Sea Grant
Minnesota

rusty crayfish: a nasty invader

biology, identification, and impacts by jeffrey gunderson 2008 **minnesota sea grant**

overview

Rusty crayfish (*Orconectes rusticus*) have invaded much of Minnesota, Wisconsin, Michigan, Illinois, Ontario, and portions of 17 other states (**Figure 1**). Although native to the Ohio River basin and the states of Ohio and Kentucky, rusty crayfish continue to spread into many lakes and streams where they cause a variety of ecological problems.

Rusty crayfish are probably spread by non-resident anglers who bring them along to use as fishing bait. As rusty crayfish populations increase in many areas, they are harvested for the regional bait market, biological supply companies, and food. Such activities might---help spread the species farther. Invading rusty crayfish frequently:

- displace native crayfish,
- reduce the amount and kinds of aquatic plants,
- decrease the density and variety of invertebrates (animals lacking a backbone), and
- reduce some fish populations.

Environmentally sound ways to eradicate introduced populations of rusty crayfish have not been developed, and none are likely in the near future. Preventing or slowing the spread of rusty crayfish into new waters is the best way to prevent the ecological problems they cause.

origin and distribution

There are over 350 species of crayfish in North America. Sixty-five of these species, including rusty crayfish, belong to the genus *Orconectes*.

Rusty crayfish were not found in Wisconsin in a 1932 survey, but populations have rapidly expanded throughout Wisconsin lakes and streams since their introduction around 1960 (Capelli and Magnuson 1983). Rusty crayfish have been observed in 430 Wisconsin lakes and streams and the occurrence of rusty crayfish in sites that support crayfish has increased from 3% in the 1970s to approximately 50% in 2007 (Olden et al. 2006 and UW-Madison Center for Limnology, unpublished data 2008).

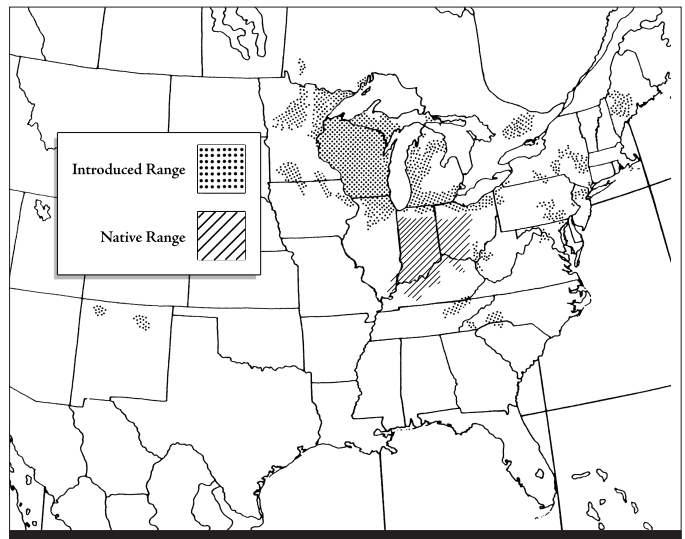


Figure 1. Geographic distribution of rusty crayfish. Adapted from USGS Rusty Crayfish Fact Sheet (2007).
http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=214

The first observation of rusty crayfish in Minnesota was in 1967 at Otter Creek in southern Minnesota. Since then, their range has expanded to approximately 50 different lakes and streams spanning 13 counties. Helgen (1990) was the first to survey rusty crayfish comprehensively in Minnesota.

Populations of crayfish identified as rusty crayfish in Iowa and southern Minnesota (Des Moines and Cedar River basins) may be golden crayfish, *Orconectes luteus* (Wetzel et al. 2004). Rusty crayfish from east central Minnesota (St. Croix River and tributaries) may have resulted from the natural dispersal of introduced populations from Wisconsin. People most likely spread rusty crayfish to the other waters of Minnesota where they are currently found.

