***Orconectes rusticus*** 正體中文

**System:** Freshwater

| Kingdom | Phylum | Class | Order | Family |
|---|---|---|---|---|
| Animalia | Arthropoda | Malacostraca | Decapoda | Cambaridae |

**Common name** rusty crayfish (English)

**Synonym**

**Similar species** *Orconectes virilis, Orconectes propinquus, Orconectes immunis, Orconectes luteus*

**Summary** *Orconectes rusticus*, the rusty crayfish, is an aquatic invasive spread by anglers who use them as bait. It is native to the portions of Ohio, Indiana, Illinois, and Kentucky and has spread to surrounding areas as well as northeastern United States. *O. rusticus* is an aggressive and rapidly spreading crayfish that displaces cogeners, reduces macrophyte and invertebrate abundance, preys on native snails, and reduces sport fish populations.

view this species on IUCN Red List

**Species Description**
*Orconectes rusticus* is a relatively large crayfish that may reach 10 cm in length and has robust claws and dark, rusty spots on either side of its carapace (Gunderson, 2008; USGS, 2010). The rusty spots are usually prominent and appear on each side of the posterolateral margins of the carapace but are reported to be not always present or well developed on rusty crayfish from some waters. A rust-colored band also appears dorsally down the center of the abdomen. Overall *O. rusticus* has a aquamarine, greenish color that is most pronounced on the walking legs (Wetzel *et al*, 2004; Gunderson, 2008). Its claws are grayish-green to reddish-brown with black bands at the tips and fairly smooth (Gunderson, 2008; ANSIS, 2007). Form I males are characterized by large claws, a hook on one pair of their legs, and hardened gonapods. The hook and the larger claws are used for grasping females during mating. Males are usually larger than females of the same age (Gunderson, 2008).

**Lifecycle Stages**
The eggs of *Orconectes rusticus* hatch within three to six weeks depending on water temperature. Once hatched, young crayfish cling to the female's swimmerets for three to four molts. Young crayfish may stay with the female for several weeks. Juveniles undergo eight to ten molts before they mature, which may occur during the first year, but more often take two. *Orconectes rusticus* reaches maturity at a total length of 3.5 cm and reach a maximum length of about 10 cm. A typical rusty crayfish lives three to four years. A mature adult male molts twice a year and a female molts once hence why males of the same age are usually larger (Gunderson *et al*, 2008).

**Uses**
*Orconectes rusticus* is a commonly used live fishing bait. The majority of its introductions are believed to be the result of their intentional or unintentional release as such (Olden *et al*, 2009; Perry *et al*, 2001; Peters & Lodge, 2009). *O. rusticus* preys on a reduces populations of the invasive zebra mussel *Dreissena polymorpha* (Perry *et al*, 1997; Perry *et al*, 2000).

**Habitat Description**
*Orconectes rusticus* inhabits permenant lotic and lentic environments of lakes, ponds, and streams that provide suitable water quality year-round (Gunderson, 2008). Suitable substrates include clay, silt, sand, gravel, or rock, but *O. rusticus* is almost always found in areas with cobble and carbonate substrates and occasionally found in habitats with gravel substrate and woody debris (Kershner & Lodge, 1995; Flynn & Hobbs, 1984; Taylor & Redmer, 1996; Gunderson, 2008). *O. rusticus* prefers well oxygenated water and a temperature range of 20-25°C but can withstand seasonal water temperatures of 0-39°C within its native range. In temperatures over 30°C, adults have been observed digging burrows to escape the heat (ANSIS, 2007). Systems with cobble abundance may be more susceptible to invasion. *O. rusticus* is most often found in depths of less than 1 m but has been collected to a depth of 14.6 m in Lake Michigan (Taylor & Redmer, 1996).

**Reproduction**
*Orconectes rusticus* reproduces sexually and oviparously. Mating typically occurs in the fall and eggs are laid in the spring, but mating is reported to also occur in late summer, early spring (USGS, 2010; Gunderson *et al*, 2008). Males transfer sperm to the female who stores the sperm until the eggs are laid, which usually occurs in the spring when water temperatures rise. The eggs are externally fertilized by the female and attached to the swimmerets on the underside of the female's abdonmen. *O. rusticus* females lay from 80 to 575 eggs (Gunderson, 2008). Since females store sperm, only one female carrying sperm is necessary to begin a new population (Gunderson, 2008; USGS, 2010).

