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Gill Ectoparasites of Juvenile Rainbow Trout and Brown Trout in the Upper Colorado River

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Abstract.—During 1996 and 1997, 112 rainbow trout *Oncorhynchus mykiss* and 204 brown trout *Salmo trutta,* all young of the year, were sampled from a 40-km study area of the upper Colorado River and were examined for gill parasites. *Ambiphrya, Chilodonella, Ichthyobodo, Apiosoma, Trichodina, Trichodinella, Tripartiella, Epistylis,* and an unidentified cochliopodid amoeba were the representative protozoan genera observed on fish examined. Significant month–year–species interactions ($P = 0.0295$) were revealed, reflecting the changes in infestation prevalence among months, years, and species of salmonid. Greater ectoparasite richness was observed in downstream sections of the study area, most notably near Hot Sulphur Springs, Colorado. Peaks of infestation intensity and ectoparasite richness occurred in August and September of both years, presumably because of high mean water temperatures and low flows during that time.

The health of wild and feral fish populations in the Rocky Mountain west has recently become more important due to the decline or complete loss of year-classes of rainbow trout *Oncorhynchus mykiss* in rivers such as the Madison River in Montana and the upper Colorado River in Colorado. Although these disappearances have been attributed to whirling disease (caused by the myxozoan parasite *Myxobolus cerebralis*), other factors may be contributing to the declines in these fish populations. Preliminary sampling during fall of 1994 and 1995 in the upper Colorado River revealed that several genera of gill ectoparasites were present among fish in the drainage. Evaluations of freshwater protozoan fish ectoparasites in wild salmonid populations have been largely overlooked in the past. Our objectives were to identify genera of gill ectoparasites, quantify the relative number of parasites on juvenile rainbow trout and brown trout *Salmo trutta,* and identify seasonal or species-specific trends that might contribute to the loss of rainbow trout year-classes in the drainage.

Methods

The study area consisted of 40 km of the upper Colorado River starting at Granby Reservoir and extending downstream just past Parshall, Colorado. This reach has been the focus of several years' study of the disappearance of rainbow trout year-classes. Brown trout abundance in the river has not been noticeably affected. Preliminary sampling indicated that rainbow trout fingerlings may be more severely affected than brown trout fingerlings by gill ectoparasites in the drainage (Walker and Nehring 1995).

Young-of-the-year rainbow trout and brown trout were captured and examined at 2–4-week intervals from June through October 1996 and from June through September 1997. On each sampling occasion, two sampling points were randomly chosen from 40 possible locations in the study area. Fish were captured by using a backpack electroshocker set at 150 V pulsed DC current (50% pulse width, 100 Hz). We obtained 68 rainbow trout and 86 brown trout in 1996 and 44 rainbow trout and 88 brown trout in 1997.

Fish were euthanized with an overdose of tricaine methanesulfonate (MS-222) immediately before gill examination. All four gill arches were removed from the right side of each fish, mounted on microscope slides, and examined under 400×

