

Rapid Communication**First records of alien crayfish of the *Procambarus acutus* species complex in Belgium**Kevin Scheers^{1,2,*}, Pieter Boets^{3,4}, Thomas Abeel⁵ and Tom Van den Neucker^{2,6}¹Research Institute for Nature and Forest (INBO), Havenlaan 88 bus 73, 1000 Brussels, Belgium²Biodiversity Inventory for Conservation NPO (BINCO), Walmersumstraat 44, 3380 Glabbeek, Belgium³Provincial Centre of Environmental Research, Godshuizenlaan 95, 9000 Ghent, Belgium⁴Ghent University, Department of Animal Science and Aquatic Ecology, Coupure Links 653, 9000 Ghent, Belgium⁵Odisee Campus Sint-Niklaas, Aqua-ERF, Hospitaalstraat 23, 9100 Sint-Niklaas, Belgium⁶University of Antwerp, Department of Biology, Ecosystem Management Research Group, Universiteitsplein 1C, 2160 Wilrijk, Belgium

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OPEN ACCESS**Abstract**

We present the first Belgian records of potentially invasive alien crayfish of the *Procambarus acutus* species complex, including the first confirmed record of *P. acutus acutus*. The species complex was observed at four different sites in three provinces in the north of the country. Only at one site the presence of a form I male specimen made identification to species level possible, based on gonopod morphology. The other three observations are considered as belonging to the *P. acutus* species complex. *Procambarus acutus acutus* is the fifth alien crayfish species known to Belgium. In Europe, it was previously only known as an established alien species from the Netherlands and Great Britain.

Key words: eastern white river crayfish, crawfish, invasive species, impact**Introduction**

While native crayfish are under serious threat and face extinction in many European countries (Boets et al. 2009, 2012; Holdich et al. 2009; Richman et al. 2015), the number of alien crayfish species has increased rapidly (Kouba et al. 2014). In Central and West-Europe there are to date twelve invasive alien crayfish species present with established populations (Kouba et al. 2014; Collas 2019a). Four of these, *Faxonius limosus* (Rafinesque, 1817), *Pacifastacus leniusculus* (Dana, 1852), *Pontastacus leptodactylus* (Eschscholtz, 1823) and *Procambarus clarkii* (Girard, 1852) are also well established in Belgium (Boets et al. 2012, 2016). Most alien crayfish species have only been introduced into Europe after 1990, and several are expanding their range (Holdich et al. 2009; Kouba et al. 2014). For instance, in 2019 alone, three new alien crayfish species were recorded for France – *Cherax destructor* Clark, 1936, *Faxonius rusticus* (Girard, 1852) and *Procambarus virginalis* Lyko, 2017 (Collas 2019a, b; Vigneron 2019).

One of the recently established species in Europe is the eastern white river crayfish *Procambarus acutus acutus* (Girard, 1852). *Procambarus acutus acutus* is a medium sized crayfish with a distinctive dark longitudinal dorsal fascia on the abdomen, a rather short rostrum, an open areola and black and white tubercles on the claws (Walls 2009). It strongly resembles *P. zonangulus* Hobbs & Hobbs, 1990 and study of the gonopod morphology of sexually mature (form I) males is necessary for identification (Swecker et al. 2010). According to Hobbs (1989), *P. acutus* s.l. is a species complex which includes *P. acutus acutus*, *P. acutus cuevachicae* Hobbs, 1941 and *P. zonangulus*. Further revision of this complex in its native range, using genetic methods, is necessary to disentangle this species complex (Filipová et al. 2011).