**Nutrition**
*Orconectes rusticus* feed heavily on benthic invertebrates like mayflies, stoneflies, midges, side-swimmers, aquatic worms, leeches, snails, clams, crustaceans, waterfleas, fish eggs, and small fish (Roth *et al*, 2006; Gunderson, 2008). They are larger, attain higher population densities, and have higher metabolisms than most crayfish causing them to feed more. Researchers estimate that *O. rusticus* consumes twice food as a similar sized *O. virilis*. *O. rusticus*, especially juveniles, are primarily predators but do supplement their diet with detritus and plant material (Roth *et al*, 2006).

**General Impacts**
*Orconectes rusticus* has a range of ecological impacts on introduced environments that include competition and displacement of native crayfish, increased predation on snails, native and threatened bivalves, reduction of macrophyte abundance, reduction of sport-fish abundance, reduction of macroinvertebrate abundance, increases in periphyton activity, and other cascading trophic interactions. The wide range of impacts associated with *O. rusticus*, its aggressive nature, rapid expansion rates, dense populations, and ability to spread through bait trade make it a very problematic aquatic invasive.
*O. rusticus* aggressive nature, greater fitness, and large chelae and body size allow it to displace native crayfish from food and habitat (Byron & Wilson, 2001; Garvey *et al*, 2003; Garvey & Stein, 1993; Hill & Lodge, 1999; Klocker & Strayer, 2004). Displacement from food causes reduced fitness to its cogeners and displacement from habitat increases predation pressure (Hill & Lodge, 1994). *O rusticus* displaces native crayfish, *O. virilis*, and previous invader, *O. propinquus*, from lakes throughout northern Wisconsin (Byron & Wilson, 2001; Garvey & Stein, 1993; Hill & Lodge, 1994). Along with direct competition and displacement, research indicates that fish and other predators avoid *O. rusticus* because of its larger chelae and body size and this selective predation pressure is likely an important driver in the replacement of crayfish species by rusty crayfish (Roth & Kitchell, 2005; DiDonato & Lodge, 1999). *O. rusticus* is known to hybridize with native crayfish *O. propinquus* in Lake Michigan (Jonas *et al*, 2005). In northeastern United States, *O. rusticus* may pose a threat to native crayfish *O. limosus*, which it was found to dominate in shelter competition and aggression trials (Klocker & Strayer, 2004).
Rusty crayfish prey on threatened, native bivalves in northeastern United States. Although native crayfish also prey on these bivalves, *O. rusticus* can live at very high densities so the threat of increased predator populations can harm already threatened unionid populations (Klocker & Strayer, 2004; Kuhlmann & Hazelton, 2007). *O. rusticus* also preys on snails and in Trout Lake, Wisconsin snails declined from >10 000 to <5 snails•m2 in one of the initially invaded areas (Wilson *et al*, 2004). Relative to control treatments, rusty crayfish were found to reduce the biomass of northeastern US native *Lymnaea* and *Physa* snails by >90% (Johnson *et al*, 2009). Furthermore, *O. rusticus* has been found to co-occur with *Bellamya chinensis*, an invasive snail with a thick shell that prevents predation by *O. rusticus*, in northern temperate lakes throughout the United States. The predation pressure of *O. rusticus* on native snail communities combined with competition and displacement by the *B. chinensis* has resulted in the reduction of native snail biomass (Johnson *et al*, 2009).
The reduction of macrophyte abundance is another important impact of *O. rusticus*. Small-scale, comparative, and multi-lake studies confirm that macrophyte species richness and abundance decline significantly in lakes invaded by *O. rusticus* (Alexander *et al*, 2008; Rosenthal *et al*, 2006; Roth *et al*, 2007; Wilson *et al*, 2004). In northern Wisconsin, studies found the proportion of sites with no macrohpyte cover to increase from 40-73% (Roth *et al*, 2007), and submerged macrophyte species richness to decline by as much as 80% with the invasion of *O. rusticus* (Wilson *et al*, 2004).
*O. rusticus* introduction is also believed to reduced sport fish populations especially pan-fish *Lepomis macrochirus* and *L. gibbossus* by either egg predation or competition with juveniles. Researchers have calculated fisheries damages of *O. rusticus* in Vilas County, Wisconsin to be about 1.5 million annually (Keller *et al*, 2008).
Additional cascading ecological impacts have been associated with *O. rusticus*. Decreasing macroinvertebrate densities and increasing periphyton productivity have been found to correlate with increasing *O. rusticus* densities (Charlebois & Lamberti, 1996). In Trout Lake, Wisconsin, mean abundance of Odonata, Amphipoda, and Trichoptera decreased significantly lake-wide with the invasion of *O. rusticus* (Wilson *et al*, 2004).