Although there is no direct evidence, presumably people can spread crayfish in several ways. Anglers using crayfish as bait are thought to be the primary means of spread. While crayfish never were a significant compo-

nent of Minnesota live bait sales, they are popular in other states and may have been brought to Minnesota by non-resident anglers.

Rusty crayfish are also sold to schools by biological supply houses. Even though a warning not to release rusty crayfish into the wild accompanies these crayfish, such warnings may be forgotten, or live crayfish may be given away to students. Crayfish from schools or collected from the wild and placed in home aquariums may eventually be released.

Developing a viable commercial harvest of rusty crayfish from natural lakes could be incentive for unscrupulous trappers to plant them into other waters. In fact, this may have contributed to the spread of rusty crayfish in Wisconsin, according to Wisconsin Department of Natural Resources (DNR) Fisheries Manager, Harland Carlson (personal communication 1994).

The harvest of rusty crayfish for food and bait may provide the only beneficial use for this exotic. Harvest for bait has been going on for over 40 years in Wisconsin. Commercial harvest for food is more recent and varies from year to year in Wisconsin and Minnesota. Regulations in both states make it illegal to introduce rusty crayfish into any waters. In Minnesota, it is illegal to sell live crayfish as bait or as aquarium pets. A DNR permit is required to commercially harvest or culture crayfish.

life history

Rusty crayfish inhabit lakes, ponds, and streams. They prefer areas that offer rocks, logs, or other debris as cover. Bottom types may be clay, silt, sand, gravel, or rock. Rusty crayfish inhabit both pools and fast water areas of streams. They generally do not dig burrows other than small pockets under rocks and debris, although there have been reports of more substantial burrows. Unlike some species (such as the papershell crayfish, *Orconectes immunis*), which dig burrows to escape ponds that are drying up or becoming inhospitable, rusty crayfish need permanent lakes or streams that provide suitable water quality year-round.

Mature rusty crayfish mate in late summer, early fall, or early spring. The male (**Figure 2**) transfers sperm to the female (**Figure 3**). She stores the sperm until her eggs are ready to fertilize, typically in the spring (late April or May) as water temperatures begin to increase. Stored sperm are released as eggs are expelled and external fertilization occurs. The eggs are then attached to the swimmerets on the underside of the crayfish's abdomen ("tail section"). Just prior to egg laying, white patches appear on the underside of the tail section, especially on the tail fan (**Figure 3**). These white patches are glair — a mucus-like substance secreted during egg fertilization and attachment. Rusty crayfish females lay from 80 to 575 eggs.

Eggs hatch in three to six weeks, depending on water temperature. Once hatched, young crayfish cling to the female's swimmerets for three to four molts (molting is when crayfish shed their old shell to allow growth). Young crayfish may stay with the female for several weeks. She offers them protection during this vulnerable

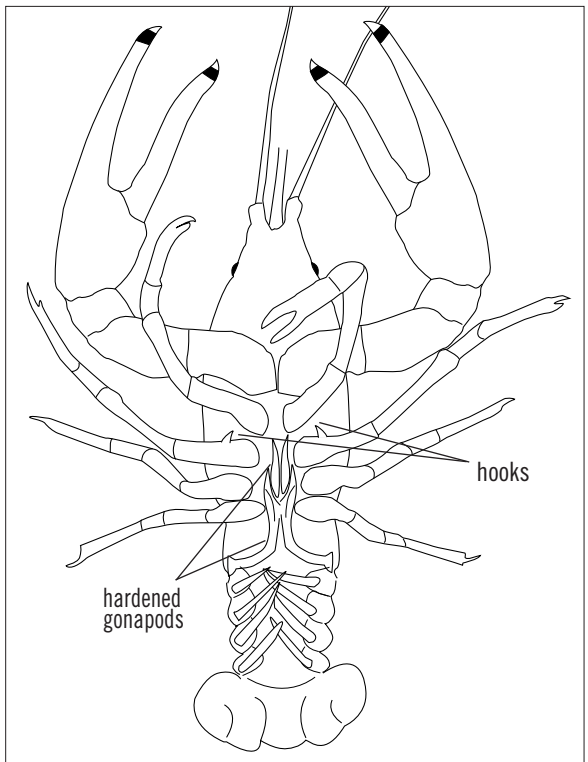


Figure 2. The underside of a Form I male crayfish shows one pair of legs with hooks and hardened gonapods.

