Pacific Northwest Invasive Species Profile:

Virile/northern crayfish, *Orconectes virilis*

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Figure 1. Virile/northern crayfish, *Orconectes virilis*.

Diagnostic Information

Classification

Order: Decapoda

Family: Cambaridae

Genus: *Orconectes*

Species: *O. virilis*

Common names: Virile crayfish, northern crayfish

Identification Key

The virile crayfish (*Orconectes virilis*) is a typically olive-brown colored freshwater crayfish with large broad flattened chelae (claws) (WDFW 2009). It can grow to 5 inches total body length. The unique identifying characteristic of *O. virilis* is that its chelae have yellow tuberculations (bumps) (Loughman 2010, Figure 2). The chelae can be blue or green, and have orange tips.

Figure 2. *O. virilis* chelae. (WDFW 2009)

Life-history and basic ecology

Life cycle

O. virilis mate in late summer or autumn. The onset of the breeding season is indicated by the presence of Form 1 males when they molt from their non-reproductive form (Form 2) to their reproductive form (Form 1). In their native range, in Michigan and in northwestern Ontario, this molting occurs from July-September (Weagle and Ozburn 1972, Momot 1967). but the timing varies with temperature and with latitude. For instance, in their introduced range in Arizona, males molt to Form 1 in September-October because this region has a later autumn season (Rogowski et al. 2013).

During mating males use their gonopods, which are modified swimming appendages, to transfer sperm to the females. Females retain the sperm until they are ready to lay their eggs, which occurs in the spring (Momot 1967). In a sheltered place, the females shed their eggs, release the stored sperm to externally fertilize the eggs, and then attach the eggs to their swimmerets with a substance called glair. Females have on average 150-200 eggs (Momot 1967; Rogowski et al. 2013). Females generally stay in places of refuge to protect their eggs (Rogowski et al. 2013), but continue to feed (Momot 1967). During the spring, males molt back to their non-reproductive form.

Eggs hatch in 1 to 2 months depending on temperature conditions and the newly hatched first-instar juveniles stay attached to the mother while they undergo two molts. Recently hatched juveniles resemble miniature versions of adults but without hard exoskeletons. When they reach the third-instar, free-swimming stage after 1-2 weeks, they leave their mother. There is high survival from eggs to the free-swimming juvenile stage because of the female's parental care (Rogowski et al. 2013).

The juveniles continue to develop and molt as they grow larger. *O. virilis* has moderate growth rates, compared to other similar species (Bovbjerg 1970). They molt around five times during their first summer and around 3-4 times during their first year of life, but in their second and third years they only molt once or twice (Weagle and Ozburn 1972).

O. virilis generally become sexually mature during their second summer (Momot 1967). Males molt back and forth between their reproductive and non-reproductive forms each year. Mortality rates are higher during molting periods, because individuals are vulnerable while their exoskeleton hardens (Momot 1967). One study found that mortality is highest in the middle of the second year for females, and in the middle of the third year for males (Momot 1967). This suggests that females may be more likely to die after their first reproductive season. The average lifespan is 3 years, though some can live to age 4 (Momot 1967).

Feeding habits

O. virilis are nocturnal and generally feed at night. They are opportunistic omnivores that have been observed to eat periphyton, detritus, carrion and smaller conspecifics (Loughman 2010). Their generalist diet is one trait that makes them an effective invasive species.

Reproductive strategies

Males and females are very active in search of mates during the mating season (Rogowski et al. 2013). Males exhibit competition for mates, which is why the male reproductive form has larger claws, a longer body, more spines, and a tougher exoskeleton than its non-reproductive form. Females provide parental care for offspring, by bearing the eggs and live young (Figure 3).

Figure 3. Crayfish bearing live hatchlings. Source: http://www.thefishsite.com/articles/832/crawfish-biology

Environmental optima and tolerances

The activity level of *O. virilis* greatly decreases and molting stops under conditions of cold temperature around 10-13°C during the winter (Momot 1967; Rogowski et al. 2013). In a laboratory experiment, *O. virilis* seemed to show a preference for temperatures around 24°C (Peck 1985).

