirs of Merced and Tuolumne counties, but its occurrence in Lake Tahoe has not been documented. In 2006 several rainbow trout (*Oncorhynchus mykiss*) with *S. californiensis* attached to their gill filaments were caught in Lake Tahoe by a local angler who subsequently removed 15 parasites from 1 of the trout, froze them, and provided the parasite specimens to us. We preserved the copepod specimens in formalin and sent them to the USGS Great Lakes Science Center (Ann Arbor, MI), where they were identified to species (Patrick T. Hudson, Scientist [emeritus], USGS Great Lakes Science Center, Ann Arbor, MI, personal communication). The angler reported that he did not remove all the parasites from the captured rainbow trout; thus, infection intensity could potentially have been >15 parasites per individual. Also, the same angler estimated that 30% of his *O. mykiss* catch in summer 2006 were infected with parasites morphologically similar to the copepod specimens he provided to us (Chris Wichman, Captain Chris' Fishing Charters, Tahoe City, CA, personal communication).

After initial contact between host and parasite, completion of the parasite's life cycle takes 28–30 days. The parasite makes a

[1]Department of Natural Resources and Environmental Science, University of Nevada, Reno, Limnology Lab, 1000 Valley Road, Mailstop 186, Reno, NV 89512.
[2]Tahoe Environmental Research Center, University of California–Davis, 291 Country Club Drive, Incline Village, NV 89451.
[3]E-mail: mkamerath@cabnr.unr.edu

depression in the host tissue at the attachment site by scraping with the claws on its maxillipeds. It is not uncommon for the parasite to excavate several depressions before selecting a suitable attachment site (Kabata and Cousens 1973). Upon attachment to the host, a female continues to grow and is fertilized when a male becomes attached to her genital area. After fertilization the males are free-swimming and can fertilize other females. Successful reproduction produces free-swimming copepodids that can survive up to 2 days without a host (Kabata and Cousens 1973).

Even though attachment of *S. californiensis* to the host causes damage to the host tissue, the threat of mortality to the fish host is low, if the parasite remains at low densities. Although *S. californiensis* is considered nonpathogenic to humans, fish in infected populations may be at risk of poor health and reduced reproductive output, which ultimately reduce production and economic value of the fishery—two major concerns of fisheries managers and anglers (Modin and Veek 2002). Rainbow trout populations infected with *S. californiensis* at Mt. Shasta, California, exhibited lower egg production than uninfected populations (Gall et al. 1972), and another population experienced extensive damage to gill tissues when 83% of the population was infected with an average of 4.6 copepods per individual (Sutherland and Wittrock 1985). In addition a 6-fold decline in trout production occurred following a heavy infestation (>50 copepods per individual) of parasitic copepods from 1992 to 1997 at a hatchery near Merced, CA. Elevated infection rates were exacerbated by high fish densities in the fish hatchery, whose water source, the Merced River and the upstream reservoir system, was infected with *S. californiensis* (Modin and Veek 2002).

It is possible that *S. californiensis* has infected fish in Lake Tahoe prior to this documentation, because parasitic copepod infestations are an increasing problem in northern California reservoirs (Jay Rowan, Biologist, California Department of Fish and Game, Sacramento, CA, personal communication). A literature review and interviews with fish-and-wildlife management staff failed to find documentation of *S. californiensis* in the Lake Tahoe Basin. While it is possible that the *Salmincola* sp. parasite found in Lake Tahoe in the late 1950s could have been *S. californiensis,* the current infestation of rainbow trout is noteworthy, as many infected fish were observed compared to only one infected fish reported in the 1950s.

The infected fishes that provided the *S. californiensis* samples identified herein were caught from a dock on the northwest shore of Lake Tahoe proximal to the Truckee River outlet dam. The parasitic copepod could have been transported from fish stocked within Lake Tahoe and surrounding waters, including Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) stocked in Fallen Leaf Lake and *O. mykiss* and *O. clarki henshawi* stocked downstream in reservoirs and in the Truckee River, Lake Tahoe's only outflowing stream.

If parasites are being introduced from stocked species, management agencies should be cautioned to monitor for these parasites. If these parasites become common in Lake Tahoe, they are capable of parasitizing lake trout (*Salvelinus namaycush*) and kokanee salmon (*O. nerka*) (Modin and Veek 2002), 2 important recreational fisheries in Lake Tahoe. Largemouth bass (*Micropterus salmoides*), recently established in southern portions of Lake Tahoe, might also be a potential host, as they have been parasitized by copepods in other ecosystems (Hudson and Bowen 2002).

Management agencies should prevent further infestation by conducting a comprehensive screening of fish for parasitic copepods at the gills and fins prior to stocking in the Tahoe Basin and Truckee River watersheds. Furthermore, a program for fisheries should be developed to quickly detect introductions and monitor early population dynamics of parasitic copepods in the Lake Tahoe fishery. The same program could be developed to manage undesirable alternate host species, like largemouth bass, to minimize spread of parasitic copepods. Monitoring activities should especially occur in areas of high fish density. High fish densities increase probability of attachment of the parasite to the host species and can increase infestation prevalence (Modin and Veek 2002). Habitats with high potential host densities include creek mouths during spawning season of *O. nerka* and *O. mykiss,* and the Tahoe Keys and Taylor Creek in summer months when *M. salmoides* populations are at peak densities.

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