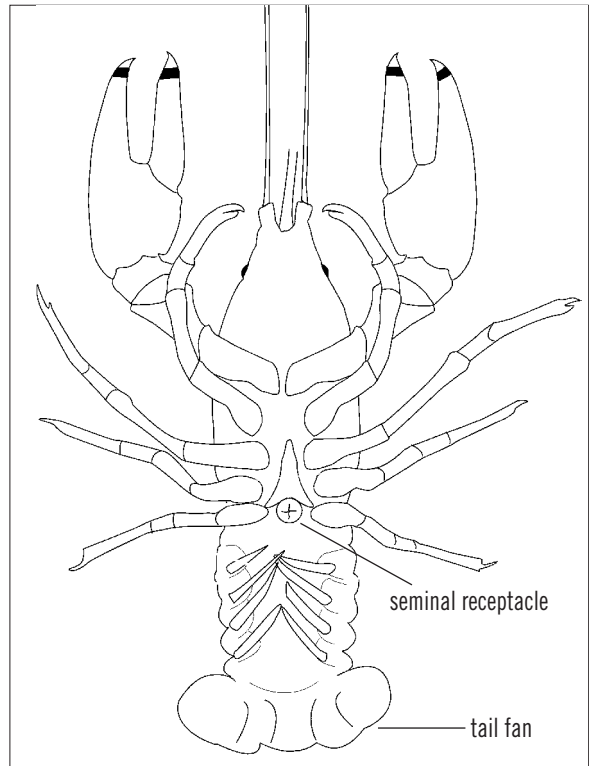


Figure 3. The underside of a female crayfish shows the seminal receptacle where the sperm capsule is held by the female until eggs are fertilized.

life stage. Eventually, the young leave the female. They undergo eight to ten molts before they mature, which may occur during the first year, but more likely in the following year. Rusty crayfish reach maturity at a total length of one and three-eighths inches (3.5 cm) and reach a maximum length of about four inches (10 cm), not including claws. In Wisconsin collections (Hobbs and Jass 1988), they averaged two and one-half inches (6.4 cm).

It is important to note that it is not necessary to introduce both a male and a female crayfish to begin a new infestation. One female carrying viable sperm could begin a new population if released into a suitable environment. Rusty crayfish readily mate in captivity so it is reasonable to expect that mature females, whether used as fishing bait or as science class specimens, could produce offspring.

Growth slows considerably after crayfish attain maturity. While mature males molt (shed their shells) twice per year, females usually only molt once. Females molt after the release of their young, typically in June or early July. In the spring, males will molt into a sexually inactive form (called Form II) and then molt back into the reproductively competent form (Form I) in summer. Form I males are characterized by large claws, a hook on one pair of their legs (**Figure 2**), and hardened gonapods. The hook and the larger claws are used for grasping females during mating. Because males have an additional molt each year, they are usually larger than females of the same age. A typical rusty crayfish lives three to four years.

food habits

Crayfish are considered opportunistic feeders. Rusty crayfish feed on a variety of aquatic plants, benthic invertebrates (like aquatic worms, snails, leeches, clams, aquatic insects, and crustaceans such as side-swimmers and waterfleas), detritus (decaying plants and animals, including associated bacteria and fungi), fish eggs, and small fish. Juveniles especially feed on benthic invertebrates like mayflies, stoneflies, midges, and side-swimmers.

