History of the range extension of *Orconectes rusticus* into northwestern Ontario and Lake Superior

Walter T. Momot

Dept. of Biology
Lakehead University
Thunder Bay, Ontario P7C 5N5
Canada

ABSTRACT

First discovered in one lake in 1985, *Orconectes rusticus*, an introduced exotic, has now extended its distributional range in Northwestern Ontario to 10 localities extending from the international border (Pigeon River) to the Sibley Peninsula. It has reached nuisance densities in three locations, eliminating the native species; has established reproducing populations in 5; and is currently expanding into 5 new localities. Its downstream rate of expansion varies from 0.9 to 3.7 km/yr upstream at 0.5 km/yr. Serial impoundment of streams by beavers temporarily slows the rate of expansion. Waterfalls and dams prevent upstream movement. If present rate of expansion continues, *Orconectes rusticus* will become the dominant species in Western Lake Superior tributaries and portions of the lake.

Key words: Lake Superior, *Orconectes rusticus*, range extension

FRESHWATER CRAYFISH 11 pp.61-72

I. INTRODUCTION

The crayfish, *Orconectes rusticus*, an introduced species, was originally native to the Ohio River drainage of the midwest region of the United States. From this area it has spread to many portions of the U.S. From Ohio it has moved westward and northward to Michigan, Minnesota, Wisconsin, Illinois and Ontario (Hobbs III and Jass 1988). The northward expansion of its range resulted in the replacement of native species of crayfish and has also caused a variety of ecological problems. The presence of *Orconectes rusticus* in northwest Ontario was first recorded by Crocker and Barr in 1964 in Lake-of-the-Woods (Crocker and Barr 1968). This large lake is near the Manitoba border at the extreme edge of northwestern Ontario. This isolated occurrence far from its natural range was likely a bait-bucket introduction. No other records from this region were known until 1985 when *Orconectes* was found in Pounsford Lake, Sibley Peninsula (Momot 1992). This was a well established population with many individuals of a variety of sizes collected.

In northern boreal waters *Orconectes rusticus* remains a potential nuisance species, if not a threat to the community structure of such ecosystems (Momot, 1995).

Crayfish often dominate the biomass of the benthic fauna of many boreal lakes and streams. This is in part because of their polytrophic feeding habits. They ingest both animal and plant material. While searching for animal protein they also ingest large amounts of herbacious and detrital material. In dense populations, as animal protein is exhausted, crayfish become facultative herbivores. At high densities their extended foraging activity can modify habitat: *e.g.* destruction of macrophyte beds, algal mats, *etc.*; and seriously reduce or even eliminate animals and plants from lakes and rivers.

This is because in low nutrient, rocky boreal lakes and streams of the Thunder Bay area, effective crayfish predators, such as Centrarchid (Sunfish) and Ictalurid (Catfish) fishes are absent. In the absence of such predators, because the rocky littoral provides both shelter and food, and because *Orconectes rusticus* is an aggressive species with a high metabolic rate and high ingestion rate to match, this species often supersedes the native *Orconectes virilis* and builds up very dense populations (Momot, 1995). For a detailed review of this problem see Momot (1995).

Because of the potential of *Orconectes rusticus* to have significant detrimental impacts on the native flora and fauna both in inland lakes and streams and in the warmer bays of Lake Superior, this study was conducted to document the expansion of its range in the area.

This study encompasses the invasion/expansion monitoring project conducted by Dr. W. Momot and Lakehead University students over the past several years including Trevor Williams, James Hiscox, Robyn Rynanen and Cheryl Zawacki.

II. MATERIALS AND METHODS

The present survey examined 16 areas within the Thunder Bay area (Table 1) (Fig. 1). Each site was sampled at least once and usually twice between the months of June and September, 1995. Samples were obtained by employing modified minnow traps. The cylindrical traps were constructed of galvanized steel mesh with two 4 centimetre diameter openings at each end, allowing crayfish to easily enter the traps. Traps were baited with either one-third to one-half of a smelt (*Osmerus mordax*) or with small chunks of longnose sucker (*Catostomus catostomus*). These traps were set into the creek, river, or lake during the day or evening and retrieved the next morning.