O. virilis is also sensitive to conditions of low pH, because physiological stress from acidic conditions can interfere with the hardening of the carapace after molting (Schindler and Turner 1982). At a pH of 5.8 to 6, populations of *O. virilis* greatly declined primarily due to high egg mortality (Schindler and Turner 1982).

O. virilis is not tolerant of low oxygen conditions (Bovbjerg 1970). Other crayfish species burrow under conditions of low oxygen when the water level is low, but *O. virilis* is a tertiary burrower, meaning that they only make shallow burrows for refuge and for when females lay their eggs (Loughman 2010). This limitation may exclude *O. virilis* from habitats that experience summer drying (Bovbjerg 1970).

O. virilis are susceptible to poor water quality and heavy metal toxins (Mirenda 1986). Water pollution has led to local reductions in fecundity in some areas (IUCN 2010).

O. virilis prefer low or moderate-velocity habitat, since in experiments they cannot hold their position well under conditions of high-velocity (Maude and Williams 1983).

Biotic associations (pathogens, parasites, and commensals)

O. virilis is a carrier of the crayfish plague, *Aphanomyces astaci* (Ahern et al. 2008). *A. astaci* is an oomycete, or water mold, endemic to North America that parasitizes freshwater crayfish and eventually leads to death. North American crayfish species like *O. virilis* have developed defense responses to the parasite, but European crayfish species experience death within weeks of infection. Protozoan parasites

Thelohania spp. also infect *O. virilis* and rates of infestation increase under conditions of acidification (Schindler and Turner 1982).

Current geographic distribution

Distribution in the PNW and the United States

O. virilis has one of the largest natural ranges of all North American crayfishes (Lodge et al. 2000). It is found in Canada in Alberta, Manitoba, Ontario, Québec, and Saskatchewan (IUCN 2010), and also has a wide natural distribution in the northern, central US (Figure 4). It has since invaded many areas in the western and eastern US (Figure 4).

O. virilis may be the most widely invasive crayfish species in the Pacific Northwest, as it is found in Washington, Idaho, Montana, and California (Larson and Olden 2011).

History of invasiveness

In the US, *O. virilis* were reported in areas such as Maryland and West Virginia in the 1960s though invasion my have occurred earlier than that (Kilian et al. 2010). *O. virilis* was first found in Washington in 2006 (Larson and Olden 2011). This introduction may have been from natural dispersal of *O. virilis* from introduced populations in Montana (Larson and Olden 2011). *O. virilis* was found in the UK in 2004, and has also been found in the Netherlands (Ahern et al. 2008). It also invaded Mexico, France and Sweden (IUCN 2010).

Invasion process

Pathways, vectors and routes of introduction

O. virilis was introduced into the Pacific Northwest through several different pathways. It was introduced into California from escapes from a laboratory pond, while it was deliberately stocked in Utah and Montana as forage for warmwater fishes (Larson and Olden 2011). In other parts of the US, *O. virilis* has mainly been introduced through baitfish bucket releases from anglers (Loughman and Welsh 2010; Kilian et al. 2010). In the UK and the Netherlands, the introduction of *O. virilis* was most likely due to releases of aquarium pets (Ahern et al. 2008).