potential impacts

Rusty crayfish may cause a variety of negative environmental and economic impacts when introduced to new waters. This aggressive species (Capelli and Munjal 1982) often displaces native or existing crayfish species. Displacement of crayfish, such as *Orconectes virilis* and *Orconectes propinquus* has occurred in many northern Wisconsin lakes, northern Ontario, in the Kawartha Lakes region of southern Ontario (Capelli 1982; Hill and Lodge 1994; Lodge et al. 1986; Olsen et al. 1991; Olden et al. 2006), and in Ohio, *Orconectes sanbornii* has been displaced (Mather and Stein 1993).

Rusty crayfish displace other crayfish species through three primary mechanisms:

1) Crayfish-to-crayfish competition (Hill and Lodge 1994; Garvey et al. 1994). Rusty crayfish are better able to exclude other crayfish from shelters and better able to compete for limited food resources.

2) Increased fish predation (DiDonato and Lodge 1994; Garvey et al. 1994; Hill and Lodge 1993; Roth and Kitchell 2005). Rusty crayfish can increase fish predation on native crayfish in a variety of ways. They force native species from the best hiding places. As the native crayfish try to swim away from a fish or rusty crayfish attack, this makes them more vulnerable to capture by fish. Rusty crayfish, on the other hand, assume a claws-up defensive posture that reduces their susceptibility to fish predation. Also, rusty crayfish are larger and have larger claws than most native species, which results in fish preying upon native species over rusty crayfish.

3) Hybridization (Perry et al. 2001a,b). While rusty crayfish do not hybridize with *Orconectes virilis*, they do hybridize with *Orconectes propinquus*. This hybridization results in fertile and vigorous offspring, but ultimately results in the decline of *Orconectes propinquus*. The competitive superiority of the hybrids helps exclude genetically pure *Orconectes propinquus* faster than *Orconectes rusticus* would without hybridization. Rusty crayfish were also found to hybridize with *Orconectes limosus* (Smith 1981). While *Orconectes limosus* numbers declined four years later, no conclusions regarding the cause of the decline were discussed.

The destruction of aquatic plant beds is perhaps the most serious impact. Rusty crayfish have been shown to reduce aquatic plant abundance and species diversity (Lodge and Lorman 1987; Olsen et al. 1991, Wilson et al. 2004). This can be especially damaging in relatively unproductive northern lakes, where beds of aquatic plants are not abundant. Submerged aquatic plants are important in these systems for:

- habitat for invertebrates (which provide food for fish and ducks),
- shelter for young gamefish, panfish, or forage species of fish,
- nesting substrate for fish, and
- erosion control (by minimizing waves).

Although other crayfish eat aquatic plants, rusty crayfish eat even more because they have a higher metabolic rate and appetite (Jones and Momot 1983). They also grow larger, hide less often from predators – and therefore feed longer (Stein 1977) – attaining high population densities.

Estimates suggest that a rusty crayfish might consume twice as much food as similar-sized *O. virilis* because of its higher metabolic rate (Momot 1992). Rusty crayfish are more likely to compete with juvenile game fish and forage fish species for benthic invertebrates than are native crayfish species. Displacement of native crayfish by rusty crayfish could result in less food for fish.

Crayfish are eaten by fish, but because of the higher ratio of their thick exoskeleton (shell) relative to soft tissue, their food quality is not as high as many of the invertebrates that they replace. Less food or lower food quality means slower growth, which can reduce fish survival.