At each location, placement and the number of traps employed varied depending on water conditions (water depth, current flow) and habitat type (Table 1). After trap retrieval all species caught had sex determined and the carapace length (C.L. -

Table 1. The total number and placement of traps set each night in 16 locations in the summer of 1995 within the Thunder Bay area of Ontario.

Location	Date Sampled	Number of Traps Set	Placement of Traps
Pounsford Lake (48 29'0.5", 88, 46'0.5"W)	June 8, 9	50	10 rows, 5 traps/row at 5m intervals between rows with 1 row set 3-4m from shore
Wiswell Lake (48 29'0"N, 88 46'0.5"W)	June 12, 13, 19, 20	50	same as above
Lizard Lake (48 28'0"N, 89 45'0"W)	June 8, 9	50	same as above
Portage Creek (48 29'0.5"N, 88 45'0.5"W)	July 26, 27	50	majority of traps set at headwaters, then at 5-10m intervals
Kaministiquia River (48 22'0"N, 89 34'0"W)	August 3, 4	20	groups of 5 traps in optimal habitat
Mission River (48 22'0"N, 89 34'0"W)	August 7, 8	50	same as above, plus single traps set at 15m intervals
McKellar River (48 22'0"N, 89 34'0"W)	August 3, 4	40	same as above
McIntyre River (48 32'0"N, 89 20'0"W)	July 10-14	120	same as above
Neebing River (48 32'0"N, 89 21'0"W)	July 14-17	80	same as above
Neebing Marsh (48 24'0"N, 89 13'0"W)	July 20-21 August 11-14	50	spread evenly along shoreline at 15m intervals

Table 1. Continued...

Location	Date Sampled	Number of Traps Set	Placement of Traps
Mission Marsh (48 24'0"N, 89 15'0"W)	July 24, 25 August 11-13	50	same as above
Current River (48 27'0"N, 89 11'0"W)	August 21, 22	25	spread evenly along shoreline at 5m intervals
McVicars Creek (48 26'0"N, 89 13'0"W)	August 21, 22	25	same as above
Little Pine River (48 02'0"N, 89 32'0"W)	June 25-29 July 4, 5	190	majority set at headwaters of the river, spaced evenly at 5-10m intervals, from mid-river to mouth spread at 20m intervals
Pigeon River (48 00'0"N, 89 37'0"W)	August 14, 15	25	spread evenly along the shoreline at 15-20m intervals
Pigeon Bay (48 00'0"N, 89 35'0"W)	August 15, 16	100	same as above, with no traps along beaches