The native range of *P. acutus acutus* comprises large parts of the eastern United States, from Louisiana and Florida in the south to Minnesota and New York in the north (Taylor et al. 2007). However, its exact distribution is not well documented because of the taxonomic confusion with the morphologically similar *P. zonangulus*. Within the United States, introduced populations of *P. acutus acutus* occur in California, Connecticut, Kentucky, Maine, Massachusetts and Rhode Island (Taylor et al. 2007). In its native range, *P. acutus acutus* inhabits marshes, lakes and sometimes ditches or small to medium sized streams (Pflieger 1996). Together with several other species from the genus *Procambarus*, it is known to construct burrows, in which specimens can retreat for more than four months (CABI 2015; Huner and Barr 1991). In the 1980s, *P. acutus* was introduced into Egypt in the river Nile and seems to be well established there (Ibrahim et al. 1997). In Europe, an attempt to deliberately introduce *P. acutus* for aquaculture in Spain in the 1970s proved unsuccessful (Gutiérrez-Yurrita et al. 1999), but in 2005 the species was found in the Netherlands (Soes and van Eekelen 2006) and subsequently in Great Britain (Kouba et al. 2014). Since *P. acutus* s.l. was first recorded in the Netherlands, the species has expanded its range significantly (Soes and Koese 2010). This raises concerns that *P. acutus* s.l. may rapidly spread throughout continental Europe.

Here, we report the first records of the eastern white river crayfish *P. acutus acutus* and the *P. acutus* species complex in Belgium.

Materials and methods

This paper provides an overview of incidental observations made by the authors during two independent sampling campaigns. The first campaign concerned a fish inventory of the Molenbeek near Zandhoven (province of Antwerp) using electrofishing on May 23, 2019. The Molenbeek is a small, slow running lowland river, about 2 m wide, with riparian vegetation consisting of grass and sedges. The bottom consists mainly of sand with only a very thin silt layer (less than 5 cm). The water was turbid at the moment

of sampling. The second campaign carried out on July 17, 2019, concerned water sampling in a pond at Verrebroek (province of East-Flanders) as part of a monitoring project of aquatic habitats protected by the Habitats Directive. At the latter site, after the discovery of the first specimen of the *P. acutus* complex, a short targeted survey was carried out on July 19, 2019 in search of additional specimens, by looking under stones and amongst debris. Following these findings, all crayfish records with photographic evidence submitted by citizen scientists to the digital data platform www.waarnemingen.be were checked for additional records of the *P. acutus* species complex.

Results

On May 23, 2019 a single adult female individual belonging to the *P. acutus* complex was caught as by-catch of electrofishing during the fish inventory campaign in the Molenbeek stream (coordinates: 51°13.06'N; 4°42.91'E). This female specimen is deposited in the collection of the second author.

On July 17, 2019, a single dead female specimen of the *P. acutus* complex was found at the edge of a pond at Verrebroek, in the nature compensation reserve of Linkeroever (coordinates: 51°15.82'N; 4°11.78'E). During the short follow-up survey performed two days later, one live form I male (Figure 1) was found underneath a stone in shallow water, in a reed bed at the northern littoral zone of the pond. The morphology of the gonopods of this specimen (Figure 2) fits the description and figures of *P. acutus acutus* provided by Walls (2009) perfectly. They are notably symmetrical and lacking a distinct shoulder at the base of the cephalic process. These distinct features distinguish *P. acutus acutus* from *P. zonangulus* (Walls 2009) and allowed an unambiguous identification of the specimen as *P. acutus acutus*. The identity of this male specimen was confirmed by Dr. Christopher A. Taylor of the Prairie Research Institute, Illinois, USA (*pers. comm.*). Additionally, one live subadult female was collected from a burrow in a dried out, narrow ditch directly connected to the pond. This burrow consisted of molehill-like chimney 15 cm high with a 20–25 cm long vertical shaft leading to a chamber filled to about halfway with water (Figure 3). The two specimens collected on July 19, 2019 were deposited in the collection of the Royal Belgian Institute of Natural Sciences (RBINS) under the number I.G.34161 (register numbers INV.138413 (female specimen), INV.138414 (male specimen) and INV.138414/1 (first left gonopod of male specimen)).

Two earlier observations of specimens of the *P. acutus* complex were found on the digital data platform www.waarnemingen.be. In both cases the specimens were misidentified as *P. clarkii*. However, *P. clarkii* has distinctive red tubercles on the claws, a closed areola, a long and sharply protruding rostrum and lacks the distinctive blackish longitudinal fascia on the abdomen (Taylor et al. 2007). The first observation concerned one



Figure 1. Male specimen of *Procambarus acutus acutus* (Girard, 1852) collected at the site near Verrebroek. Photo by K. Scheers.

