Research Brief

An alien ectosymbiotic branchiobdellidan (Annelida: Clitellata) adopting exotic crayfish: a biological co-invasion with unpredictable consequences

Iván Vedia,[1] Javier Oscoz,[1] Juan Rueda,[2] Rafael Miranda,[1]* Eduardo M. García-Roger,[2] Enrique Baquero,[1] and Stuart R. Gelder[3]

[1] *Department of Environmental Biology, University of Navarra, Pamplona, Navarra, Spain*
[2] *Cavanilles Institute for Biodiversity and Evolutionary Biology, University of Valencia, Burjassot, Spain*
[3] *Department of Math-Science, University of Maine at Presque Isle, ME, USA*
**Corresponding author: rmiranda@unav.es*

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Abstract

Invasive alien species present a global threat to biodiversity, particularly where pathogens and symbionts are involved. Branchiobdellidans are clitellate annelids with an obligate ectosymbiotic association primarily on astacoidean crayfish. There are several examples of branchiobdellidan species adopting a geographically exotic host where endemic and exotic crayfishes cohabit the same water body. The first records of a western North American branchiobdellidan, *Xironogiton victoriensis*, adopting the eastern North American crayfish, *Procambarus clarkii*, in 2 river basins in Spain provide further evidence of the ectosymbionts' tolerance to adopt an exotic host. Given worldwide translocations of these and other commercial crayfish species, limnologists and agency managers need to be alert for further introductions of *X. victoriensis* and other branchiobdellidans. Impacts of these exotic ectosymbionts on habitat and biota at a new location are unknown, as are their consequences on native biodiversity.

Key words: biological conservation, dispersal, freshwater, invasive species, invertebrates, *Xironogiton victoriensis*

Introduction

Biological invasions are serious global phenomena that threaten biodiversity of freshwater fauna and flora in particular (Dudgeon et al. 2006). Invasive alien species are leading to increasing global biogeographical homogeneity, with widespread ecological and evolutionary implications (Olden et al. 2004). Pathogens of these alien host species are adding a further concern to the increasing number of biological invasives, particularly symbionts associated with translocated hosts that in turn infect native hosts (Prenter et al. 2004).

North American crayfishes, signal crayfish *Pacifastacus leniusculus* (Dana, 1852) and red swamp crayfish *Procambarus clarkii* (Girard, 1852), are considered a major threat to stream ecosystems in Europe, where these species have been successfully introduced. Native European crayfishes have been driven to local extinction as a result of crayfish plague, *Aphanomyces astaci* (Schikora, 1906), introduced from the North American crayfishes (Vedia and Miranda 2013). These crayfishes are hosts to other exotic pathogens and symbionts, such as the branchiobdellidans.

Branchiobdellidans, or crayfish worms, are clitellate annelids with an obligate ectosymbiotic association primarily on astacoidean crayfish (Gelder and Williams 2015). The worms form a monophyletic order, Branchiobdellida (Annelida: Clitellata), with a discontinuous Holarctic distribution (Gelder 1999). Of the 22 genera, 6 are endemic to the Palaearctic and 16 to the Nearctic realms. These 2 realms each contain 2 distinct regions: the Euro-Mediterranean and East Asia, and Eastern and Western North America (separated by the Continental Divide; Bănărescu 1990). Genera in North America are

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endemic to either eastern or western regions, and 3 genera have species in both regions, although these species are similarly restricted to only one region or the other. The ectosymbiont's crayfish hosts are also endemic to these respective regions.

Although most branchiobdellidans live on freshwater crayfish, some species have adopted other crustaceans such as isopods, crabs, and shrimps (Holt 1973a, 1973b, Gelder et al. 2002), and some of these, such as *Cambarincola mesochoreus* (Hoffman, 1963), occur on both crayfish and estuarine crabs (Gelder and Messick 2006). Locations where a branchiobdellidan seem to be host species-specific are more likely the result of limited host availability in the area, for example *Uglukodrilus hemophagus* (Holt, 1977) and *Sathodrilus* spp. (Holt, 1981).

Branchiobdellidans adaptability and acceptability of new hosts can be explored where endemic and exotic crayfishes cohabit the same water body. The North American spinycheek crayfish, *Orconectes limosus* (Rafinesque, 1817), was first translocated to Poland in 1890 and has successfully spread in Europe to Italy, England, and the Pyrenees Mountains (Souty-Grosset et al. 2006). Vogt (1999) observed sympatric populations of stone crayfish, *Austropotamobius torrentium* (Schrank, 1803), and *O. limosus* in a tributary to Steinbeck Creek (Hess, Germany), where both hosts carried European *Branchiobdella parasita* (Henle, 1805) and *B. pentodonta* (Whitman, 1892). A similar adoption of *O. limosus* by these 2 *Branchiobdella* species plus *B. balcanica* (Moszynski, 1938) and *B. hexadonta* (Gruber, 1883) was found in the Czech Republic (Ďuriš et al. 2006). Although no endemic branchiobdellidans have been introduced on *O. limosus*, 2 other exotic North American crayfishes, signal crayfish and red swamp crayfish, did bring some of their endemic branchiobdellidans into Europe (Gelder et al. 1999). A list of branchiobdellidan species reported on these 3 commercially important crayfish in North America is given in Gelder (2004); therefore, any branchiobdellidan found where these crayfishes have been introduced is likely on this list.