**Management Info**

Preventative measures: Educating anglers, crayfish trappers, bait dealers, teachers, and the general public about the ecological threats posed by *Orconectes rusticus* will help reduce the risk of its spread to new areas (Olden *et al*, 2006). Monitoring boat docks, fishing areas, or setting up check points in order to halt the use of *O. rusticus* as bait may also be effective in preventing their establishment (Keller *et al*, 2008). Regulations in both Minnesota and Wisconsin now make it illegal to introduce *O. rusticus* into any waters. In Minnesota, it is illegal to sell live crayfish as bait and a Department of Natural Resources permit is required to commercially harvest or culture crayfish (Gunderson, 2008). Regulations regarding *O. rusticus* in other states differ depending on state and vector. Many states have regulations that specifically targeted the invasive rusty crayfi sh. However, these regulations were enacted reactively only after rusty crayfi sh had become established in the state. The lack of regulatory consistency among the Great Lakes jurisdictions is creating a multiple weak links problem and making success unlikely in efforts to slow the spread of *O. rusticus* and other invasive species throughout the region (Peters & Lodge, 2009). In Wisconsin, it is illegal for anglers to possess any crayfish. In Pennsylvania it is illegal for anglers to possess, aquarists to raise, and bait dealers or pet traders to sell *O. rusticus*. In Ohio, it is illegal to move crayfish from a natal lake in or for aquarists to rear *O. rusticus*. In Michigan, it is illegal for bait dealers and pet traders to sell and for aquarists to rear *O. rusticus*. In Illinois, it is illegal for anglers to possess, bait shops to sell, and for aquarists to rear *O. rusticus*. In Ontario, it is illegal move crayfish from a natal lake and for bait dealers to sell crayfish (Peters & Lodge, 2009)\n

Physical: Intensive harvest will not eradicate or control crayfish, but may help reduce adult populations and minimize some impacts.

\nSome researchers have suggested that nuisance populations of rusty crayfish are the result of poor fishery management and that by restoring a healthy population of bass and sunfish, *O. rusticus* would be less disruptive in some lakes.

Populations of *Orconectes rusticus* may be reduced by trapping or fish predation. Although neither practice may provide eradication both have been found to be effective means of reducing negative impacts and decreasing population sizes of *O. rusticus* (Hein *et al*, 2006; Hein *et al*, 2007). The use of electric fences along with hand removal in experimental plots was also found to reduce densities of *O. rusticus* and may have implications for macrophyte restoration efforts (Peters *et al*, 2008).

The control of a rusty crayfish population in Sparkling Lake, an isolated lake in northern Wisconsin by trapping adult crayfish and restricting fishing, thereby increasing fish populations and predation on small crayfish was found to effectively reduce *O. rusticus* populations there. To protect and enhance populations of rusty crayfish predators, the Wisconsin Department of Natural Resources instated strict regulations on smallmouth bass. Also, wire minnow traps with an enlarged (3.5 cm diameter) opening were baited with 4 to 5 frozen smelt (8–13 g each), set 1–2 m deep at ~10 m intervals, and used to capture *O. rusticus*. Over a 3 year period, traps and predatory fishes removed substantial portions of the rusty crayfish population. Because more crayfish were vulnerable to and removed by fish predation than by trapping, fish predation caused a larger decline in the population growth rate. However, trapping removed crayfish with the highest reproductive value and caused the largest decline in population growth rate per individual crayfish removed. Researchers estimated that traps and fish removed a total of 1,212,148 individuals and 1212 kg of crayfish over three years of removal. Together they removed approximately 55% of the population in 2003 (Hein *et al*, 2006). Removal trapping catch rates declined by 95% over the last 4 years of removal from Sparkling Lake (Hein *et al*, 2007). Trapping was found to be most effective on cobble substrates (Hein *et al*, 2006). A similar trapping study of *O. rusticus* found that captured individuals left in traps excluded uncaptured individuals from entering traps (Ogle & Kret, 2008).

The experimental use of electric fencing along with hand removal were able to significantly reduce *O. rusticus* densities in electric plots compared to non-electric control plots in Lake Ottawa, located in the Ottawa National Forest, Michigan. Macrohpytes *Potamogeton richardsonii* and *Elodea canadensis* were eliminated within a matter of days in the control plots and within 3 wk in the electric plots (Peters *et al*, 2008).