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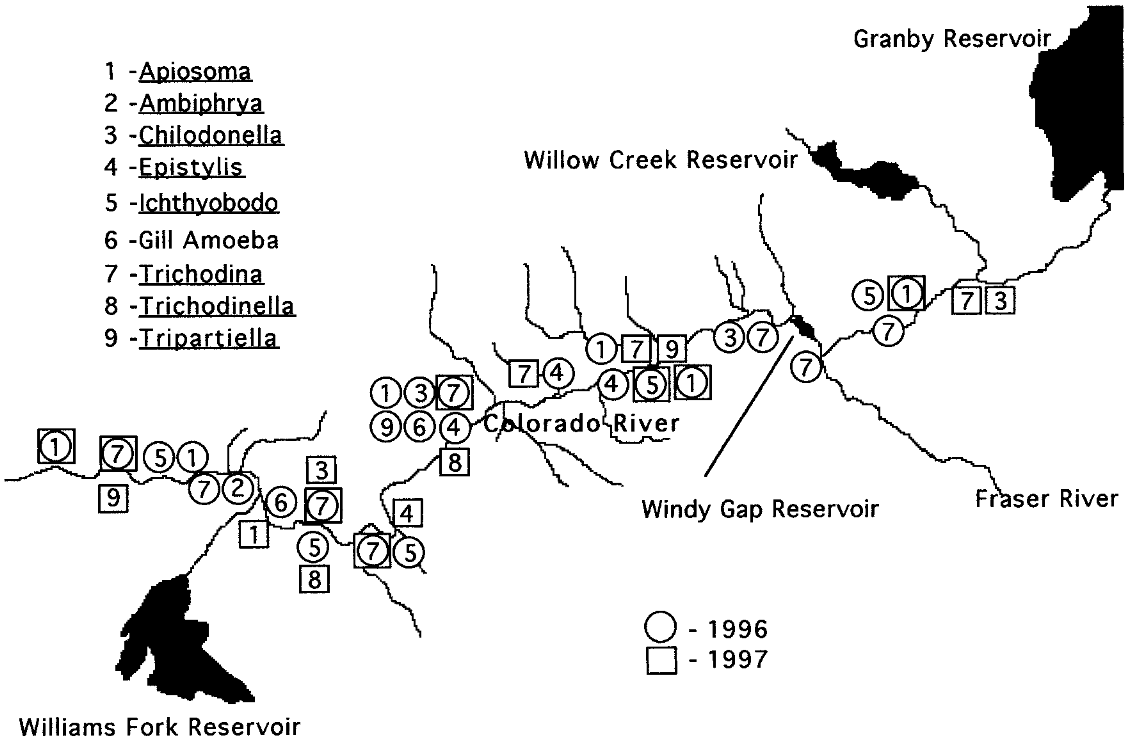

FIGURE 1.—Distribution of ectoparasite genera recovered from young-of-the-year rainbow trout and brown trout in the upper Colorado River during 1996 and 1997.

magnification for presence or absence of protozoans. Protozoans were quantified by recording the total number by genera on 10 randomly chosen gill filaments per arch (40 total filaments per fish). The average number of protozoans per filament was calculated by dividing the total number of protozoans found (per fish) by the number of filaments examined. Relative abundance of each protozoan genus was classified as light, medium, heavy, or none, defined as follows:

none: no protozoans found;

light: mean $\leq$ 0.1 protozoans per filament ($N \leq 4$ individual protozoans);

medium: $0.1 <$ mean < 1 protozoans per filament ($4 < N < 40$ individuals);

heavy: mean $\geq$ 1 protozoan per filament ($N > 40$ individuals).

Logistic regression analysis was used to test the null hypotheses that prevalences of infestations were independent of sampling month, year, and species of fish. Month and year were treated as continuous variables, whereas species of fish was treated as a class variable. Prevalence of infestation by all ectoparasites collectively was used as the response variable.

Results and Discussion

Nine genera of ectoparasites were observed in the drainage during the course of the study. These included *Apiosoma, Ambiphrya, Chilodonella, Epistylis, Ichthyobodo, Trichodina, Trichodinella, Tripartiella*, and an unidentified cochliopodid gill amoeba. Numbers of genera observed throughout the study area varied widely (Figure 1). The greatest richness of ectoparasites in 1996 occurred near Hot Sulphur Springs, where six of eight genera observed that year were found. The lowest richness was observed in the furthest upstream sampling locations; and no ectoparasites were observed above the Willow Creek confluence of the Colorado River. During 1997, ectoparasite prevalence and richness was lower with only seven genera of ectoparasites observed.

A temporal effect on numbers of genera was observed during both years of sampling (Figure 2). Numbers of genera were lowest in June, increased in July and August, and declined in September (and October 1996).