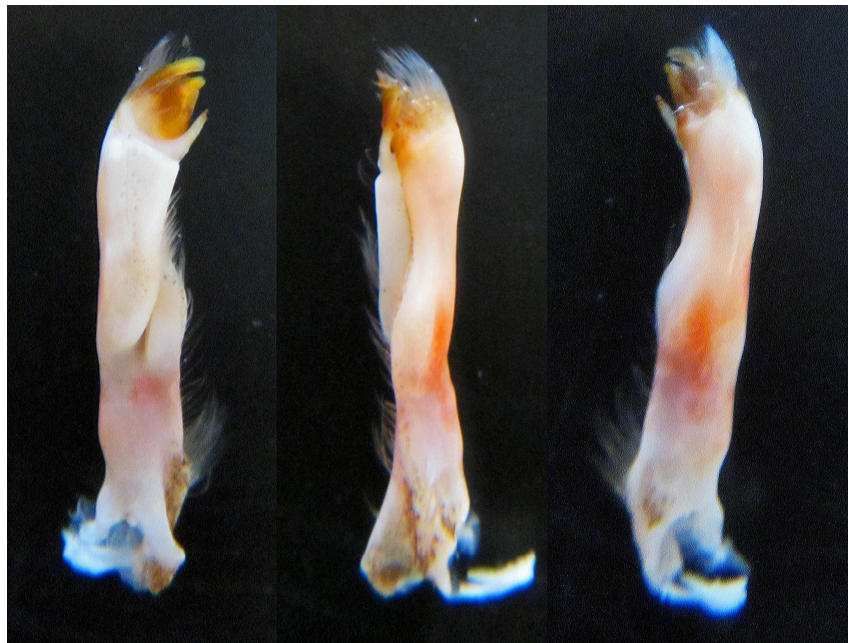


Figure 2. First left gonopod in mesial (left), caudal (middle) and lateral view (right) of form I male *Procambarus acutus acutus* (Girard, 1852) collected at Verrebroek. Photo by K. Scheers.



Figure 3. Underground burrow (with top of chimney removed for inside view) at the site near Verrebroek. In this burrow, one subadult female of *Procambarus* cf. *acutus acutus* was collected. Photo by K. Scheers.

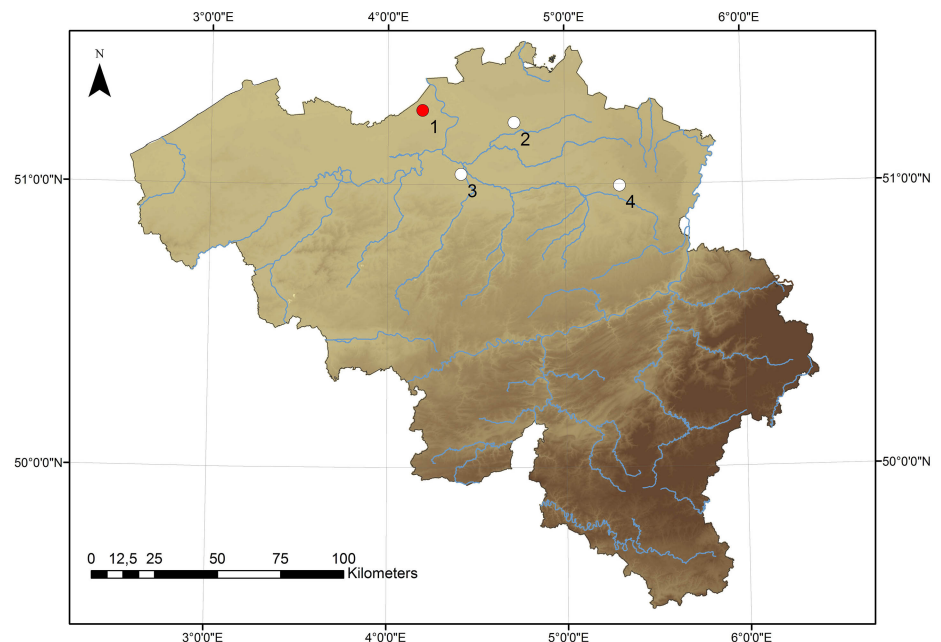


Figure 4. Records of *Procambarus acutus acutus* (Girard, 1852) (red dot) and the *P. acutus* species complex (white dots) in Belgium (1. Verrebroek, 2. Zandhoven, 3. Leest and 4. Zonhoven).