Chemical: There are means of chemical control for *Orconectes rusticus*. However, none currently registered have been found to selectively kill *O. rusticus* without effecting other species of crayfish (Gunderson, 2008). An evaluation of several potential chemical controls found a synthetic pyrethroid (Baythroid) at 25 .mu.g/L was most effective and produced a complete kill of crayfish in the pond and was also the most selective for crayfish in laboratory tests (Bills & Marking, 1992). High, sub-lethal concentrations of metolachlor (80 ppb) may interfere with the ability of *O. rusticus* to receive or respond to social signals and thus affect certain agonistic behavior, implications may be useful to its management (Cook & Moore, 2008).

**Pathway**
*Orconectes rusticus* have reportedly been intentionally released in some locations in efforts to control nuisance weeds (Olden *et al*, 2009).*Orconectes rusticus* is transported and traded as a pet (Peters & Lodge, 2009).*Orconectes rusticus* is used as a laboratory species for school science programs. Local and national biological supply companies are known to ship live *O. rusticus* to schools for study (Olden *et al*, 2009).

**Principal source:**

**Compiler:** National Biological Information Infrastructure (NBII) & IUCN/SSC Invasive Species Specialist Group (ISSG)

**Review:** Dr. Brian Hazlett. Department of Ecology and Evolutionary Biology, University of Michigan, Ann Arbor. USA

**Pubblication date:** 2010-07-21

**ALIEN RANGE**

**[2]** CANADA
**[1]** LAKE MICHIGAN
**[1]** FRANCE
**[22]** UNITED STATES

**Red List assessed species 13: EN = 1; NT = 4; LC = 8;**

Cambarus bartonii **LC**
Cambarus reduncus **LC**
Fallicambarus fodiens **LC**
Fallicambarus macneesei **LC**
Fallicambarus petilicarpus **EN**
Orconectes margorectus **NT**
Orconectes virilis **LC**
Cambarus lenati **NT**
Cambarus robustus **LC**
Fallicambarus harpi **NT**
Fallicambarus oryktes **NT**
Orconectes luteus **LC**
Orconectes obscurus **LC**

**BIBLIOGRAPHY**
**77** references found for **Orconectes rusticus**

**Managment information**
Aquatic Nusiance Species Information System (ANSIS), 2007. Species Profiles: *Orconectes rusticus* - Rusty Crayfish
**Summary:** Available from: http://el.erdc.usace.army.mil/ansrp/ANSIS/ansishelp.htm#html/orconectes_virilis_northern_crayfish.htm [Accessed 13 February 2010]
Bills T. D; Marking L. L., 1992. Control of Nuisance Populations of Crayfish with Traps and Toxicants. Progressive Fish-Culturist. 50(2). 1988. 103-106.
Bowen, Debbie 2003. *Rusty Crayfish Factsheet*. Minnesota Sea Grant.
**Summary:** Available from: http://www.seagrant.umn.edu/exotics/rusty.html [Accessed 26 October]
Byron, Carrie J.; Wilson, Karen A., 2001. Rusty crayfish (*Orconectes rusticus*) movement within and between habitats in Trout Lake, Vilas County, Wisconsin. ournal of the North American Benthological Society. 20(4). December, 2001. 606-614.
Hein, Catherine L.; Roth, Brian M.; Ives, Anthony R.; Vander Zanden, M. Jake, 2006. Fish predation and trapping for rusty crayfish (*Orconectes rusticus*) control: a whole-lake experiment. Canadian Journal of Fisheries & Aquatic Sciences. 63(2). FEB 2006. 383-393
Hein, Catherine L.; Vander Zanden, M. Jake; Magnuson, John J., 2007. Intensive trapping and increased fish predation cause massive population decline of an invasive crayfish. Freshwater Biology. 52(6). JUN 2007. 1134-1146.
Keller, Reuben P.; Frang, Kristin; Lodge, David M., 2008. Preventing the spread of invasive species: Economic benefits of intervention guided by ecological predictions. Conservation Biology. 22(1). FEB 2008. 80-88.
Kluza, Daniel A. 2004. Emerging threats: Potential geographic distributions of temperate aquatic invasive species. In Abstracts: 13th International Conference on Auatic Invasive Species, September 20-24, 2004. Lynch West County Hotel, Ennis, County Clare, Ireland.
**Summary:** Using a computer based model to help predict possible global distributions of invasive species.
Momot, Walter T., 1992. Further range extensions of the crayfish *Orconectes rusticus* in the Lake Superior basin of northwestern Ontario. Canadian Field-Naturalist. 106(3). 1992. 397-399.
Ogle, Derek H.; Kret, Lori, 2008. Experimental evidence that captured rusty crayfish (*Orconectes rusticus*) exclude uncaptured rusty crayfish from entering traps. Journal of Freshwater Ecology. 23(1). MAR 2008. 123-129.
Peters, Jody A.; Lodge, David M., 2009. Invasive Species Policy at the Regional Level: A Multiple Weak Links Problem. Fisheries (Bethesda). 34(8). AUG 2009. 373-381