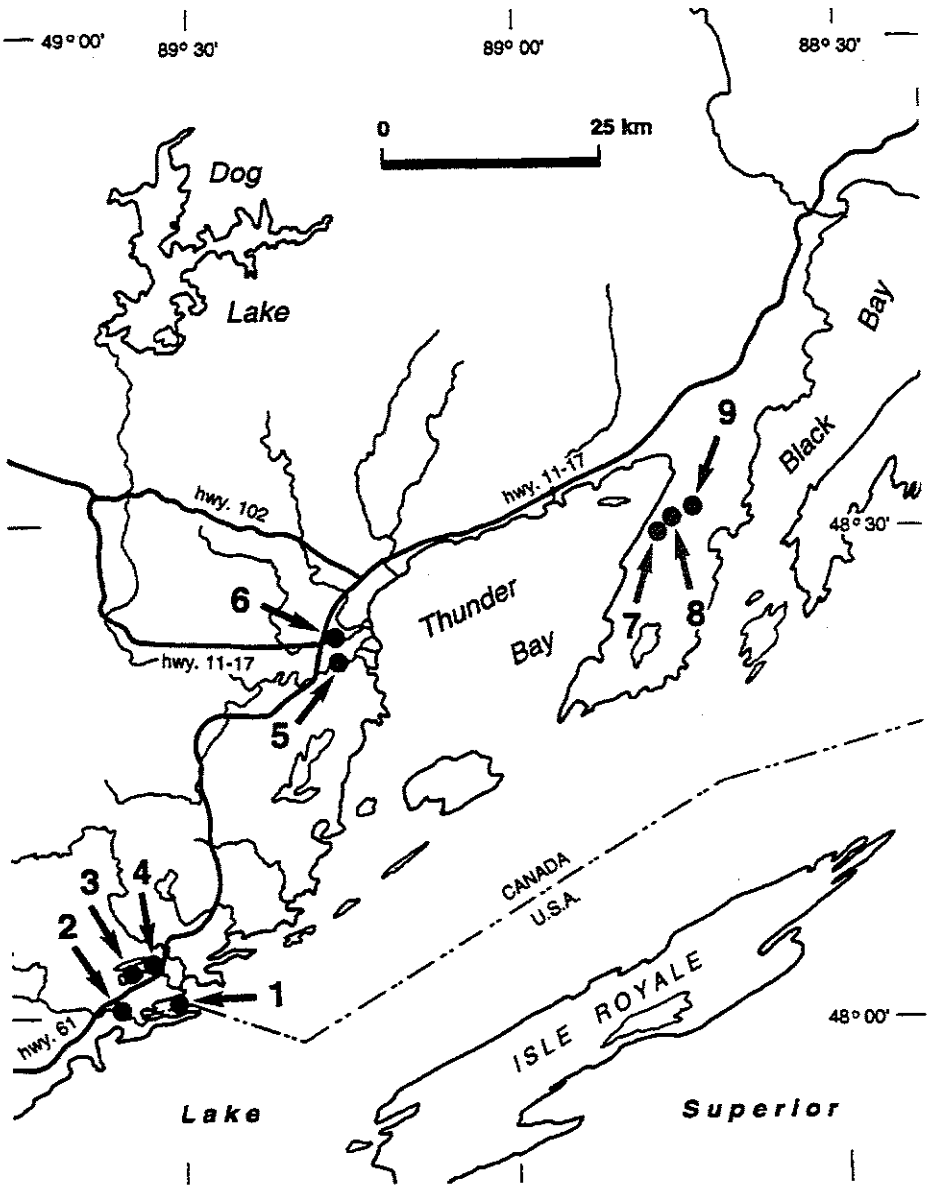

Figure 1. Map showing locations where *O. rusticus* has established populations in the Thunder Bay area of Lake Superior and Northwestern Ontario.

The location areas are as follows: (1) Pigeon Bay, Lake Superior; (2) Pigeon River (3) Lake Lenore (4) Little Pine River (5) Kaministiquia River (6) Neebing-McIntyre Rivers (7) Pounsford Lake (8) Wiswell Lake (9) Portage River.

anterior tip of rostrum to posterior dorsal edge of carapace) recorded.

Trap catches are biased and usually do not accurately reflect the actual population structure. Baited traps select for larger male crayfish (Somers and Stechey, 1986). The baited traps serve as a shelter from predators as well as a free meal and crayfish will defend against other individuals wishing to enter it. This type of sampling method is used since it is inexpensive and is not labour intensive. Traps are useful for determining species composition and distribution in an area but not actual density (Capelli, 1975).

Species identification of *Orconectes rusticus* was easily determined. It is readily distinguished from *Orconectes virilis* by displaying an overall reddish colouration with a distinct red spot in the posterior lateral area of the carapace and a distinct jet black band near the orange tips of the fingers of its large smooth chelae (Crocker and Barr, 1968). The sex was determined by examining males for copulatory stylets (gonopodia) and females for an ovate opening (*annulus ventralis*) located ventrally anterior to the tail segment.

III. RESULTS

SIZE OF TRAPPED ANIMALS

As expected, since males dominate females, they comprised most of the trap catch (80% males for *O.rusticus* and about 78% males for *O. virilis*). The mean carapace length for trap caught *O.rusticus* in Pounsford Lake was low at 33.2 mm ± 3.2 mm for males and 31.6 mm ± 4.1 mm for females (Table 2). This is suggestive of a very high density of stunted *O.rusticus* in Pounsford Lake. These overcrowded crayfish compete for limited food and shelter availability reducing growth. In the Neebing River males were 35.3 mm ± 2.8 mm; females were 33.9 mm ± 2.9 mm while in the Little Pine River males were 34.4 mm ± 4 mm; females were 31.6 mm + 3.1 mm in carapace length, about an average size for this species (Table 2).

