GLOBAL INVASIVE SPECIES DATABASE

FULL ACCOUNT FOR: ***Procambarus virginalis***

Procambarus virginalis **System:** Freshwater

Kingdom	Phylum	Class	Order	Family
Animalia	Arthropoda	Malacostraca	Decapoda	Cambaridae

Common name

Synonym

Similar species

Summary

The marmorkrebs is a parthenogenetically reproducing freshwater crayfish. One of it's major threats is the ability to establish viable populations from a single individual, which makes the incidence of introductions very easy and eradication nearly imposible. It's a popular species in the pet trade; this is the main pathway of introduction. Its origin is unknown, but it is though to originate from North America. It is currently introduced throughout much of central Europ and Madagascar, where its main impacts are the spread of pathogens to indigenous crayfish and its competitive ability.

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Species Description

Medium sized crayfish with an overall length of 13cm, although smaller specimens are common (Lyko, 2017). Its common name comes from the characteristic coloration of the carapace, a marmorated pattern that is more prominent in aquarium stocks than in wild individuals (Lyko, 2017). The overall coloration is dark brown or green, with darker spots forming the marmorated pattern. It has a light crem-tan median longitudinal stripe extending throughout its length, and a cream area between the cervical spines on its head (Kawai et al., 2009). Due to its recent discovery, there is little research about its behavioral characteristics. Studies on the closely related P. fallax show that it can exhibit a sporadic behavior, where periods of remaining in one location are interrupted by long travels in a short time to settle new locations (Van der Heiden, 2012). The formal description is as follows: Body pigmented, eyes well developed. Rostrum with marginal spine and lacking median carina. Carapace with cervical spine. Areola 5 to 7 times as long as wide, constituting 30 to 35 percent carapace length. Suborbital angle obtuse and weak. Postorbital ridge well developed with cephalic spine. Hepatic area punctate. Antennal scale approximately 2.5 times as long as wide, widest at midlength. Annulus ventralis bellshaped, about 1.6 times as broad as long, bisected by narrow furrow leading caudally into median depression. Sinus originating on median line, continuing longitudinally on anterior half, then curving dextrally before curving caudally before continuing and terminating on median line. Sternum immediately cephalic to annulus with no tubercles or projections and not overhanging annulus. Unadorned bell-shaped postannular sclerite with central longitudinal furrow, width similar to annulus. First pleopods present (Lyko, 2017).

Notes
This species was discovered in the aquarium trade in Germany in the 1990s (Scholtz et al., 2003). Its origin is unknown, as no primary wild populations have been found. Because its closest phylogenetic relationship is P. fallax, it is considered a North American species. It may have originated in the native range of its mother species or in captivity (Vogt, 2015). The common name “Marmorkrebs”, or marbled crayfish, comes from its spotted pattern, which makes it an attractive species in the pet trade, as well as the novelty factor of its parthenogenetic reproduction (Vogt et al., 2014). The taxonomy of the species was uncertain for many years, and it was temporarily called “Marmorkrebs” or P. fallax forma virginalis (Martin et al., 2010). Recently, it was formally described as an independent species under the name of Procambarus virginalis in Lyko, 2017. This stems from its reproductive incompatibility with wild P. fallax, and triploid genome. Global warming is a cause of concern for the establishment of populations in Europe. The low temperatures in Europe have been regarded as an obstacle for the establishment of populations, as they are below the optimum temperature for development and reproduction (Martin et al., 2010).

Lifecycle Stages
Its lifespan is around four years in a broad range of conditions. During this time, they can reproduce up to seven times (Vogt, 2015). Depending on the rearing temperature, the first spawning can occur at an age of 25 weeks, at 25°C, or 35 weeks, at 20°C. This also depends on day length cycles, as short-day illumination (6 h light/18 h dark) was shown to promote gonadal maturation, while long-day illumination (18 h light/6 h dark) inhibited maturation. Embryonic development lasts 17 to 22 days, after which the first two juvenile stages are non-feeding and permanently carried under the mother’s abdomen. After this, juveniles stay with their mother for two to five weeks. Their pigmentation gradually increases with molting, sexual characters are complete around two months after hatching, and sexual maturity is eventually reached at a length of roughly 4cm (Vogt et al., 2004).