Puth, Linda M.; Allen, T. F. H., 2005. Potential corridors for the rusty crayfish, *Orconectes rusticus*, in northern Wisconsin (USA) lakes: Lessons for exotic invasions. Landscape Ecology. 20(5). JUL 2005. 567-577.
Rosenthal, Sadie K.; Stevens, Samantha S.; Lodge, David M., 2006. Whole-lake effects of invasive crayfish (*Orconectes* spp.) and the potential for restoration. Canadian Journal of Fisheries & Aquatic Sciences. 63(6). JUN 2006. 1276-1285.
Taylor, Christopher A.; Redmer, Michael, 1996. Dispersal of the crayfish *Orconectes rusticus* in Illinois, with notes on species displacement and habitat preference. Journal of Crustacean Biology. 16(3). 1996. 547-551.
Usio, N.; Nakata, Kazuyoshi; Kawai, Tadashi; Kitano, Satoshi, 2007. Distribution and control status of the invasive signal crayfish (*Pacifastacus leniusculus*) in Japan. Japanese Journal of Limnology. 68(3). DEC 2007. 471-482.

**General information**

Acquistapace, Patrizia; Hazlett, Brian A.; Gherardi, Francesca, 2003. Unsuccessful predation and learning of predator cues by crayfish. Journal of Crustacean Biology. 23(2). May 2003. 364-370.
Alexander, Mara L.; Woodford, Michele P.; Hotchkiss, Sara C., 2008. Freshwater macrophyte communities in lakes of variable landscape position and development in northern Wisconsin, USA. Aquatic Botany. 88(1). JAN 2008. 77-86.
Benson, Amy and Fuller, Pam 1999. *Nonindigenous Crustaceans in the United States*. Florida Integrated Science Center, U.S.Geological Survey.
**Summary:** Available from: http://cars.er.usgs.gov/posters/Nonindigenous/Nonindigenous_Crustaceans/nonindigenous_crustaceans.html [Accessed 26 October 2010]
Bobeldyk, Angela M.; Lamberti, Gary A. 2008. A decade after invasion: Evaluating the continuing effects of rusty crayfish on a Michigan river. Journal of Great Lakes Research. 34(2). JUN 2008. 265-275.
Capelli, Gregory M., 1982. Displacement of Northern Wisconsin Crayfish by *Orconectes rusticus* (Girard). Limnology and Oceanography, Vol. 27, No. 4 (Jul., 1982), pp. 741-745
Charlebois, Patrice M.; Lamberti, Gary A, 1996. Invading crayfish in a Michigan stream: Direct and indirect effects on periphyton and macroinvertebrates. Journal of the North American Benthological Society. 15(4). 1996. 551-563.
Cook, Michelle E.; Moore, Paul A. 2008. The effects of the herbicide metolachlor on agonistic behavior in the crayfish, *Orconectes rusticus*. Archives of Environmental Contamination & Toxicology. 55(1). JUL 2008. 94-102.
Cooper, John E.; Armstrong, Suzanne A., 2007. Locality records and other data for invasive crayfishes (Decapoda : Cambaridae) in North Carolina. Journal of the North Carolina Academy of Science. 123(1). SPR 2007. 1-13.
Delivering Alien Invasive Species Inventories for Europe (DAISIE), 2006. Species Factsheet *Orconectes rusticus*
**Summary:** Available from: http://www.europe-aliens.org/speciesFactsheet.do?speciesId=53408# [Accessed 13 February 2010]
Didonato, Guy T.; Lodge, David M., 1993. Species replacements among *Orconectes* crayfishes in Wisconsin lakes: The role of predation by fish. Canadian Journal of Fisheries & Aquatic Sciences. 50(7). 1993. 1484-1488.
Drury, Kevin L. S. & David M. Lodge, 2009. Using mean first passage times to quantify equilibrium resilience in perturbed intraguild predation systems. Theor Ecol (2009) 2:41–51
Ellrott, Brian J.; Marsden, J. Ellen; Fitzsimons, John D.; Jonas, Jory L.; Claramunt, Randall M., 2007. Effects of temperature and density on consumption of trout eggs by *Orconectes propinquus* and *O. rusticus*. Journal of Great Lakes Research. 33(1). MAR 2007. 7-14.
Fitzsimons, John D.; Williston, Bill and Fodor, Georgina 2004. An assessment of the direct and indirect impacts of aquatic invasive species on lake trout restoration in the Great Lakes. In Abstracts: 13th International Conference on Aquatic Invasive Species, September 20-24, 2004. Lynch West County Hotel, Ennis, County Clare, Ireland.
**Summary:** Impacts of some invasive species on native species within the Great Lakes.
Flynn M. F; Hobbs H. H III., 1984. Parapatric Crayfishs in Southern Ohio USA Evidence of Competitive Exclusion. Journal of Crustacean Biology. 4(3). 1984. 382-389.
Fullerton, Aimee H.; Watson, Brian T., 2001. New distributional records for two nonindigenous and one native crayfish in North Carolina. Journal of the Elisha Mitchell Scientific Society. 117(1). Spring, 2001. 66-70
Garvey, James E.; Rettig, Jessica E.; Stein, Roy A.; Lodge, David M.; Klosiewski, Steven P., 2003. Scale-dependent associations among fish predation, littoral habitat, and distributions of crayfish species. Ecology (Washington D C). 84(12). December 2003. 3339-3348.
Garvey, James E.; Stein, Roy A., 1993. Evaluating how chela size influences the invasion potential of an introduced crayfish (*Orconectes rusticus*). American Midland Naturalist. 129(1). 1993. 172-181.
Garvey, James E.; Stein, Roy A.; Thomas, Heather M., 1994. Assessing how fish predation and interspecific prey competition influence a crayfish assemblage. Ecology (Tempe). 75(2). 1994. 532-547.
Gherardi, Francesca, 2006. Bioinvasions in fresh waters and the Nero dilemma. Polish Journal of Ecology. 54(4). 2006. 549-561.
Gunderson, J. 2008. Rusty Crayfish: A Nasty Invader. Minnesota Sea Grant.
**Summary:** Available from: http://www.seagrant.umn.edu/ais/rustycrayfish_invader [Accessed 17 June 2010]
Hayes, Nicole M.; Butkas, Katrina J.; Olden, Julian D.; Vander Zanden, M. Jake, 2009. Behavioural and growth differences between experienced and naive populations of a native crayfish in the presence of invasive rusty crayfish. Freshwater Biology. 54(9). SEP 2009. 1876-1887.
Hazlett, Brian A.; Acquistapace, Patrizia; Gherardi, Francesca, 2003. Differences in memory capabilities in invasive and native crayfish. Journal of Crustacean Biology. 22(2). May, 2002. 439-448
Hill, Anna M.; Lodge, David M., 1994. Diet changes in resource demand: Competition and predation in species replacement among crayfishes. Ecology (Tempe). 75(7). 1994. 2118-2126.
Hill, Anna M.; Lodge, David M., 1999. Replacement of resident crayfishes by an exotic crayfish: The roles of competition and predation. Ecological Applications. 9(2). May, 1999. 678-690.
Hill, Ann M.; Sinars, Damon M.; Lodge, David M., 1993. Invasion of an occupied niche by the crayfish *Orconectes rusticus*: Potential importance of growth and mortality. Oecologia (Heidelberg). 94(3). 1993. 303-306

