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Short Communication

Rapid range expansion of rusty crayfish *Orconectes rusticus* (Girard, 1852) in the John Day River, Oregon, USA

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Abstract

The rusty crayfish, *Orconectes rusticus* (Girard, 1852), native to the eastern U.S., was discovered west of the Rocky Mountains in the John Day River in Oregon in 2005. In the five years since then, the known range of *Orconectes rusticus* has more than doubled to 145 river km along the mainstem of the river and populations have achieved high densities in several locations. To arrive at this estimate, the present study employed commercial crayfish traps, D-frame kick nets, and snorkel surveys to assess crayfish communities in the upper John Day basin. Natural dispersal, multiple introductions, a more thorough survey of the study area, or a combination of these factors could account for the expansion of the known distribution *O. rusticus* within the basin. The limit of *O. rusticus* expansion in the John Day River and broader Columbia River Basin, and the likely consequences for invaded ecosystems remain to be resolved.

Key words: rusty crayfish, distribution survey, Columbia River basin

The native crayfish fauna west of the Rocky Mountains is depauperate, with five species from a single genus, a stark contrast to the 358 native species east of the Rockies (Taylor et al. 2007). Human activity has begun to decrease this diversity gradient; at least six extra-regional crayfish species have already become established in the states of Oregon and Washington (Larson and Olden 2011). One invader notable for aggressive range expansion and broad ecological effects elsewhere in North America (e.g. Taylor and Redmer 1996; Hamr 2010) is the rusty crayfish, *Orconectes rusticus* (Girard, 1852), first recorded along 64 river km of the John Day River, Oregon in 2005 (Olden et al. 2009).

Orconectes rusticus is native to the lower Ohio River basin (Taylor et al. 1996), from where it has expanded across the eastern U.S. and Canada (e.g. Momot 1997; Olden et al. 2006; Hamr 2010). Introduction of *O. rusticus* has caused population declines and local extirpation of native species in Midwest lakes (Capelli 1982; Olsen et al. 1991), and *O. rusticus* is known to hybridize with congeneric crayfish (Perry et al. 2001). In addition to their impact on native crayfishes, *O. rusticus* invasion is often associated with declines in macrophytes, snails, and fishes (Lodge and Lorman 1987; Olsen et al. 1991; McCarthy et al. 2006; Roth et al. 2007). Bait bucket release by anglers has been a main driver of *O. rusticus* range expansion east of the Rockies (DiStefano et al. 2009), but release of live crayfish provided to schools may account for their presence in the John Day River (Larson and Olden 2008).

Given the invasion history of *O. rusticus* and its well-documented impacts on aquatic food webs, monitoring and control efforts have been recommended (Larson and Olden 2011). To that end, one objective of our study was to elaborate on the known range of *O. rusticus* in the John Day basin (Olden et al. 2009; Larson and Olden 2011). Our intent is to establish a baseline for management decisions and as a guide for future research into the effects of a changing crayfish fauna on fish and invertebrates in invaded areas.

All sampling took place between May 7 and November 14, 2010 (Appendix 1). Sites were selected from available public access points to provide data spread widely throughout the basin. The upper mainstem was emphasized, because previous surveys (Olden et al. 2009) found that *O. rusticus* had initially established there. Traps, kick netting, and manual searches were