Numbers of infested fish varied widely during the course of both sampling seasons, but trends appearing in the raw data indicated that preva-

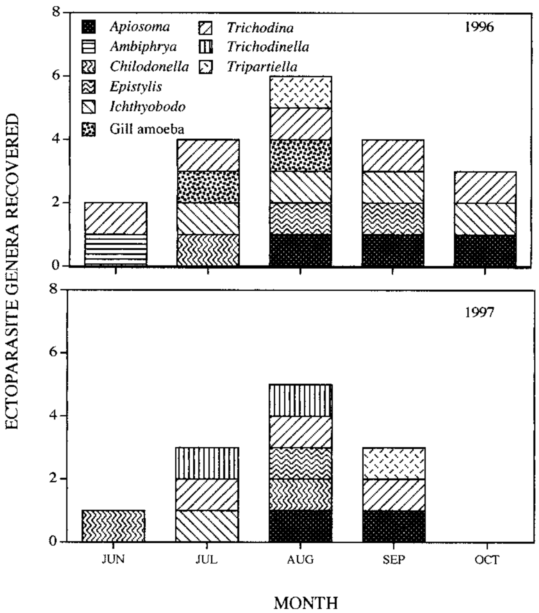

FIGURE 2.—Ectoparasite genera recovered from young-of-the-year rainbow trout and brown trout in the upper Colorado River during 1996 and 1997.

lences of infestations were related to seasonal effects, with higher prevalences occurring in August and September (Figure 3). Apparent differences in infestation between fish species were observed in 1996, with 31.4% of all brown trout ($N = 86$) and 55.9% of all rainbow trout ($N = 68$) infested with at least one genus of ectoparasite. In 1997, the prevalence of infestations on brown trout (18.6 %, $N = 118$) was much closer to the prevalence of infestations on rainbow trout (29.5%, $N = 44$).

When rainbow trout and brown trout data collected in 1996 were separated by species (Figure 3), rainbow trout had a higher prevalence of infestations than did brown trout in August and September. In 1997, prevalence of infestation was higher on rainbow trout than on brown trout in August but not in September.

A significant month–year–species interaction ($P = 0.0295$) was revealed, reflecting the changes in infestation prevalence among months, years, and species of salmonid. Because of the strong interaction effects observed, individual effects were difficult to interpret. As a result, Fisher's exact tests were used to test for differences in infestation prevalence between fish species during each month and year of sampling. The results indicated that ectoparasite infestations occurred on rainbow trout more frequently than brown trout during August of 1996 ($P < 0.0001$). Species differences were not significant for all other months of sampling.

Solitary Ectocommensal Ciliates

Two genera of solitary ectocommensal ciliates were identified among the sampled fish. *Ambiphrya* was observed in a single brown trout sampled 2 km downstream of the Williams Fork River confluence of the Colorado River in June 1996 (Figure 1). *Apiosoma* was observed throughout the drainage in both 1996 and 1997, appearing as a light infestation in 5.2%, medium infestation in 5.8%, and heavy infestation in 1.9% of the fish sampled in 1996. In 1997, this commensal ciliate was identified as a light infestation in 1.9%, medium in 1.2%, and heavy in 1.2% of the fish sampled.

Colonial Ectocommensal Ciliates

Epistylis infestations were observed in the middle sections of the study area, below Windy Gap Reservoir, and at Hot Sulphur Springs in 1996. Infestations were light in four rainbow trout sampled in August and September, and in every case *Apiosoma* was also present on the infested fish. During 1997, light and medium infestations of *Epistylis* were seen on two rainbow trout sampled 5 km above the Williams Fork River confluence in August. These fish were also infested with *Apiosoma.*

Chilodonella

In June 1996 a light *Chilodonella* infestation of one rainbow trout was observed directly below Windy Gap Reservoir, and a medium infestation of another rainbow trout was observed at Hot Sulphur Springs. In 1997 a light infestation of one brown trout was seen above Windy Gap Reservoir, and a medium infestation of one was observed 5 km above the Williams Fork River confluence. Although very few fish were found to be infested during both years of sampling, this ectoparasite is known to cause mass mortality in wild populations (Langdon et al. 1985). Fish dying as a result of infestation by this parasite are unlikely to be sampled.

