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## NOTE ON MORTALITY OF THE EMERGING STONEFLY *PTERONARCYS CALIFORNICA* ON THE JOCKO RIVER, MONTANA, USA

Isaac P. Rockwell<sup>1</sup> and Robert L. Newell<sup>2</sup>

**ABSTRACT.**—Cold air temperatures may have killed several emerging nymphs and adult *Pteronarcys californica* on the Jocko River, Montana. Some aquatic insect taxa emerge early on the Jocko River, likely due to warm water temperatures in winter and spring. At this location, *P. californica* emerges approximately 5–7 weeks earlier than it does on many other streams or rivers across the United States. We hypothesize that this earlier emergence may be a mortality factor when cold fronts cause air temperatures to drop below freezing. Other mortality factors are also discussed.

*Key words:* *Pteronarcys californica*, salmonfly, emergence, freezing, mortality, Jocko River, Montana.

The giant stonefly *Pteronarcys californica* Newport ranges throughout the Mountain and Pacific Northwest (Baumann et al. 1977, Stewart and Stark 2002) and usually lives in large streams and rivers with loose, unconsolidated substrates and swift currents (Elder and Gaufin 1973). Newell and Minshall (1979) reported the species from several small Idaho streams. Older larvae and adults often weigh in excess of 1 g and reach lengths of over 5 cm (Poole 1981, Townsend and Pritchard 1998). Whereas Sheldon (1999) and DeWalt and Stewart (1995) reported mortality of newly emerged adults of this aquatic insect, they dealt primarily with predation by birds. Jay Sumner (Montana Peregrine Institute, personal communication) reported Peregrine Falcons (*Falco peregrinus*), Red-tailed Hawks (*Buteo jamaicensis*), American Kestrels (*Falco sparverius*), and Common Ravens (*Corvus corax*) hawking *Pteronarcys* over the Blackfoot and Gallatin rivers. Muttkowski (1925) reported predation by birds, snakes, frogs, spiders, and ground squirrels. In this note we report that freezing temperatures may also kill newly emerged adult *Pteronarcys*.

We made our observations during a study on the influence of water temperatures on the growth and emergence of *Pteronarcys californica* on the Jocko River, which is located in northwestern Montana on the Flathead Indian Reservation in Sanders County, 47°19'N, 114°18'W. The river has a drainage area of 984 km<sup>2</sup> and an average annual discharge of 229 cfs or 6.5 cubic meters per second (USGS

2008a). Elevations range from over 2134 m at the headwaters to 762 m at the confluence with the Flathead River. The annual hydrograph for the Jocko River is typical of snowmelt-dominated systems and generally exhibits one peak-flow period that occurs during May or June. In 2007 a thermograph that was deployed in the lower Jocko River showed a low temperature of –0.1 °C in January and a high temperature of 20.8 °C in July (C. Barfoot unpublished data).

On other rivers in Montana, Idaho, Colorado, and Alberta, *Pteronarcys* emerges from late May to early June (Poole 1981, DeWalt and Stewart 1995, Townsend and Pritchard 1998, Sheldon 1999, Gregory et al. 2000), but on the Jocko River it emerges 5–7 weeks earlier—from early April through early May. Newell and Minshall (1979) have one aberrant report of *Pteronarcys* emerging from a small stream in Idaho in March, but in their study the majority emerged in May and June.

We hypothesize that the earlier emergence on the Jocko River is a consequence of relatively warm thermal regimes during winter and spring. The lower Jocko River is warmer at that time because there are abundant groundwater inputs that elevate water temperatures (Barfoot personal communication). Gregory et al. (2000) found a similar pattern with the Henry's Fork Catchment in Idaho. There, *Pteronarcys* nymphs experiencing a higher water temperature in April due to groundwater inputs emerged earlier than those experiencing a lower temperature.

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We compared water temperatures and *Pteronarcys* emergence times on Rock Creek, another western Montana stream that lies 50 air miles southeast of the Jocko River. Rock Creek is similar in size to the Jocko River and is subject to similar weather patterns. Yet on the Jocko River, *Pteronarcys* emerges from early April to mid-May, while on Rock Creek it emerges from late May to early June (Sheldon 1999). While summer water temperatures on the 2 streams are similar—accumulated degree days for the period 1 June–31 August 2000 were 1407 on the Jocko River (Barfoot unpublished data) and 1387 on Rock Creek (USGS 2008b)—winter and spring water temperatures on the Jocko are much warmer. In 2000, the most recent water year for which there are complete water temperature data for both streams, the accumulated degree days for the period 1 December–30 April were 829 for the Jocko River and 473 for Rock Creek.

Though winter and spring water temperatures may be warmer on the Jocko River than on other waterways, early emergence times increase the chances that emerging Jocko River *Pteronarcys* will encounter below-freezing air temperatures.

From 1 April 2008 to 10 May 2008, we placed emergence traps (Sheldon 1999) along a 0.3-km stretch of stream 1.25 km from the river's mouth and checked them daily. On 4 April we observed the first *Pteronarcys* emerging, and over the next 15 days we observed 5 additional individuals that emerged. The mean minimum air temperature for these days was  $-1.7^{\circ}\text{C}$ . The mean water temperature over the same period was  $7.9^{\circ}\text{C}$  (Barfoot unpublished data). On 20 April a cold front moved in and the minimum air temperature dropped to  $-10.0^{\circ}\text{C}$  (unpublished data from a local farm). The mean water temperature that day was  $5.2^{\circ}\text{C}$ . We found only a single, fully emerged dead adult *Pteronarcys* in one of our traps. The next day, when the minimum temperature was  $-8.0^{\circ}\text{C}$  and the mean water temperature was  $5.9^{\circ}\text{C}$ , we found another 2 dead stoneflies, both partially emerged with only a portion of their bodies outside of the exuviae. On 22 April the minimum air temperature was  $-6.0^{\circ}\text{C}$ , and the mean water temperature was  $6.5^{\circ}\text{C}$ . That day we found a fourth stonefly that was dead. Only one of the dead stoneflies was found in an emergence trap. Aside from the cold air temperatures, there was no other

apparent cause of death for any of these individuals, and we did not capture any live stoneflies during those 3 days. On 23 April the air temperature increased to  $-2.0^{\circ}\text{C}$  and the cold front ended. Thereafter, we did find 3 dead stoneflies outside of the traps during the 40 days the traps were deployed. One of these was an adult and the other 2 were in the process of emerging. All 3 were being mobbed by wood ants (*Formica* spp.). While we cannot be absolutely sure about the cause of death, it appeared to be the ants. We frequently observed common garter snakes (*Thamnophis sirtalis*), as many as 5 at a time, basking at a bridge abutment where many stoneflies emerge, but we did not observe predation by these snakes. We did not find any other dead individual *Pteronarcys* for the remainder of the emergence period, which ended on 9 May. Overall, we found 203 stoneflies over a 34-day emergence period. The peak emergence date was 3 May.

We hypothesize that the exceptionally early emergence period on the Jocko River may have contributed to an isolated occurrence of *Pteronarcys* mortality from exposure to cold air temperatures—a phenomenon that to our knowledge has not previously been reported for this species. Another potential contributing factor to what we assume to be temperature-related mortality is the fact that these stoneflies emerge mainly at night (Sheldon 1999) when temperatures are generally lowest. Winter stoneflies such as *Taenionema pacificum* and arctic species (Stewart et al. 1990) have evolved a defense against subzero temperatures.

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