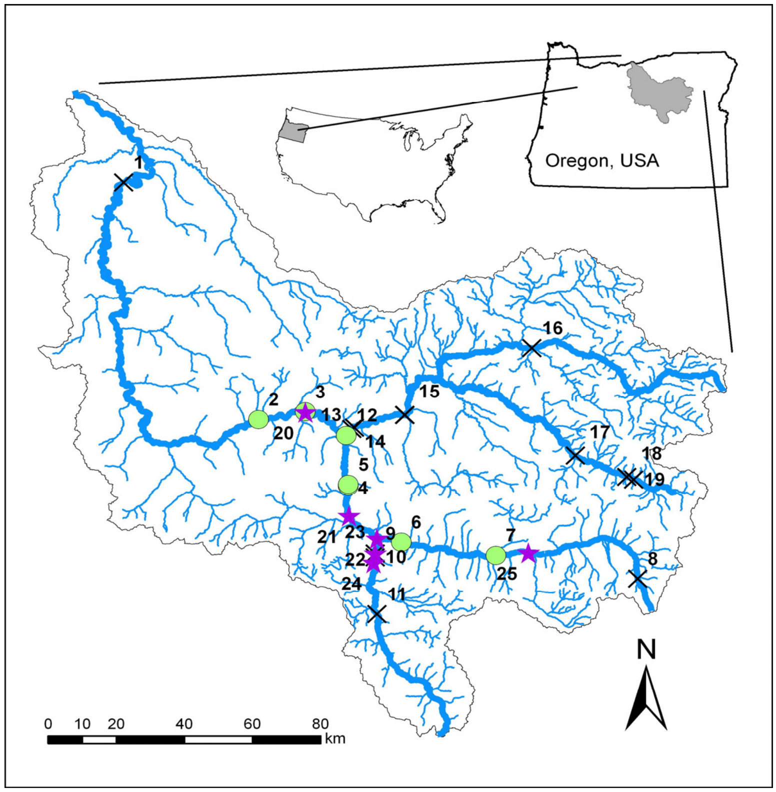

Figure 1. Distribution of *Orconectes rusticus* in the John Day basin. Circles represent sites with *O. rusticus* present, and X symbols indicate that *O. rusticus* was not found at a sampled site. Locations reported by Larson and Olden (2011) are indicated with stars. Site numbering corresponds with Appendix 1.

employed, as detailed below. Presence or absence of crayfish was assessed, and trap catch per unit effort (CPUE) data and the results of manual searches are reported in Appendix 1. Coordinates of occurrences from a contemporaneous survey by ER Larson and JD Olden (unpublished data) are also included in Figure 1 and Appendix 1.

Commercial crayfish traps were baited with beef or pork liver, weighted with rocks, and fished overnight 16–24 hours (cf. Olsen et al. 1991).Traps were fished in sets of three with traps 3 to 4 meters apart, to increase the chance of catching crayfish when crayfish were present. Two sets of three traps were fished at each site sampled.

A manual search protocol was also used at many sites (Appendix 1). Searching began with 30 minutes of netting with a D-frame kick net (1.2 mm mesh size, 30.5 cm mouth). In many sampled reaches, all habitat was accessible to kick netting, but at downstream sites where the channel was deeper, only habitat that could be accessed by wading was kick netted. Kick netting was especially suited to cobble substrates small enough to be easily moved, but was also effective at capturing crayfish in sandy or muddy habitat. Most habitat in the sampled reaches of the John Day River was cobble, typical of the river overall (K. Sorenson, personal observation).

If no crayfish were captured with kick nets, an hour of snorkel searching commenced. Full snorkel surveys were only conducted at sites visited in summer months, when flows were low and water clarity was good. Surveys were conducted during the day. Snorkelers moved downstream, patrolling from bank to bank, turning over cobble and attempting to capture any crayfish encountered. If both traps and snorkel surveys were used to assess a site, the snorkel survey took place after retrieving the traps.

Orconectes rusticus were present and abundant in reaches from Clyde Holliday State Park to the John Day Fossil Beds Sheep Rock unit, where they were found in 2005 (Olden et al. 2009). We found *O. rusticus* as far downstream on the mainstem as the Muleshoe recreation area (Appendix 1, Figure 1), further than reported by Larson and Olden (2011). Densities (CPUE) were very low toward the downstream limit of our survey, even though we were consistently able to sample in cobble habitat, the preferred substrate of *O. rusticus* (e.g. Hill and Lodge 1994; Taylor and Redmer 1996). At the downstream end of our survey, where river volume was greatest, cobble habitat was also available at greater depths than we could sample efficiently. We may therefore have underestimated the abundance of *O. rusticus* at downstream sites. However, *O. rusticus* abundance has been shown to correlate negatively with water depth (Jansen et al. 2009), so our methods were likely to detect *O. rusticus* in reaches where they were present.