To date, only *C. mesochoreus* has been reported on exotic *P. clarkii* in northern Italy (Gelder et al. 1994). Subsequently, *P. clarkii* specimens were reported in the same area where white-clawed crayfish, *Austropotamobius pallipes* (Lereboullet, 1858), were found to carry *B. parasita* and *B. italica* (Canegallo, 1928). This sympatric association of crayfishes resulted in some *P. clarkii* being adopted by *B. parasita* and *B. italica*, but no *A. pallipes* were found with *C. mesochoreus* (Gelder et al. 1999). A new dimension to branchiobdellidan adoptions in the Euro-Mediteranean region was the first report of branchiobdellidan cocoons on Chinese mitten crabs, *Eriocheir sinensis* (Edwards, 1853), in Lake Dąbie, northwest Poland (Sobecka et al. 2011). This is the only non-crayfish host of branchiobdellidans in the region and indicates that *Branchiobdella* species are more adaptable to adopting additional crustacean hosts than previously thought.

Although *P. clarkii* were introduced into Japan in 1927 (Kawai et al. 2003) and soon spread across the country, no exotic branchiobdellidans have been found on them. In contrast, *P. leniusculus* were also introduced into Japan during the late 1920s (Kamita 1970), and they were subsequently found to have carried 3 branchiobdellidan species (Ohtaka et al. 2005). None of these exotic branchiobdellidans have been recorded on endemic *Cambaroides japonicus* (De Haan, 1841) or exotic *P. clarkia*, however. Signal crayfish in Europe with *Xironogiton victoriensis* (Gelder and Hall, 1990) are widely distributed from southern Scandinavia to Italy and westward to northern Spain (Gelder and Williams 2015).

Procambarus clarkii and *P. leniusculus* are quite common in the Iberian Peninsula (Vedia and Miranda 2013) and cohabit in several waterbodies (Oscoz et al. 2010); however, only studies in northern Spain have found *X. victoriensis* on *P. leniusculus* (Gelder 1999, Oscoz et al. 2010). Yet, while the Iberian Peninsula has only the endemic *Austropotamobius italicus* (Faxon, 1914), no branchiobdellidans are known to be associated with them (Gelder 1999). A meeting of *A. italicus* with either signal or red swamp crayfishes would almost certainly result in the death of *A. italicus*; therefore, exotic *X. victoriensis* or any other North American branchiobdellidan would not present a problem to endemic Iberian crayfish.

From rice fields in the Júcar Basin at Sueca, Valencia (39°17′22″N; 0°19′32″W), 2 specimens of *X. victoriensis* were found on *P. clarkii* (7 Dec 2012). Moreover, during the annual ecological sampling of selected waterbody sites in the Ebro Basin, Spain (16 July 2013), *P. clarkii* and *P. leniusculus* were collected in the Piedra River at Cimballa, Zaragoza (41°6′8″N; 1°46′31″W), and both carried *X. victoriensis*. Also, during the samplings of 2014 in the Ebro Basin, 12 specimens of *X. victoriensis* were found on *P. clarkii* (7 Aug 2014) in the Zadorra river at Villodas, Álava (42°50′6″N; 2°46′55″W). These are the first records of a western North American branchiobdellidan on an eastern North American crayfish. Signal crayfish is considered a "cold water" species, which tend to keep their distribution separate from "warm water" red swamp crayfish. While true in general, environmental conditions at some locations enable both crayfishes to cohabit (Oscoz et al. 2010). Such a situation has also been reported in Hokkaido, Japan (Nakata et al. 2006).

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Because *X. victoriensis* on *P. clarkii* in the Júcar Basin (Sueca) is 450 km from the reported Ebro Basin location (Villodas), such adoptions are likely more widespread than currently recognized, and more should be expected to arise. Although *P. clarkii* were introduced into California (Riegel 1959) and recently found in eastern Washington State, USA (Larson and Olden 2013), an exchange of endemic branchiobdellidans between the 2 host species has not been reported in these Pacific states, USA. Following the extensive worldwide translocations of these crayfishes, however, it is noteworthy that the first record of a western branchiobdellidan onto an eastern crayfish was observed in Spain.

Most branchiobdellidans, particularly *X. victoriensis*, have a nutritional relationship with their host, which, using ecological definitions of Boucher et al. (1982), can be commensal, parasitic, or mutualistic (reviewed in Skelton et al. 2013) as prevailing conditions such as abundance, microhabitat, and water quality, dictate. How and to what extent branchiobdellidans affect crayfish behaviour with respect to the local fauna, flora, and physical environment remain to be investigated, although efforts are being made (Brown and Lawson 2010). To date, *X. victoriensis* seem to be host-specific to signal crayfish; therefore, limnologists and agency managers have a further example of an exotic branchiobdellidan on an unexpected crayfish species. The effects of branchiobdellidans on wild crayfish species are unknown, which complicates any meaningful conservation measures. Both signal and red swamp crayfish have a significant impact on the introduced habitat's ecology, however, and, for the moment, authorities must focus on them (Usio and Townsend 2004).

Efforts by the European Union to identify and track expansions of exotic host and symbiont species will help develop strategies to maintain endemic diversity. Such monitoring also enables early detection of pathogens. These circumstances and our first report of an exotic branchiobdellidan and crayfish association emphasize the need for freshwater body monitoring and accurate identification of collected invertebrates worldwide. Monitors sorting samples can no longer rely entirely on existing taxonomic keys for a region, but must also be capable tracking and identifying new exotic species.

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