Ichthyobodo

Ichthyobodo necator occurred as a light infestation in 6.5% of the rainbow trout and brown trout sampled in 1996. It was widely distributed throughout the drainage and was observed from the end of July through October. During 1997 only one light infestation occurred in a single brown trout sampled in August. Ichthyobodiasis has been

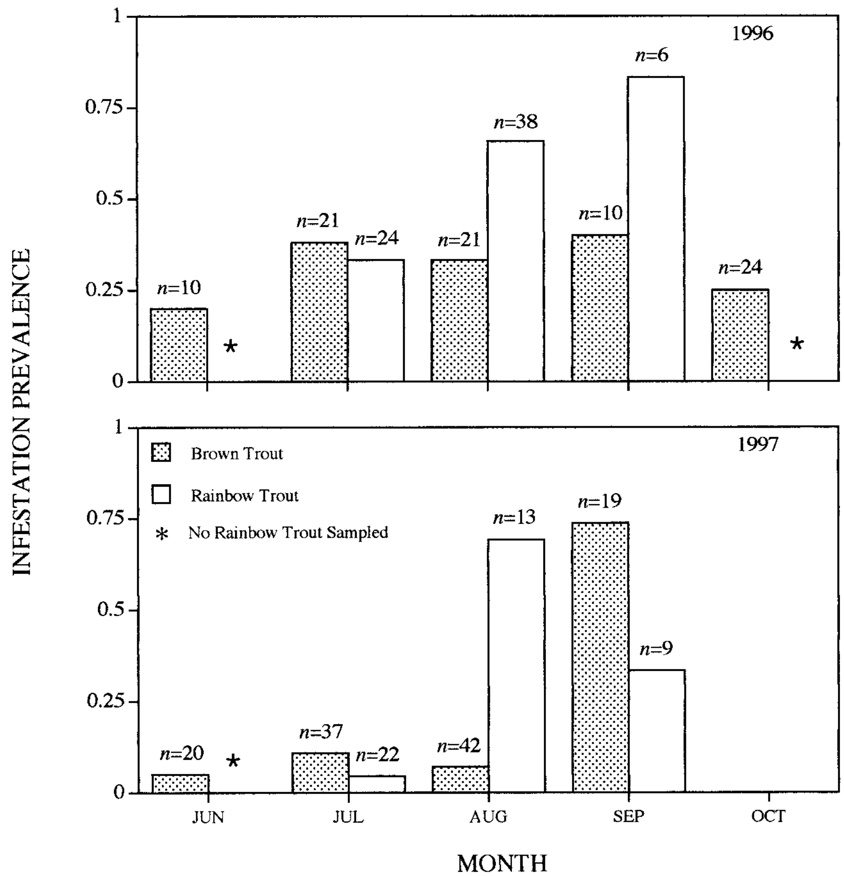

FIGURE 3.—Ectoparasite prevalence on young-of-the-year rainbow trout and brown trout in the upper Colorado River during 1996 and 1997; n = number of salmonids sampled.

shown to cause up to 25% mortality among salmonid fry (Robertson 1979) and is considered a very important pathogen in fish culture.

Gill Amoebas

Infestations by an unidentified cochliopodid gill amoeba were medium in 3.9% and heavy in 1.9% of the individuals sampled in 1996. These were observed only at Hot Sulphur Springs and above the Williams Fork River confluence in July and August. However, preliminary sampling in the late falls of 1994 and 1995 identified the amoeba in locations above Windy Gap Reservoir and below the Williams Fork River confluence. Gill amoebas were associated only with brown trout in 1996 but with both species in 1994 and 1995. No gill amoebas were found among fish sampled in 1997.

