

Short communication

The spread of the parthenogenetic marbled crayfish, *Marmorkrebs* (*Procambarus* sp.), in the North American pet trade

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Abstract

The parthenogenetic marbled crayfish *Marmorkrebs* was discovered in the pet trade in Europe in the 1990s. Since then, its distribution through the pet trade has spread from Europe to other continents, including North America. North American pet owners were surveyed online with the aims of trying to track when *Marmorkrebs* entered the North American pet trade, the ways in which it spread through the pet trade, and how widely distributed *Marmorkrebs* are throughout the continent. *Marmorkrebs* have been in the North American pet trade since at least 2004, with the number of people increasing every year. While many *Marmorkrebs* are sold through online sources, face-to-face personal contacts account for almost as many acquisitions. The increasing spread of *Marmorkrebs* through the pet trade increases the probability that *Marmorkrebs* will be released into North American ecosystems.

Key words: crustacean, aquaria, hobbyists

Marmorkrebs are an entirely female lineage of crayfish that reproduces by parthenogenesis (Scholtz et al. 2003; Martin et al. 2007). *Marmorkrebs* appear to be closely related to *Procambarus* species in the southeastern United States (Scholtz et al. 2003; Keith Crandall, personal communication), but there is no known native founder population of *Marmorkrebs*. They were discovered in the pet trade (Scholtz et al. 2003), and have since been introduced into natural ecosystems (Blanke and Schulz 2003; Martin et al. 2010; Holdich and Pöckl 2007; Marzano et al. 2010; Jones et al. 2009; Kawai et al. 2009). Attempts to uncover the original source of these animals have failed, with information arising being described as “totally confusing and unreliable” (Vogt et al. 2004). Marzano and colleagues (2009) reported a rumour that *Marmorkrebs* were a transgenic experiment in Hong Kong that was released accidentally, but their cited source makes no such claim.

Since their discovery, there has been great concern about the possibility that *Marmorkrebs* could become an invasive species; in fact, *Marmorkrebs* were dubbed “the perfect invader” (Jones et al. 2009). These fears are no doubt founded on the fact that many other crayfish

species have become invasive (Gherardi 2006; Holdich and Pöckl 2007; Holdich et al. 2009), including members of the genus *Procambarus*. To date, *Marmorkrebs* have been introduced into multiple countries on two continents: Germany (Blanke and Schulz 2003; Martin et al. 2010), the Netherlands (Holdich and Pöckl 2007), Italy (Marzano et al. 2009), and Madagascar (Jones et al. 2009; Kawai et al. 2009). Whether these introductions are deliberate or accidental is unclear, but there is great concern that these introductions could result in *Marmorkrebs* becoming an invasive species, particularly in Madagascar. That *Marmorkrebs* are parthenogenetic means that the risk of release creating a self-sustaining population is much greater than for similar sexually reproducing species. While a lone male, for instance, cannot create a new population alone, a parthenogenetic female certainly can.

The pet trade has been the source of many introductions of alien species that have been unwanted or invasive (Duggan 2010). The pet trade could become a major pathway for *Marmorkrebs* to be released into natural ecosystems. First, *Marmorkrebs* circulated in the European pet trade for several years before the first major scientific publication about them

(Scholtz et al. 2003). Second, Marmorkrebs are the only known parthenogenetic crayfish, which gives them a high novelty value that is attractive to pet owners. Third, they are being actively promoted as pets to hobbyists (Robbins 2009). The goal of this project was to discover when Marmorkrebs were introduced into, and how Marmorkrebs are spreading through, the pet trade in North America.

An electronic survey was created, then reviewed and approved by The University of Texas-Pan American's Institutional Review Board for human subjects research (IRB#2009-02-01). The survey included the following questions (among others; see Jimenez and Faulkes 2010 for other questions in the survey related to animal care):

- About what year did you get your first Marmorkrebs?

- Where did you get your first Marmorkrebs from?

- Where do you live?