specimen of the *P. acutus* complex encountered on July 23, 2013 in a private garden in a residential area in Leest (Province of Antwerp) (coordinates: 51°2.16'N; 4°24.9'E), most probably escaped from a nearby garden pond. The second observation, from July 6, 2017, concerned a single specimen photographed on a hiking trail in the nature reserve Wijvenheide-Noord, near Zonhoven (Limburg) (coordinates: 50°59.64'N; 5°18.6'E). These two records were identified here solely based on the photographs of specimens in dorsal view available at the www.waarnemingen.be database, and were designated as belonging to the *P. acutus* species complex.

A map with all the records of the *P. acutus* complex in Belgium is presented in Figure 4.

Discussion

The revision of crayfish observations submitted to the digital data platform www.waarnemingen.be by citizen scientists revealed the presence of the *P. acutus* species complex in Belgium as early as 2013. However, the photographs provided by the citizen scientists lacked enough detail to determine the identity of the observed specimens as being either *P. acutus acutus*, *P. acutus cuevachicae* or *P. zonangulus*. As such, the male specimen collected at Verrebroek on July 19, 2019 should be regarded as the first confirmed record of *P. acutus acutus* in Belgium, as gonopod morphology allowed an unambiguous identification (Walls 2009). The capture of three specimens, including one subadult female and an adult pair, may indicate the existence of a viable population at Verrebroek. Although it may be reasonable to assume that all specimens of the *P. acutus* species complex caught at Verrebroek are, in fact, *P. acutus acutus*, genetic analyses of *P. cf. acutus* in the Netherlands revealed two divergent mitochondrial lineages within the same area, of which one was assigned to *P. acutus acutus* and the other to *P. zonangulus* (Filipová et al. 2011). Consequently, only genetic analysis of the female specimens collected at Verrebroek could provide absolute certainty about their identity.

How species from the *P. acutus* complex were introduced into Belgium is difficult to ascertain. In May 2011, multiple specimens were offered for sale in a store specialised in ornamental aquaculture about ten kilometres from the site at Verrebroek (T. Abeel *pers. obs.*). It is likely that specimens sold at such stores escaped from garden ponds or have been deliberately released (Drake et al. 2015).

It is unknown to which extent a further range expansion of *P. acutus* s.l. may have adverse effects. However, *P. acutus* s.l. may impair the stability of dykes due to its burrowing activity (Soes and Koese 2010). The species is known to construct burrows in which it retreats for reproduction and during droughts. Burrows consist of simple vertical shafts 30–40 cm deep, ending in an enlarged cul-de-sac, and up to five 15 cm-high chimneys may be present at their entrances (CABI 2015). The species can survive in a burrow for more than 4 months (Huner and Barr 1991).

The impacts of this species on native ecosystems are mostly unknown. However, they could be similar to those of most other invasive alien crayfish, especially of species belonging to the genus *Procambarus*. Many species are known to diminish submerge vegetation and have a negative impact on the clarity of the water (increasing turbidity) and, as a consequence, also on native biodiversity (Gherardi 2007; Soes and Koese 2010). In addition, many species, including *P. clarkii*, also predate on native molluscs, macroinvertebrates, amphibians and fish (Gherardi 2007). The native range of *P. acutus acutus* and *P. zonangulus* extends to more northern latitudes than that of *P. clarkii*, therefore both species are hardier

and tolerate lower temperatures. As such, although *P. clarkii* is an invasive species largely established and widespread in Europe, *P. acutus acutus* and *P. zonangulus* may have a competitive advantage over *P. clarkii* in northern Europe (Soes and Koese 2010). Several invasive alien crayfish species of American origin have been identified as carriers of the fungus *Aphanomyces astaci* Schikora, 1906, which causes crayfish plague (Tilmans et al. 2014), the main cause of the decline of native crayfish species in Europe (Holdich et al. 2009; Richman et al. 2015). *Procambarus acutus* is expected to be a vector for *A. astaci*, although this pathogen has not yet been detected in *P. acutus* specimens (Tilmans et al. 2014; CABI 2015). More research on the introduced populations of the *P. acutus* species complex is necessary to better understand its potential impacts and invasiveness.