Paramoeba sp. was reported by B. L. Munday and others (unpublished, 1988) to cause severe gill disease among saltwater-reared Atlantic salmon *Salmo salar* and rainbow trout in Tasmania. Kent et al. (1988) reported *P. pemaquidensis* infestations of saltwater-reared coho salmon *Oncorhynchus kisutch* in Washington and California. Occurrence of amoeba-like cells associated with nodular gill disease in freshwater-reared rainbow trout were reported by Daoust and Ferguson (1985). *Thecamoeba hoffmani* has been described from fingerling hatchery-reared freshwater salmonids in Washington, Oregon, and Michigan (Sawyer et al. 1974). This protozoan is described as a free-living species that only infests fish gills under suboptimal water quality conditions. Although the specific identity of the amoebae observed in the present study is not known, to our knowledge this is the first diagnosis of a gill amoeba in a wild population of salmonids in the United States.

Trichodina and Tripartiella

Trichodina, the most common gill ectoparasite, was observed on both rainbow trout and brown trout throughout the drainage, occurring as a light infestation in 9.7%, medium in 4.5%, and heavy in 4.5% of the fish sampled in 1996. Light infestations were found in 11.1%, and medium infestations in 1.9% of the fish sampled in 1997. On the basis of gross morphology, *Trichodina* was the only genus for which more than one species was observed. Two or more *Trichodina* species were sometimes observed from the same sampling site and occasionally on the same fish.

Tripartiella was observed near Hot Sulphur Springs on both rainbow trout and brown trout in 1996 as a light infestation in 2.6% of the fish sampled and as a heavy infestation on one fish. It occurred as a light infestation among 3.1% of the fish sampled in 1997. The majority of these infestations were found downstream of the Williams Fork River confluence.

Trichodinella, not observed in 1996, was identified in one heavy and two light infestations near Hot Sulphur Springs during 1997. Four individuals were found with light infestations downstream of the Williams Fork River confluence.

Incidental Fish Sampling

Several species of nonsalmonids were incidentally captured in the study area, including white sucker *Catostomus commersoni,* longnose dace *Rhinichthys cataractae,* speckled dace *Rhinichthys osculus,* fathead minnow *Pimephales promelas,* and mottled sculpin *Cottus bairdi.* Ectoparasites were found in the majority (64%) of these fish. Although the sample size was quite small (N = 14), infestations among these fish appeared to be much more frequent and severe than among rainbow trout and brown trout fingerlings. It is possible that these fish are reservoirs of infestation for young-of the year salmonids.

Conclusions

Ectoparasites found among fish in this study are commonly associated with poor water quality, high organic loads, or crowded conditions when found in fish culture operations. The differences in genera composition and temporal variation of ectoparasites in the study area indicate that infestation by these organisms in wild fish populations is a dynamic process. Environmental conditions, opportunities for transmission, and the health of potential hosts all play a role in this process. Water temperatures in the upper Colorado River are greatest in August and September, corresponding closely with greatest ectoparasite abundance. Low flows during this time of year may exacerbate the problem either by forcing fish into closer proximity to each other or by reducing water velocities that may otherwise help rid fish of ectoparasites. Infection rates by *M. cerebralis* are higher and overt clinical signs of whirling disease among young-of-the-year rainbow trout and brown trout are more prevalent during late summer months in the Colorado River (G. J. Schisler and others, unpublished observations). Weakening of *M. cerebralis*-infected fish may make them more likely than healthy fish to become infested with ectoparasites.

This study indicates that gill ectoparasites are relatively common among young-of-the-year trout in the upper Colorado River. Although gill ectoparasites may contribute to the loss of some individual fish, they do not appear to be abundant enough to explain the total collapse of rainbow trout year-classes observed in this reach of the Colorado River. However, they may contribute to mortality of *M. cerebralis*-infected rainbow trout. Examinations of wild and feral fish in more pristine habitats and establishment of baseline infestation rates in other drainages are needed to improve our understanding of the dynamics of ectoparasites in wild and feral populations and their potential role in the survival of salmonids.

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