- Have any of your Marmorkrebs reproduced successfully?

- Optional: If you are willing to be contacted for follow-up questions, please leave an email address.

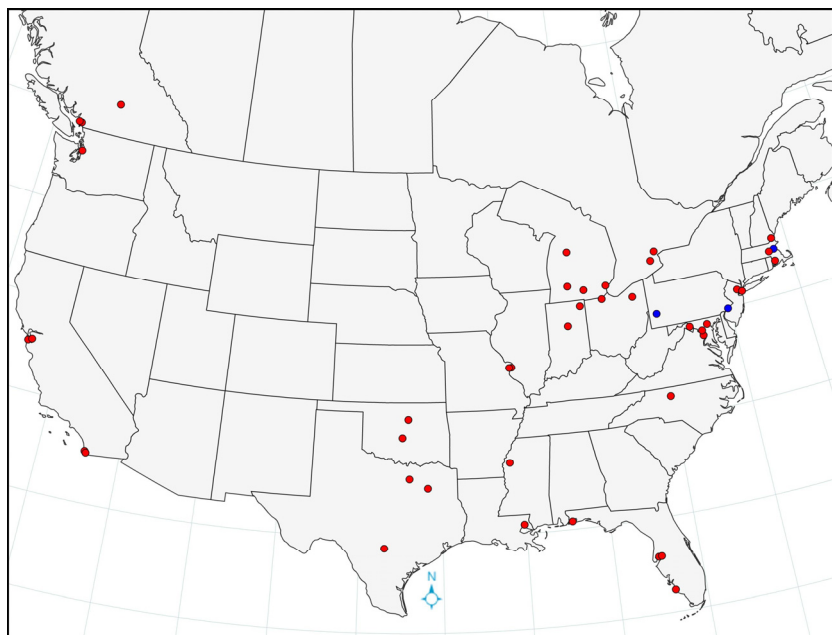
The survey was run using the SurveyMonkey service (<http://surveymonkey.com>). A link to the

survey was placed on home page of the Marmorkrebs.org website (<http://marmorkrebs.org> and <http://marbledcrayfish.org>) from 20 January 2009 to 20 January 2010. Visits to Marmorkrebs.org were tabulated using Google Analytics (<http://www.google.com/analytics>). Locations of survey takers were plotted using Google Maps (<http://maps.google.com>) and Indiemapper (<http://indiemapper.com>).

During the survey period, the Marmorkrebs.org website received 2,716 visitors, most of which came from the United States. 55 respondents completed the survey. Five respondents were removed from the analysis: one because the respondent was not over 18 as required by the survey; three because the respondents did not live in North America; one because the respondent did not own Marmorkrebs, leaving 50 responses for analysis. The survey could be submitted without answering all the questions; i.e., respondents could skip over some questions and leave the answers blank. Thus, some totals given below are less than 50.

Respondents were located across 20 U.S. states and two Canadian provinces (Figure 1). The majority of pet owners responding were in the eastern regions of the United States. The distribution of Marmorkrebs owners probably reflects the population density of these regions.

Figure 1. Distribution of pet owners keeping Marmorkrebs as pets across North America. Blue markers are locations reporting two respondents.



The earliest report of Marmorkrebs being available in the North American pet trade was in 2004, just one year after the first scientific paper in English on Marmorkrebs (Scholtz et al. 2003). Acquisitions have increased sharply from 2007 onwards (Figure 2).

About 66% (30 out of 45) of acquisitions were made “in person,” either from a friend, acquaintance, or relative (collectively labelled as “Friend”), a pet store, or an aquarium club (Figure 3). Interestingly, purchases on the internet rose in 2008, while those from pet stores and aquarium clubs increased in 2009, which is perhaps indicative of Marmorkrebs becoming more “mainstream” in the pet trade.