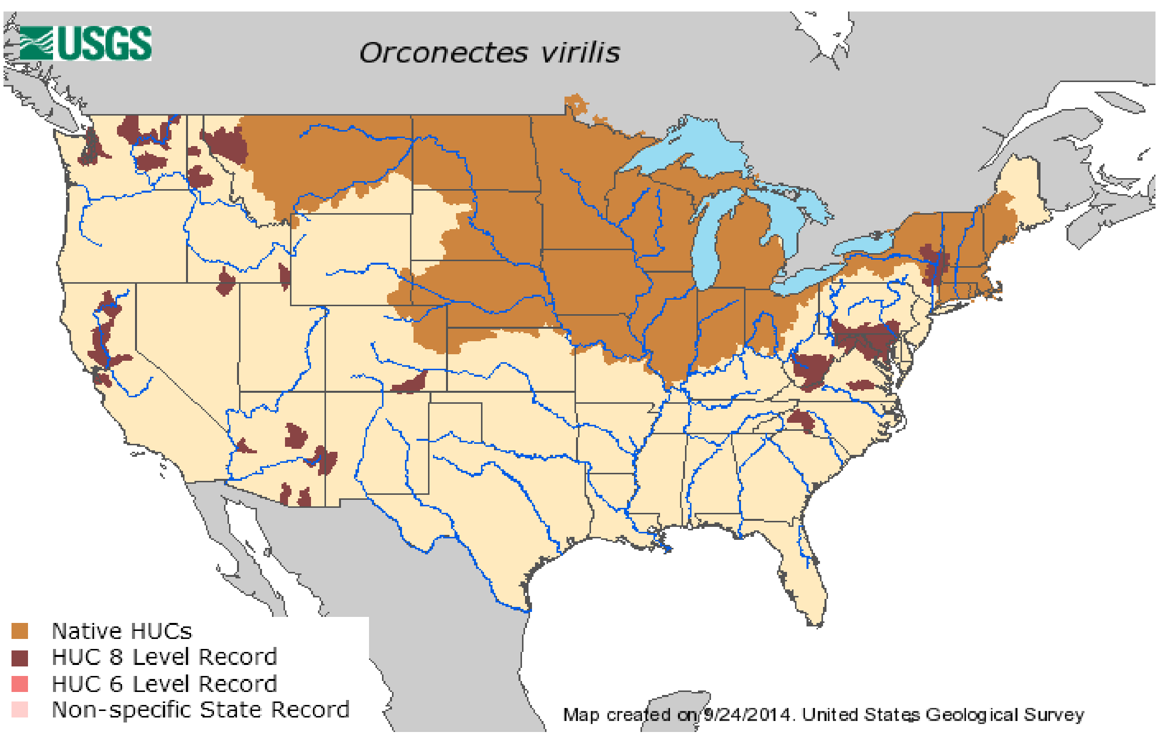

Figure 4: Native and introduced distribution of *O. virilis* in the US. Source: USGS.

Factors influencing establishment and spread

Environmental factors may limit the establishment of *O. virilis*. They are less likely to establish in places with winter water temperatures below 10°C, low oxygen conditions, low pH, or poor water quality. They are also less likely to establish in bodies of water that experience summer drying periods because they are not primary burrowers (Bovbjerg 1970). Overall though, their wide natural distribution indicates that *O. virilis* generally has wide environmental tolerances, making it likely to be able to establish in a wide variety of environments.

Spread of *O. virilis* occurs at short and long-distance ranges. Short-distance spread may be limited because, unlike the rusty crayfish *O. rusticus*, *O. virilis* is not able to hold its position in high-velocity microhabitats (Maude and Williams 1983) and may have limited ability to spread in regions with high gradient streams such as West Virginia (Loughman and Welsh 2010). The spread of *O. virilis* in such regions is more likely from long-distance transfers from anglers releasing unused live bait (Kilian et al. 2010). However, in less high-velocity waters, *O. virilis* could presumably spread far through natural movements. A recent study using radio transmitters indicated that *O. virilis* could move 500 m per month in the River Lee in the UK.

Potential ecological and/or economic impacts

O. virilis displaces native crayfish species, through competitive exclusion or disease transmission (Lodge et al. 2000, Kilian et al. 2010). Observational evidence suggests that the virile crayfish is more aggressive than native crayfish and monopolize refuge habitat (Loughman and Welsh 2010). They also compete for food with native crayfish, and are able to kill competitors (Loughman 2010). In the UK, the invasive signal crayfish, *Pacifastacus leniusculus*, and *O. virilis* are both vectors of the crayfish plague that has severely decimated native crayfish populations (Ahern et al. 2008).

This ecological impact of *O. virilis* is augmented because *O. virilis* are able to thrive in disturbed ecosystems because they are able competitively exclude native crayfishes for refugia (Loughman and Welsh 2010). In West Virginia, one study found that only *O. virilis* were present in homogenized stream habitats, while in streams with multiple macrohabitats, the native *O. obscurus* crayfish could coexist with *O. virilis* (Loughman 2010). Thus, habitat degradation can enhance the negative ecological impact of *O. virilis* on native crayfishes.