The mean size of trap caught *O.rusticus* crayfish in Wiswell Lake (males 37.0 mm ± 0.9 mm), Portage Creek (males 37.0 mm ± 0.8 mm; females 33.5 mm + 1.5 mm) and the McIntyre River (males 37.3 mm ± 2.1 mm; females 32.6 mm ± 1.8 mm), suggests that the newly invading *O.rusticus* crayfish maintained an average or above average growth in size (Table 2). While this suggests that crayfish from newly invaded areas may show above average growth perhaps due to lower density the Pigeon River data do not conform to this pattern. The Pigeon River contains a high density population of *O.rusticus* of a very large mean sizes (males 38.8 mm ± 4.8 mm; females 33.8 mm ± 2.8 mm) (Table 2). This suggests that the Pigeon River provides optimal conditions supporting a large, highly dense population. These conditions could include abundant food, adequate shelter and probably warmer temperatures for encouraging this optimal growth but this remains to be investigated.

Table 2. The mean size ($\bar{x} \pm$ S.E.) of *O. rusticus* captured using traps in the summer of 1995 within the Thunder Bay area. The numbers within the parentheses represent the size range from smallest to largest crayfish captured during sampling.

Area	Location	Mean Size of O. rusticus	
		M	F
Sibley Peninsula	Pounsford Lake	33.2mm ± 3.2mm (23mm : 44mm)	31.6mm ± 4.1mm (24mm : 38mm)
	Wiswell Lake	37.0 ± 0.9mm (25mm : 40mm)	N/A
	Portage Creek	37.0mm ± 0.9mm (36mm : 38mm)	33.5mm ± 1.5mm (32mm : 35mm)
Thunder Bay	Neebing River	35.3mm ± 2.8mm (29mm : 43mm)	33.9mm ± 1.8mm (28mm : 40mm)
	McIntyre River	37.3mm ± 2.1mm (34mm : 41mm)	32.6mm ± 1.8mm (30mm : 35mm)
South of Thunder Bay	Little Pine River	34.4mm ± 4.1mm (25mm : 43mm)	31.6mm ± 3.0mm (27mm : 39mm)
	Pigeon River	38.8mm ± 4.8mm (24mm : 54mm)	33.8mm ± 2.8mm (30mm : 37mm)
	Pigeon Bay	36.3mm ± 1.8mm (34mm : 39mm)	N/A

RATE OF EXPANSION OF *Orconectes rusticus* IN THE THUNDER BAY AREA OF ONTARIO.

By 1991, established populations of *Orconectes rusticus* had been recorded from Wiswell Lake, the first lake downstream from Pounsford Lake; Lake Lenore located southwest of the City of Thunder Bay near the U.S. Canadian border; Pigeon River which forms the international boundary between Minnesota and Ontario; Pigeon River located within the City of Thunder Bay (Momot 1992).

By 1995 this species had spread to the Little Pine River, the outlet of Lake Lenore; the McIntyre River within the City of Thunder Bay; the Portage River, the outlet of Wiswell Lake; Neebing Marsh, Thunder Bay, Lake Superior; and the Kaministiquia River, in the City of Thunder Bay (Table 3). Thus within 10 years since its first discovery, this species now exists in a number of watersheds along Lake Superior extending from the Pigeon River to the Sibley Peninsula. Furthermore, a record is now known from Basswood Lake, Quetico Provincial Park, this is a first record for the Park, and for the area of northwestern Ontario lying between Lake Superior and Lake-of-the-Woods.

The rapid expansion of this species in Northwest Ontario has been documented in a few water bodies (Table 3). For example in the Little Pine River the crayfish moved a distance of 1.3 km in one year (1994) then a further distance of 0.1 km downstream by 1995. In the Portage Creek area, within 9 years it had expanded from Pounsford Lake in 1993 to the inlet with Wiswell Lake 2.5 km downstream and then by 1995 a

Table 3. Estimated annual rate of movement (minimum distance) in km/yr of *Orconectes rusticus* in lakes and streams of northwestern Ontario.