About 33% (15 out of 45) reported getting their animals from online sources (Figure 3). Of these, eight named the source website; these included MarbledCrayfish.com (<http://marbledcrayfish.com>), eBay (<http://ebay.com>), Aquabid (<http://aquabid.com>), and BlueCrayfish.com (<http://bluecrayfish.com>).

That Marmorkrebs have been distributed in the North American pet trade since 2004 is somewhat surprising, given that the first major scientific publication was only the previous year (Scholtz et al. 2003). Although this survey was unable to pinpoint the time or location of the original introduction of Marmorkrebs into the North American pet trade, it seems that the informal networking of aquarium hobbyists has played a larger role in the initial distribution of Marmorkrebs through the last decade as opposed to organized promotion of Marmorkrebs as pets by businessmen. Nevertheless, one website in particular, MarbledCrayfish.com, has been actively promoting Marmorkrebs as pets and aquaculture, as evidenced in part by the owner’s article in one of the leading hobby magazines (Robbins 2009). It seems highly likely that the number of people keeping Marmorkrebs as pets will continue to rise, thus increasing the risk of Marmorkrebs establishing themselves in North America.

Marmorkrebs are highly appealing for hobbyists because their marbling is pretty, and pet owners crave the unusual and often enjoy breeding animals. Given the poor track record of the pet trade in containing aquatics to their tanks, policy and plans should be enacted in advance to prevent introductions, and mitigate any that may occur – an event that, unfortunately, seems inevitable. Many North American jurisdictions have no laws concerning crayfish imports, exports, release, or sales, and monitoring trade of

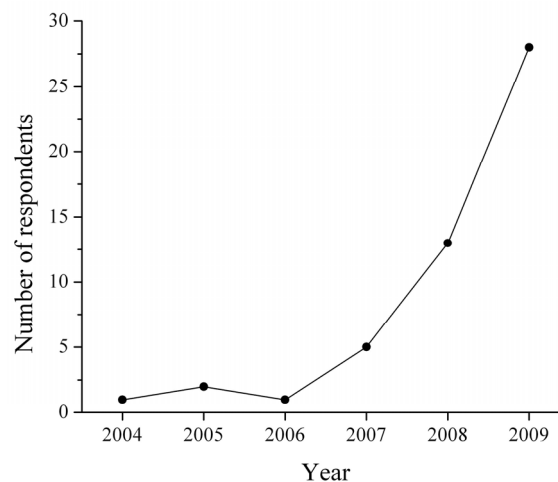


Figure 2. Year in which respondents reported obtaining their first Marmorkrebs.

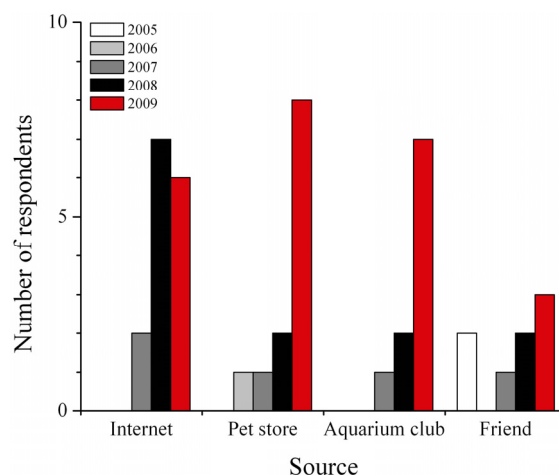


Figure 3. Sources from which respondents reported getting their first Marmorkrebs.

such small, easily transported animals is extremely difficult. The apparent increase in the proportion of Marmorkrebs reported as being bought through pet stores suggests that major commercial retailers should be provided with the best possible information about the ecological risks posed by Marmorkrebs.

The genus *Procambarus* unquestionably originated in North America (Hobbs 1984). If Marmorkrebs are introduced into North America, Marmorkrebs’ invasive potential may be somewhat limited by competition with other species of their genus, which would presumably fill some of the same ecological niches. It is also

possible that Marmorcrebs may prove to be well adapted to the habitat their genus evolved in, and may be more liable to becoming irrevocably established in the wild should they be introduced.