Rusty crayfish can harm fish populations by eating fish eggs (Horns and Magnuson 1981), reducing invertebrate prey, and through loss of habitat (aquatic plants). Male bass and sunfish protect their nests until the eggs hatch and the advanced fry swim away. University of Wisconsin-Superior fishery scientist Bill Swenson (personal communication), has observed rusty crayfish attacking bluegill nests guarded by males. He also observed rusty crayfish in other unguarded nests. He did not know, however, if rusty crayfish caused the bluegills to abandon their nests. It has also been reported that pumpkinseed sunfish do a poor job of defending their eggs from rusty crayfish, especially at night (Wilson et al. 2004). A long-term study showed that fish species that compete for prey with rusty crayfish (like bluegills and pumpkinseeds) decline over time after rusty crayfish invade (Wilson et al. 2004). It was also found that total zoobenthos, larval midges, mayflies, dragonflies, and stoneflies decline as rusty crayfish populations increase (McCarthy et al. 2006).

Walleye reproduction dropped after rusty crayfish invaded Lake Metonga, Wisc. (Lodge et al. 1985); however, rusty crayfish have not seemed to damage walleye reproduction in most of the Wisconsin lakes they have invaded. Perhaps the lower quality walleye spawning substrate in Lake Metonga compared to other lakes invaded by rusty crayfish allowed the impact on walleye reproduction.

Observations and circumstantial evidence gathered by Wisconsin fishery managers suggest that bluegill and northern pike populations frequently decline following the introduction of rusty crayfish (Harland Carlson and Chris Sand, Wisconsin DNR, pers. comm. 1994). Smallmouth bass in Lake Lenore and largemouth bass in Pounsford Lake, Ontario, also seemed to decline following introduction of rusty crayfish (Dr. Walter Momot, pers. comm. 1994). Impacts on other fish species are not as obvious. The cause of bluegill, bass, and northern pike declines is probably reduced abundance and diversity of aquatic plants. Reduced food (such as mayflies, midges, and stoneflies) and egg predation may also play a role. Because impacts and population abundance of rusty crayfish vary in lakes that appear similar, it is not possible to predict what will happen when they invade a new lake.

Cabin owners on heavily infested northern Wisconsin and Minnesota lakes have even stopped swimming because large numbers of "rustys" occupy their favorite swimming area throughout the day. They fear stepping on them and getting pinched by their large claws. Other crayfish species, even if abundant, are less conspicuous during daylight hours.

control

Many chemicals kill crayfish and some are even selective for crayfish; however, none are currently registered for crayfish control (Bills and Marking 1988). And, none selectively kill rusty crayfish without killing other crayfish species. Intensive harvest will not eradicate crayfish, but may help reduce adult populations and minimize some impacts.

Researchers suggest that nuisance populations of rusty crayfish are the result of poor fishery management and that by restoring a healthy population of bass and sunfish, rusty crayfish would be less disruptive in some lakes (Momot 1984). Recent research seems to support this; a combination of intensive trapping and enhanced fish predation, through regulations that protected smallmouth bass, effectively controlled rusty crayfish in Sparkling Lake, Wisc. (Hein et al. 2006 and Hein et al. 2007). This whole-lake experiment found that aquatic plants, benthic invertebrates and sunfish increased as a result of rusty crayfish population decreases.

The best method of control, however, is to prevent their introduction. Educating anglers, crayfish trappers, bait

Rusty crayfish should not be used to manage Eurasian watermilfoil

Eurasian watermilfoil (*Myriophyllum spicatum*) is an exotic plant that forms dense mats and adversely affects swimming, boating and fishing. The use of one exotic species to control another is highly discouraged without proper long-term studies. Rusty crayfish, as well as other crayfish, cut plant stems as they feed. Much of the plant then floats away. Since Eurasian watermilfoil spreads and reproduces by plant fragmentation, crayfish could accelerate its spread. Also, Eurasian watermilfoil is more likely to establish itself in areas where rusty crayfish have disrupted the native plant community. In addition, rusty crayfish could interfere with the effectiveness of control with the freshwater weevil *Euhrychiopsis lecontei* (through predation). Since there is no research into the effectiveness of using rusty crayfish for Eurasian watermilfoil control, and rusty crayfish usually do not become abundant in the lakes most susceptible to Eurasian watermilfoil, their introduction would not likely have the desired effects. No one should introduce this species into any waters.

dealers, and teachers about the threats posed by rusty crayfish will help reduce the risk of spreading rusty crayfish to new areas.

identification

Disclaimer: These identification guidelines should not be used when positive identification is needed. Contact your local fishery management agency or Minnesota Sea Grant if positive identification is required.