Downstream	1992	1993	1994	1995
Neebing R.	0.90	3.70		
McIntyre R.				3.40
Little Pine R.			1.30	0.10*
Pigeon Bay, Lake Superior				1.60
Portage Creek				0.05*
Pounsford Lake to Outlet of Wiswell Lake				0.40**
UPSTREAM				
McIntyre R.		0.45		
Kaministiquia R.				1.50

*stream in this area obstructed by a series of beaver dams
**average rate of expansion over a 9 year period.

distance of 50 m. downstream of Wiswell Lake into Portage Creek. In Pigeon Bay *Orconectes rusticus* has expanded from the mouth of Pigeon River to a distance 1.6 km out into Lake Superior proper and now exists upstream to Partridge Falls a distance of 26 km. The best available records on the rate of expansion are for two streams within the City of Thunder Bay (Table 3, 4). Recently discovered in the Neebing River at Edward Street in 1992 this crayfish had expanded by 1993 to the mouth of the river, a distance of 3.7 km downstream. In 1995, it was found in the McIntyre River which is artificially connected to the Neebing River by a floodway channel. By 1995 this species reached the mouth of the McIntyre River at Lake Superior, a distance of 3.4 km. It also expanded 0.2 km upstream from the junction of the two rivers into the McIntyre River. Upon reaching Thunder Bay, the species has moved into the Bay and upstream to the Kaministiquia River (Table 3).

Not only has it expanded its range in 3 years to occupy all accessible portions of the Neebing River but has also increased its prevalence at all locations and within the river as a whole from 27% of the overall catch in 1992 to 60% in 1995 (Table 4).

The rate of downstream expansion for all streams and lakes within the area ranges from 0.9 to 3.7 km per year provided there are no obstacles.

OBSTACLES TO EXPANSION

The major downstream obstacle in streams appears to be beaver dams especially when these are arranged in a series. Two examples are the Portage River where *O.rusticus* has expanded by only 0.05 km downstream in one year from the

Table 4. Rate of expansion of introduced an population of *Orconectes rusticus* and prevalence expressed as percent of catch of both *O.rusticus* at a specific location over a four year period in the Neebing-McIntyre Rivers, Thunder Bay, Ontario.

Location	Downstream (Distance from Point of Introduction)	(50T)** 1992	(60T) 1993+	(80T) 1995+
Edward Street	0m	100	97	88
Ford Street	450m.	83	86	83
Brunswick Street	900m.	49	61	69
Southern Ave.	2350m.	0	34	59
Junction Neebing McIntyre R.	3250m.	0	0	42
110th Ave.	4150m.	0	30	41
Mouth (Marsh)	4600m.	0	36	38
Mean catch over the entire River =		26.7	44.0	60.0

*ten traps set 10 m. apart at each location in 1993 + 1995.

	Upstream			
Junction	0m.	0	0	36 (20T)
McIntyre-Neebing River	450m.	0	0	15 (120T)
Kaministiquia River	1500m.	0	0	12.5 (20T)

** Number in parenthesis represents total traps set at each locality.

outlet of Wiswell Lake and the Little Pine where it has expanded by only 0.1 km/yr after encountering a series of beaver dams on that stream after an initial unobstructed movement of 1.3 km (Table 3).

Upstream movements range from 0.45 to 1.5 km/yr. Upstream movement has been blocked by a flood control weir in the Neebing River. No *O.rusticus* to date have been recorded above this obstacle at Edward Street in 4 years of sampling. An experimental lamprey weir was placed in the McIntyre River in 1993 and may prevent future movement of *O.rusticus* beyond this point. Waterfalls of sufficient height can also prevent upstream movement *e.g.* no *O.rusticus* exists above Partridge Falls (7 m. in height) on the Pigeon River even though they infest the River below the Falls all the way to its mouth.

BIOLOGICAL EFFECTS

Where introduced, *O.rusticus* has apparently eliminated populations of *O. virilis* in three localities: Lenore Lake, Pigeon River below Partridge Falls, and Pounsford Lake. In the Neebing River, *O.rusticus* has increased in density and prevalence over a 3 year period and will likely become the dominant species if not the only species (Table 4).

Since most collections have been restricted to one or two days of sampling, densities expressed as catch per unit of effort where effort is expressed in one baited trap fished for 24 hrs, are only suggestive of the density of some of the populations sampled. These data only serve to point out that in established populations that exist in: the Neebing River, Lenore Lake, Pounsford Lake, Little Pine River and Pigeon River, catch rates varied from 0.94 to 18.0 crayfish per trap-day and these catches were composed mainly of males and crayfish 50 mm T.L. Weather, season, size of the population are among the many factors influencing such data. Newly developing populations in the McIntyre River, Wiswell Lake, Kaministiquia River and Pigeon Bay yielded catch rates of 0.05 to 0.28 crayfish per trap-day (Table 5).