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References

- Blanke D, Schulz H (2003) Situation des Edelkrebses (*Astacus astacus* L.) sowie weiterer Flusskrebsarten in Niedersachsen. Tagungsbericht der Deutschen Gesellschaft für Limnologie (DGL), Braunschweig, 2002. Werder, DGL: 385–389
- Duggan I (2010) The freshwater aquarium trade as a vector for incidental invertebrate fauna. *Biological Invasions*, doi: 10.1007/s10530-010-9768-x
- Gherardi F (2006) Crayfish invading Europe: The case study of *Procambarus clarkii*. *Marine and Freshwater Behaviour and Physiology* 39: 175–191, doi: 10.1080/10236240600869702
- Hobbs HH, Jr. (1984) On the distribution of the crayfish genus *Procambarus* (Decapoda: Cambaridae). *Journal of Crustacean Biology* 4: 12–24, doi:10.2307/1547892
- Holdich DM, Pöckl M (2007) Invasive crustaceans in European inland waters. *Biological Invaders in Inland Waters: Profiles, Distribution, and Threats*. Gherardi F. Dordrecht, The Netherlands, Springer, pp 29–75, doi:10.1007/978-1-4020-6029-8_2
- Holdich DM, Reynolds JD, Souty-Grosset C, Sibley P (2009) A review of the ever increasing threat to European crayfish from non-indigenous crayfish species. *Knowledge and Management of Aquatic Ecosystems* 394–395: 11, doi:10.1051/kmae/2009025
- Jimenez SA, Faulkes Z (2010) Establishment and care of a laboratory colony of parthenogenetic marbled crayfish, Marmorcrebs. *Invertebrate Rearing* 1: 10–18
- Jones JPG, Rasamy JR, Harvey A, Toon A, Oidtmann B, Randrianarison MH, Raminosoa N, Ravoahangimalala OR (2009) The perfect invader: a parthenogenetic crayfish poses a new threat to Madagascar's freshwater biodiversity. *Biological Invasions* 11: 1475–1482, doi: 10.1007/s10530-008-9334-y
- Kawai T, Scholtz G, Morioka S, Ramanamandimby F, Lukhaup C, Hanamura Y (2009) Parthenogenetic alien crayfish (Decapoda: cambaridae) spreading in Madagascar. *Journal of Crustacean Biology* 29: 562–567, doi: 10.1651/08-3125.1
- Martin P, Kohlmann K, Scholtz G (2007) The parthenogenetic Marmorcrebs (marbled crayfish) produces genetically uniform offspring. *Naturwissenschaften* 94: 843–846, doi: 10.1007/s00114-007-0260-0
- Martin P, Shen H, Füllner G, Scholtz G (2010) The first record of the parthenogenetic Marmorcrebs (Decapoda, Astacida, Cambaridae) in the wild in Saxony (Germany) raises the question of its actual threat to European freshwater ecosystems. *Aquatic Invasions* 5: 397–403, doi:103391/ai.2010.5.4.09
- Marzano FN, Scalici M, Chiesa S, Gherardi F, Piccinini A, Gibertini G (2009) The first record of the marbled crayfish adds further threats to fresh waters in Italy. *Aquatic Invasions* 4: 401–404, doi:10.3391/ai.2009.4.2.19
- Robbins M (2009) Owing clones. *Tropical Fish Hobbyist* 57: 72–74
- Scholtz G, Braband A, Tolley L, Reimann A, Mittmann B, Lukhaup C, Steuerwald F, Vogt G (2003) Parthenogenesis in an outsider crayfish. *Nature* 421: 806–806, doi: 10.1038/421806a
- Vogt G, Tolley L, Scholtz G (2004) Life stages and reproductive components of the Marmorcrebs (marbled crayfish), the first parthenogenetic decapod crustacean. *Journal of Morphology* 261: 286–311, doi:10.1002/jmor.10250