The full extent of the *O. rusticus* invasion in the John Day River is hard to quantify with certainty, but if the first record of *O. rusticus* distribution (Olden et al. 2009) captures their previous extent, it is unlikely that they have reached the mainstem of the Columbia River. The absence of *O. rusticus* in the shallows near Cottonwood Bridge (Figure 1, Appendix 1) observed by us is therefore not surprising. Based on the difference in the 2005 distribution reported by Olden et al. (2009) and our results from 2010, we estimate the downstream rate of spread of *O. rusticus* in the John Day River to be as great as 13.5 km/year.

Our estimate is much greater than previously published rates for *O. rusticus*; in streams in Ontario, *O. rusticus* advanced only 3.7 km/year downstream (Momot 1997). In a Wisconsin lake, Wilson et al. (2004) found *O. rusticus* had spread 0.68 km/year through the littoral zone. Olden et al. (2009) report declining catches toward the downstream limit of their survey, but do not report sampling reaches where *O. rusticus* were entirely absent, so it is possible our estimate is influenced by increased search effort. However, the rate calculated by this study is not outside the range of published values for other invasive crayfishes, with spread rates of *Orconectes limosus* in the Danube River estimated between 13 and 16 km/year (Pucky and Schad 2006), and *Pacifastacus leniusculus* spreading faster than 18 km/year in the Drava River, Croatia (Hudina et al. 2009). Furthermore, both Olden et al. (2009) and the present survey (Appendix 1) report declining catches toward the downstream limits surveyed, suggesting that the distance between records of *O. rusticus* in 2005 and 2010 is an adequate proxy for actual distribution.

The specific mechanisms of such a rapid range expansion are currently unknown. In a plexiglass laboratory flume, adult *O. rusticus* are known to hold their position in water flowing 40 cm/s (Maude and Williams 1983). Small crayfish are even better able to avoid entrainment in the water column, in part because they can use smaller substrates as refuge from hydraulic stress (Clark et al. 2008). While crayfish are benthic organisms that respond to high flows by flattening themselves to the substrate and moving upstream to seek refuge from hydraulic stress (Maude and Williams 1983; Clark et al. 2008), crayfish movements downstream are less controlled than upstream movements at high flows (Clark et al. 2008), and *O. rusticus* in particular has been reported to expand many times faster downstream than upstream (Momot 1997). All estimated rates of crayfish spread pale in comparison to passive transport; if the average current in the John Day were only 0.5 m/s (an underestimate for spring high flows, Sorenson et al., unpublished data), it would take only approximately 36 hours for a passive particle to drift from the previously known extent of *O. rusticus* invasion to that found in our survey.

While biophysics sets the theoretical upper bound for involuntary crayfish transport, crayfish behavior as a benthic organism likely provides the actual constraints on dispersal. *Orconectes rusticus* may engage in downstream migration to seek deeper pools in winter (Buric et al. 2009a), as mate-seeking behavior (Buric et al. 2009b), or as a density-dependent response to competition. As *O. rusticus* frequently mature at age 0+ (Hamr 2002), any migrating individuals could potentially breed in their first year, increasing the odds of establishment in new stream reaches. Multiple introductions of *O. rusticus*, either as bait-bucket releases from the popular smallmouth bass fishery (DiStefano et al. 2009) or from school aquaria (Larson and Olden 2008) are also a possible dispersal mechanism.

Our study of *Orconectes rusticus* in the John Day basin is ongoing. Further research is needed to better define the distributions and abundances of the invasive *O. rusticus* and the native crayfish *Pacifastacus leniusculus*, as well as competitive interactions between the two species throughout the John Day basin. The North Fork of the John Day River appears to remain uninvaded by *O. rusticus*, and continued monitoring there could help in predicting rates of upstream spread relevant to other tributaries of the Columbia River. In addition, the potential effects of crayfish replacement on macroinvertebrate communities and native fish (e.g., salmonid) populations deserves research and management attention.

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Supplementary material (Appendix 1: Table of sites sampled) is available as part of online article from:
http://www.aquaticinvasions.net/2012/Supplements/AI_2012_2_Sorenson_etal_Supplement.pdf