Early detection and rapid communication towards the authorities of potentially invasive species such as *P. acutus* are crucial for developing effective management strategies (Adriaens et al. 2018). Future monitoring is necessary to assess the size of the *P. acutus* species complex populations in Zandhoven and Verrebroek and to confirm the presence, or absence, of the species in nearby ponds. Although eradication of freshwater crayfish species is usually not possible, it may be feasible if the populations are small and localized. As such, because the distribution of *P. acutus* s.l. in Belgium is probably still limited, it is urgent to assess the status of these populations, to prevent further spread and to evaluate the feasibility of eradication.

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References

- Adriaens T, Vandegheuchte M, Casaer J (2018) Guidance for drafting best management practices for invasive alien species. Reports of the Research Institute for Nature and Forest 2018 (68). Research Institute for Nature and Forest, Brussels, 35 pp
- Boets P, Lock K, Cammaerts R, Plu D, Goethals PLM (2009) Occurrence of the invasive crayfish *Procambarus clarkii* (Girard, 1852) in Belgium (Crustacea: Cambaridae). *Belgian Journal of Zoology* 139(2): 173–175
- Boets P, Lock K, Adriaens T, Mouton A, Goethals PLM (2012) Distribution of crayfish (Decapoda, Astacoidea) in Flanders (Belgium): an update. *Belgian Journal of Zoology* 142(1): 86–92
- Boets P, Brosens D, Lock K, Adriaens T, Aelterman B, Mertens J, Goethals P (2016) Alien macroinvertebrates in Flanders (Belgium). *Aquatic Invasions* 11: 131–144, <https://doi.org/10.3391/ai.2016.11.2.03>
- CABI (2015) *Procambarus acutus acutus*. CAB International. <http://www.cabi.org/isc/datasheet/67841> (accessed 17 January 2020)
- Collas M (2019a) Premier signalement de l'écrevisse à taches rouges *Faxonius rusticus*, Girard 1852 en Europe, France (département de L'aveyron). <http://especes-exotiques-envahissantes.fr> (accessed 21 January 2020)
- Collas M (2019b) Premier signalement de l'écrevisse marbrée (*Procambarus virginalis*) en France. <http://especes-exotiques-envahissantes.fr> (accessed 21 January 2020)