Identifying crayfish can be difficult. Positive identification requires looking at a number of characteristics and having enough experience to interpret them. Here are some general characteristics that you can use to help identify mature adults of four common crayfish species (*O. rusticus*, *O. virilis*, *O. immunis*, and *O. propinquus*) found in the Great Lakes region. (Other species found in the region include *Cambarus diogenes, C. robustus, O. sanbornii, Procambarus acutus acutus*, and in southern parts of the region, *P. clarki*).

Rusty crayfish can generally be identified by their more robust claws, which are larger than either *O. immunis'* or *O. virilis'*, and by the dark, rusty spots on each side of their carapace. The spots are located on the carapace as though you picked up the crayfish with paint on your forefinger and thumb (**Figure 4a**). The spots may not always be present or well developed on rusty crayfish from some waters.

O. propinquus has a claw very similar to the rusty crayfish, but lacks the dark spots on each side of the carapace. Instead, *O. propinquus* has a dark brown-to-black patch on the top of the tail section. This gives the impression that a light-colored stripe runs along each side of the tail section (**Figure 4b**).

Compared to the rusty crayfish, *O. virilis* can often be distinguished by its claws, which are blue and have distinct white, wart-like bumps. The rusty's claw, by comparison, is grayish-green to reddish-brown and is smoother (**Figure 5a**).

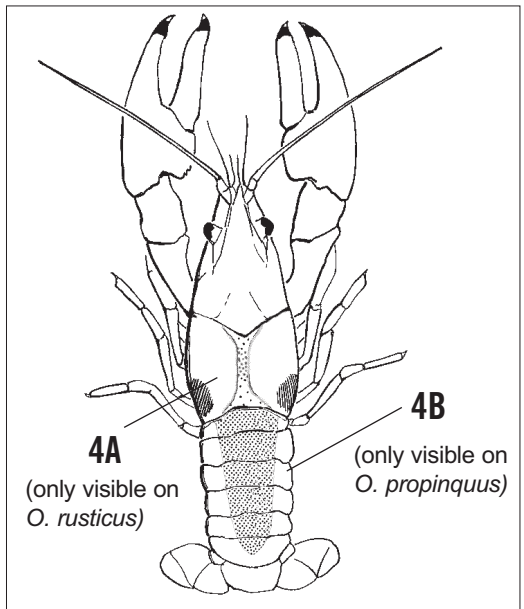


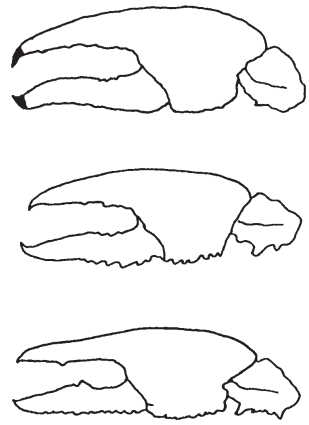
Figure 4. Composite drawing of *O. rusticus* and *O. propinquus*. **4A**: dark spot on carapace of *O. rusticus*. **4B**: dark patch and appearance of light colored stripe on abdomen (tail) of *O. propinquus*.

Figure 5. Claw shape can help distinguish between the various species.

5A: *O. rusticus, O. propinquus* – Black bands at claw tips. Oval gap when closed. Smooth, S-shaped moveable claw.

5B: *O. virilis* – No black bands. Gap is a mere slit when claw is closed. White wart-like bumps on claw.

5C: *O. immunis* – No black bands. Gap is a definite notch. Claws are narrower and elongated.



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