Table 5. Average catch per unit of effort (numbers caught/trap day) of *O. rusticus* in streams and lakes of the Thunder Bay area of Ontario. Number of traps fished and month of sampling are in parentheses and effort is expressed as the pooled catch over the entire stream or lake divided by the number of traps fished.

Established Populations	1985	1992	1993	1994	1995
Neebing R.		2.74(Aug.) (50)	3.41(Aug.) (80)		1.55(July) (80)
Pounsford L.	18.00(Sept.) (6)				4.20 (June) (50)
Pigeon R.				2.16(Aug.) (12)	2.44(Aug.) (25)
Lake Lenore			11.00(Aug.) (5)		
Little Pine R.				1.50(Aug.) (10)	0.94.(July) (190)
Invading Populations					
McIntyre R.			0.0(Aug.) (6)	0.16(Aug.) (6)	0.28(July) (120)
Wiswell L.					0.16 (June) (50)
Kaministiquia R.					0.05(Aug.) (20)
Pigeon Bay, L. Superior				0.0(Aug.) (6)	0.05(Aug.) (100)
Portage R.					0.14(July) (50)

IV. CONCLUSIONS

Most likely, *Orconectes rusticus* will continue to expand its range in the Thunder Bay Region of northwestern Ontario. It may become the dominant and most prevalent species in this area displacing the native crayfish, *Orconectes virilis*. In many localities it will reach nuisance densities (> 10/m2) and can produce severe and undesirable ecological effects such as can be witnessed in Lenore and Pounsford Lakes. It may also produce severe problems in the shallow weedy bays of Lake Superior and may even become the dominant species in Lake Superior. Expansion within Lake Superior will depend on access to sheltered bays as compared to movements in the open lake but a rate of 1km/yr. seems quite within its capability.

Other factors that could affect further range extensions of *O. rusticus* is competition with other crayfish species. However *O. rusticus* easily out competes the species found in the area. For *O. rusticus* to extend its range it must first compete and dominate the native species, *O. virilis* and *O. propinquus* (Williams 1995) another introduced species which now occurs in the Nipigon River. *O. rusticus* juveniles hatch earlier, grow faster, are more aggressive than *O. virilis* and reach a larger size than *O. propinquus*. Therefore, *O. rusticus* has the competitive advantage and will normally dominate or even eliminate the native species *O. virilis* and the introduced *O. propinquus*.

Water depths and temperature can also inhibit further range extensions of crayfish. During droughts, movement is limited due to reduced current flow which in turn inhibits travel and enhances the occurrence of shallow water obstacles. However, during high water, passive downstream movements may be assisted. In turn flooding may allow crayfish, *via* inundation of the floodplain, to surpass upstream barriers. Water temperatures are important in controlling crayfish movement. At low temperatures (<10C) crayfish are less active. This might inhibit rapid expansion in open waters which warmer temperatures will assist expansion into sheltered warmer bays, (*e.g.* Black Bay and Pine Bay) of Lake Superior.

V. REFERENCES

Capelli, G. 1975. Distribution, life history, and ecology of crayfish in northern Wisconsin. Ph.D. Thesis. University of Wisconsin. pp. 215.

Crocker, D.W. and D.W. Barr. 1968. Handbook of the crayfishes of Ontario. Univ. of Toronto Press. 158 p.

Hobbs III, H.H. and J.P. Jass. 1988. The crayfish and shrimp of Wisconsin. Milwaukee Public Museum. 177 p.

Momot, W.T. 1992. Further range extensions of the crayfish *Orconectes rusticus* in the Lake Superior Basin of Northwestern Ontario. Canadian Field-Naturalist 106(3). 397-399.

Momot, W.T. 1995. Redefining the role of crayfish in aquatic ecosystems. Reviews in Fisheries Science, 3(1):33-63.

Somers, K.N. and D.P.M. Stechey. 1986. Variable trappability of crayfish associated with bait type, water temperature, and lunar phase. The Am.Midl.Nat., 116(1):36-44.

Williams, T. 1995. The occurrence and life history of *Orconectes propinquus* in Nipigon, Ontario, HBSc Thesis, Lakehead University, 29 p.