- Drake DAR, Mercader R, Dobson T, Mandrak NE (2015) Can we predict risky human behaviour involving invasive species? A case study of the release of fishes to the wild. *Biological Invasions* 17: 309–326, <https://doi.org/10.1007/s10530-014-0729-7>
- Filipová L, Grandjean F, Chucholl C, Soes D.M., Petrusek A (2011) Identification of exotic North American crayfish in Europe by DNA barcoding. *Knowledge and Management of Aquatic Ecosystems* 401: 11, <https://doi.org/10.1051/kmae/20111025>
- Gherardi F (2007) Understanding the impact of invasive crayfish. In: Gherardi F (ed), *Biological invaders in inland waters: profiles, distribution, and threats*. Springer, Dordrecht, pp 507–542, https://doi.org/10.1007/978-1-4020-6029-8_28
- Gutiérrez-Yurrita PJ, Martínez JM, Bravo-Utrera MA, Montes C, Ilhéu M, Bernardo JM (1999) The status of crayfish populations in Spain and Portugal. In: Gherardi F, Holdich DM (eds), *Crayfish in Europe as alien species. How to make the best of a bad situation?* A.A. Balkema, Rotterdam, pp 161–192, <https://doi.org/10.1201/9781315140469-12>
- Hobbs HH (1989) An illustrated checklist of the American crayfishes (Decapoda: Astacidae, Cambaridae, and Parastacidae). Smithsonian Contributions to Zoology. Smithsonian Institution Press, Washington DC, 236 pp, <https://doi.org/10.5479/si.00810282.480>
- Holdich DM, Reynolds JD, Souty-Grosset C, Sibley PJ (2009) A review of the ever increasing threat to European crayfish from nonindigenous crayfish species. *Knowledge and Management of Aquatic Ecosystems* 11: 394–395, <https://doi.org/10.1051/kmae/2009025>
- Huner JV, Barr JE (1991) Red swamp crayfish: biology and exploitation. Sea Grant College Program, Centre for Wetland Resources, Louisiana State University, Baton Rouge, 136 pp
- Ibrahim AM, Khalil MT, Mubarak MF (1997) Ecological studies on the Exotic crayfish, *P. clarkii* and *P. zonangulus* in the River Nile, Egypt. *International Journal of Ecology and Environmental Sciences* 23: 217–228
- Kouba A, Petrusek A, Kozák P (2014) Continental-wide distribution of crayfish species in Europe: update and maps. *Knowledge and Management of Aquatic Ecosystems* 413: 1–31, <https://doi.org/10.1051/kmae/2014007>
- Pflieger WL (1996) The crayfishes of Missouri. Missouri Department of Conservation, Jefferson City, Missouri, 152 pp
- Richman NI, Böhm M, Adam SB, Alvarez F, Bergey EA, Bunn JJS, Burnham Q, Cordeiro J, Coughran J, Crandall KA, Dawkins KL, DiStefano RJ, Doran NE, Edsman L, Eversole AG, Füreder L, Furse JM, Gherardi F, Hamr P, Holdich DM, Horwitz P, Johnston K, Jones CM, Jones JPG, Jones RL, Jones TG, Kawai T, Lawler S, López-Mejía M, Miller RM, Pedraza-Lara C, Reynolds JD, Richardson AMM, Schultz MB, Schuster GA, Sibley PJ, Souty-Grosset C, Taylor CA, Thoma Roger F, Walls J, Walsh TS, Collen B (2015) Multiple drivers of decline in the global status of freshwater crayfish (Decapoda: Astacidea). *Philosophical Transactions of the Royal Society* 370: 1–11, <https://doi.org/10.1098/rstb.2014.0060>
- Soes D, Koese B (2010) Invasive crayfish in the Netherlands: a preliminary risk analysis, EISNederland and Bureau Waardenburg, Leiden, 69 pp
- Soes D, van Eckelen R (2006) Rivierkreeften, een oprukkend probleem? *De Levende Natuur* 107(2): 56–59
- Swecker CD, Jones TD, Kilian JV, Roberson LF (2010) Key to the crayfish of Maryland. Maryland Department of Natural Resources, Annapolis, 35 pp
- Taylor CA, Schuster GA, Cooper JE, DiStefano RJ, Eversole AG, Hamr P, Hobbs III HH, Robison HW, Skelton CE, Thoma RF (2007) A reassessment of the conservation status of crayfishes of the United States and Canada after 10+ years of increased awareness. *Fisheries* 32: 373–389, [https://doi.org/10.1577/1548-8446\(2007\)32\[372:AROTCS\]2.0.CO;2](https://doi.org/10.1577/1548-8446(2007)32[372:AROTCS]2.0.CO;2)
- Tilmans M, Mrugała A, Svoboda J, Engelsma MY, Petie M, Soes DM, Nutbeam-Tuffs S, Oidtmann B, Roessink I, Petrusek A (2014) Survey of the crayfish plague pathogen presence in the Netherlands reveals a new *Aphanomyces astaci* carrier. *Journal of Invertebrate Pathology* 120: 74–79, <https://doi.org/10.1016/j.jip.2014.06.002>
- Vigneron T (2019) Premier signalement de *Cherax destructor* en milieu naturel en France (Bretagne). <http://especes-exotiques-envahissantes.fr> (accessed 21 January 2020)
- Walls JG (2009) *Crawfishes of Louisiana*. Louisiana State University Press, Baton Rouge, US, 256 pp