ITIS (Integrated Taxonomy Information System), 2002. *Orconectes rusticus (Girard, 1852)* Integrated Taxonomic Information System [Online Database].
**Summary:** Available from: http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=97424 [Accessed 26 October 2003]
Jezerinac, Raymond F.; Stocker, G. Whitney; Tarter, Donald C., 1996. The crayfishes (Decapoda: Cambaridae) of West Virginia. Bulletin of the Ohio Biological Survey. 10(1). 1995. I-X, 1-193.
Jezerinac R. F., 1986. Endangered and Threatened Crayfishes Decapoda Cambaridae of Ohio USA. Ohio Journal of Science. 86(4). 1986. 177-180.
Johnson, Pieter T. J., Julian D. Olden, Christopher T. Solomon and M. Jake Vander Zanden, 2009. Interactions among invaders: community and ecosystem effects of multiple invasive species in an experimental aquatic system. Oecologia (2009) 159:161-170
Jonas, Jory L.; Claramunt, Randall M.; Fitzsimons, John D.; Marsden, J. Ellen; Ellrott, Brian J., 2005. Estimates of egg deposition and effects of lake trout (*Salvelinus namaycush*) egg predators in three regions of the Great Lakes. Canadian Journal of Fisheries & Aquatic Sciences. 62(10). OCT 2005. 2254-2264.
Kershner, Mark W.; Lodge, David M., 1995. Effects of littoral habitat and fish predation on the distribution of an exotic crayfish, *Orconectes rusticus* Journal of the North American Benthological Society. 14(3). 1995. 414-422.
Klocker, Carolyn A.; Strayer, David L., 2004. Interactions among an invasive crayfish (*Orconectes rusticus*), a native crayfish (*Orconectes limosus*), and native bivalves (Sphaeriidae and Unionidae). Northeastern Naturalist. 11(2). 2004. 167-178.
Kuhlmann, Mark L., 2008. Do invading rusty crayfish interfere with reproduction in a native congener? Journal of Crustacean Biology. 28(3). AUG 2008. 461-465.
Kuhlmann, Mark L.; Badylak, Stephanie M.; Carvin, Erin L., 2008. Testing the differential predation hypothesis for the invasion of rusty crayfish in a stream community: laboratory and field experiments. Freshwater Biology. 53(1). JAN 2008. 113-128.
Kuhlmann, Mark L.; Hazelton, Peter D., 2007. Invasion of the upper Susquehanna River watershed by rusty crayfish (*Orconectes rusticus*). Northeastern Naturalist. 14(4). 2007. 507-518.
Lewis, David Bruce, 2001. Trade-offs between growth and survival: Responses of freshwater snails to predacious crayfish. Ecology (Washington D C). 82(3). March, 2001. 758-765.
Lodge, David M.; Kershner, Mark W.; Aloi, Jane E.; Covich, Alan P., 1994. Effects of an omnivorous crayfish (*Orconectes rusticus*) on a freshwater littoral food web. Ecology (Tempe). 75(5). 1994. 1265-1281.
Lodge, David M.; Stein, Roy A.; Brown, Kenneth M.; Covich, Alan P.; Bronmark, Christer; Garvey, James E.; Klosiewski, Steven P., 1998. Predicting impact of freshwater exotic species on native biodiversity: Challenges in spatial scaling. Australian Journal of Ecology. 23(1). Feb., 1998. 53-67.
Mather, Martha E.; Stein, Roy A., 1993a. Using growth/mortality trade-offs to explore a crayfish species replacement in stream riffles and pools. Canadian Journal of Fisheries & Aquatic Sciences. 50(1). 1993. 88-96.
Mather, Martha E.; Stein, Roy A., 1993b. Direct and indirect effects of fish predation on the replacement of a native crayfish by an invading congener. Canadian Journal of Fisheries & Aquatic Sciences. 50(6). 1993. 1279-1288.