O. virilis can also have effects on native fish populations. Studies have shown that *O. virilis* can compete with native fishes for food (Carpenter 2005, Rogowski and Stockwell 2006). In their native range, *O. virilis* feeds on fish eggs and can negatively affect fish reproductive success (Dorn and Mittelbach 2004), though we do not know if this potential effect is occurring in its introduced range. In some cases, *O. virilis* can augment the ecological impacts of another invasive species. For example, in a desert river in Colorado, *O. virilis* competed with native fishes for food, and also was able to resist the predation of invasive smallmouth bass, such that the smallmouth bass increasingly preyed on native fishes (Martinez 2012). *O. virilis* has such a dynamic trophic role that it has the ability to alter food webs by consumption of macrophytes and other invertebrate

Management strategies and control methods

The main management strategy applied to *O. virilis* is to try to contain its spread. Managers are trying to limit its availability in bait stores, pet stores, and biological supply companies (Lodge et al. 2000). In some states, it is illegal to transport *O. virilis* across watersheds though it is still allowed in pet stores and as bait (Kilian et al. 2010). Effective containment cannot be achieved unless *O. virilis* is no longer allowed to be used as live bait.

Other control methods attempt to trap *O. virilis* to control populations densities, especially during important times such as the autumn breeding season when *O. virilis* is especially active (Rogowski et al. 2013).

Current research is focusing on trying to learn more about the life history of *O. virilis* in order to improve the timing of control (Rogowski et al. 2013).

Literature cited

Adams S, Schuster GA, Taylor CA (2010) *Orconectes virilis.* The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>

Ahern D, England J, Ellis A (2008) The virile crayfish, Orconectes virilis (Hagen, 1870) (Crustacea: Decapoda: Cambaridae), identified in the UK. Aquat Invasions 3:102–104. doi: 10.3391/ai.2008.3.1.18

Kilian J V., Becker AJ, Stranko S a., et al. (2010) The Status and Distribution of Maryland Crayfishes. Southeast Nat 9:11–32. doi: 10.1656/058.009.s302

Larson ER, Olden JD (2011) The state of crayfish in the Pacific Northwest. Fisheries 36:60–73.

Loughman ZJ (2010) Crayfishes of western Maryland: conservation and natural history. Southeast Nat 9:33–62.

Loughman ZJ, Welsh SA (2010) Distribution and conservation standing of West Virginia crayfishes. Southeast Nat 9:63–78.

Martinez P (2012) Invasive crayfish in a high desert river: Implications of concurrent invaders and climate change. Aquat Invasions 7:219–234. doi: 10.3391/ai.2012.7.2.008

Maude S, Williams D (1983) Behavior of crayfish in water currents: hydrodynamics of eight species with reference to their distribution patterns in southern Ontario. Can J Fish Aquat Sci 40:68–77.

Momot WT (1967) Population dynamics and productivity of the crayfish, Orconectes virilis, in a marl lake. Am Midl Nat 78:55–81.

Peck S (1985) Effects of Aggressive Interaction on Temperature Selection by the Crayfish, Orconectes virilis. Am Midl Nat 114:159–167.

Rogowski DL, Sitko S, Bonar S a. (2013) Optimising control of invasive crayfish using life-history information. Freshw Biol 58:1279–1291. doi: 10.1111/fwb.12126

Weagle KV, Ozburn GW (1972) Observations on aspects of the life history of the crayfish, *Orconectes virilis* (Hagen), in northwestern Ontario. Canadian Journal of Zoology 50:366-370. doi: 10.1139/z72-053

Other key sources of information and bibliographies (web sites)

Brief Guide to Crayfish Identification in the Pacific Northwest:

http://www.fish.washington.edu/research/oldenlab/pdf/Guide%20to%20Crayfish%20Identification%20(Dec2009).pdf

Invasive Crayfish in the Pacific Northwest

http://pubs.usgs.gov/fs/2011/3132/