Maude S. H., 1988. A New Ontario Locality Record for the Crayfish *Orconectes rusticus* from West Duffin Creek Durham Regional Muncipality Canada. Canadian Field-Naturalist. 102(1). 1988. 66-67.
McCarthy, Julia M.; Hein, Catherine L.; Olden, Julian D.; Vander Zanden, M. Jake, 2006. Coupling long-term studies with meta-analysis to investigate impacts of non-native crayfish on zoobenthic communities. Freshwater Biology. 51(2). FEB 2006. 224-235.
Momot W. T; Hartviksen C; Morgan G., 1988. A Range Extension for the Crayfish *Orconectes rusticus* Sibley Provincial Park Northwestern Ontario Canada. Canadian Field-Naturalist. 102(3). 1988. 547-548
Olden, Julian D.; Adams, Jeffrey W.; Larson, Eric R., 2009. First Record of *Orconectes rusticus* (Girard 1857) (Decapoda Cambaridae) West of the Great Continental Divide in North America. Crustaceana (Leiden). 82(10). 2009. 1347-1351.
Olden, Julian D.; McCarthy, Julia M.; Maxted, Jeffrey T.; Fetzer, William W.; Vander Zanden, M. Jake, 2006. The rapid spread of rusty crayfish (*Orconectes rusticus*) with observations on native crayfish declines in Wisconsin (USA) over the past 130 years. Biological Invasions. 8(8). DEC 2006. 1621-1628.
Olsen T. M; Lodge D. M; Capelli G. M; Houlihan R. J., 1991. Mechanism of Impact of an Introduced Crayfish *Orconectes rusticus* on Littoral Congeners Snails and Macrophytes. Canadian Journal of Fisheries & Aquatic Sciences. 48(10). 1991. 1853-1861.
Perry, William L.; Feder, Jeffrey L.; Dwyer, Greg; Lodge, David M., 2001b. Hybrid zone dynamics and species replacement between *Orconectes* crayfishes in a northern Wisconsin Lake. Evolution. 55(6). June, 2001. 1153-1166.
Perry, William L.; Feder, Jeffrey L.; Lodge, David M., 2001a. Implications of hybridization between introduced and resident *Orconectes* crayfishes. Conservation Biology. 15(6). December, 2001. 1656-1666.
Perry, William L.; Lodge, David M.; Lamberti, Gary A., 1997. Impact of crayfish predation on exotic zebra mussels and native invertebrates in a lake-outlet stream. Canadian Journal of Fisheries & Aquatic Sciences. 54(1). 1997. 120-125.
Perry, William L.; Lodge, David M.; Lamberti, Gary A., 2000. Crayfish (*Orconectes rusticus*) impacts on zebra mussel (*Dreissena polymorpha*) recruitment, other macroinvertebrates and algal biomass in a lake-outlet stream. American Midland Naturalist. 144(2). October, 2000. 308-316.
Peters, Jody A.; Kreps, Tim; Lodge, David M., 2008. Assessing the impacts of rusty crayfish (*Orconectes rusticus*) on submergent macrophytes in a north-temperate US lake using electric fences. American Midland Naturalist. 159(2). APR 2008. 287-297.
Pintor, Lauren M.; Sih, Andrew, 2009. Differences in growth and foraging behavior of native and introduced populations of an invasive crayfish. Biological Invasions. 11(8). OCT 2009. 1895-1902.
Poly, William J.; Wetzel, James E., 2003. Distribution and taxonomy of three species of *Orconectes* (Decapoda: Cambaridae) in Illinois, U.S.A. Journal of Crustacean Biology. 23(2). May 2003. 380-390
Roth, Brian M.; Hein, Catherine L.; Vander Zanden, M. Jake, 2006. Using bioenergetics and stable isotopes to assess the trophic role of rusty crayfish (*Orconectes rusticus*) in lake littoral zones. Canadian Journal of Fisheries & Aquatic Sciences. 63(2). FEB 2006. 335-344.
Roth, Brian M.; Kitchell, James F., 2005. The role of size-selective predation in the displacement of *Orconectes* crayfishes following rusty crayfish invasion. Crustaceana (Leiden). 78(Part 3). MAR 2005. 297-310.

Roth, Brian M.; Tetzlaff, Jakob C.; Alexander, Mara L.; Kitchell, James F., 2007. Reciprocal relationships between exotic rusty crayfish, macrophytes, and *Lepomis* species in Northern Wisconsin lakes. Ecosystems. 10(1). FEB 2007. 74-85.
Smily, Peter C., Jr.; Dibble, Eric D., 2000. Microhabitat use of an introduced crayfish (*Orconectes rusticus*) in Long Lake, Wisconsin. Journal of Freshwater Ecology. 15(1). March, 2000. 115-123.
Strayer, David L., 1999. Effects of alien species on freshwater mollusks in North America. Journal of the North American Benthological Society. 18(1). March, 1999. 74-98.
Takemon, Yasuhiro 2007. Present status of exotic freshwater benthic macro-invertebrates and challenges for their control in Japan . Japanese Journal of Limnology (Rikusuigaku Zasshi), 68: 445-447.
United States Geological Survey. 2010. *Orconectes rusticus*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL.
**Summary:** Available from: http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=214 [Accessed March 8th 2010]
Wetzel, James E.; Poly, William J.; Fetzner, James W. Jr., 2004. Morphological and genetic comparisons of golden crayfish, *Orconectes luteus*, and rusty crayfish, *O. rusticus*, with range corrections in Iowa and Minnesota. Journal of Crustacean Biology. 24(4). November 2004. 603-617.
Wilson, Karen A.; Magnuson, John J.; Lodge, David M.; Hill, Anna M.; Kratz, Timothy K.; Perry, William L.; Willis, Theodore V., 2004. A long-term rusty crayfish (*Orconectes rusticus*) invasion: dispersal patterns and community change in a north temperate lake. Canadian Journal of Fisheries & Aquatic Sciences. 61(11). November 2004. 2255-2266.