Uses
They are very common in the pet market due to their ease of care and the novelty of a parthenogenic crayfish. This quality has also led to its use as a model organism in laboratory research (Scholtz et al., 2003; Martin et al., 2010). Despite it’s low value, it is harvested and sold alive for consumption in markets in Madagascar (Jones et al., 2009).

Habitat Description
Has been found in lentic and lotic freshwater systems (Lyko, 2017). They can survive at temperatures below 8°C and above 30°C for several weeks, but reproduction is halted and mortality increases (Vogt et al., 2004). They can establish in gravel pit lakes, ponds, canals, ditches, rivers, lakes, wetlands and rice paddies (Chucholl, 2014). The similar species P. fallax is not exclusively nocturnal, but can also travel in the day time, and may be able to travel 83 to 2139m per year in wetland systems similar to those of the Everglades in Florida (Van der Heiden, 2012).

Reproduction
This is the only known obligate parthenogenic decapod. It can reproduce throughout the year in captivity. At 20°C it has shown two prominent spawning periods, one before spring and another before autumn, which appear to be modulated by temperature (Vogt, 2015). Clutch sizes can range between 50 and over 270 eggs depending on the size of the individual. The species appears to consist of exclusively females, as no males have been identified. The external sexual characters and gonads are exclusively female (Vogt et al., 2004). Mating with P. fallax, can occur, but the result is the production of exclusively P. virginalis genotypes (Lyko, 2017). This species is triploid, showing 276 chromosomes in mitotic metaphase, compared to the 184 chromosomes of P. fallax (Martin et al., 2016).

Nutrition
Little research has been carried out as to the diet of individuals in the wild. The stomachs of individuals studied by Kawai et al., 2009, showed only vegetable substance. The related species P. fallax also prefers plant material, but can have a more extensive diet, including snails (Vogt et al., 2004).

General Impacts
Because this species is relatively new in most invasive habitats, its impacts on ecosystems have not been thoroughly assessed. Although variable, strongly negative ecological impacts are well known to occur from multiple introduced crayfish species, such as the signal crayfish. Experimentally, these have been shown to affect all levels of freshwater food webs. They can reduce the abundance of macrophytes, prey on invertebrates such as snails and mayflies, and even reduce the abundance of amphibians and fish (Twardochleb & Olden, 2013). Hence, preventative measures to avoid this resilient species from being established are very important. Pathogens North American crayfish are typically carriers of the Crayfish Plague, A. astaci, which can severely harm vulnerable European species (Liptak & Vitazkova 2015). Wild individuals of P. virginalis have been confirmed to be carriers of this pathogen (Keller et al., 2014), which makes them a threat to already-stressed indigenous crayfish in Europe. It has also been suggested that marmorkrebs may be carriers for the causative agent of Chytridiomycosis, as the closely related species P. alleni is (Chucholl, 2014). Individuals found with infections of putative rickettsia-like organisms, and sporozoans resembling coccidians of the Eimeriida group, also raise worries about their role as disease carriers in introduced ranges (Vogt et al., 2004). Competition Although this species appears to have low levels of aggression in aquaria, they have been shown experimentally to have the potential to compete with highly successful introduced species such as P. clarkii. While the incidence of fights between two marmorkrebs is low, interspecific fights occurred, with both species initiating conflict with similar frequencies. This suggests that, if introduced, they could be a serious threat to indigenous crayfish, due to their competitive ability and high fecundity (Jimenez & Faulkes, 2011).

Management Info
The high propagule pressure steming from the species' popularity in the pet trade is linked to its likelyhood of being introduced into nature. Hence, it's widely regarded that the most effective method of mitigating risk, by far, is limiting the availability in the trade market (Chucholl, 2014). This is because the parthenogenic reproduction of the crayfish make it particularly resistant against eradication (Chucholl et al., 2012). Legislation Several countries have banned this species and carreid out risk assessments for its introduction. These are complemented by predictive models to assess the likelyhood of establishment, which show the potential invasive range of the species (Chucholl, 2014). The EU Invasive Alien Species (IAS) Regulation (1143/2014) has included marmorkrebs since July 13, 2016 to prevent further introductions and spread ("Commission Implmenting Regulation", 2016). This regulation bans the species from being brought into, kept, except through permits, bred, placed in the market, exchanged or released into the environment in member states. Member states need to take necessary measures to achieve this ("Regulation (EU) No", 2014), but it has been difficult to enforce the ban because pet-owners are often ignorant of local law (Faulkes, 2014). A number of states in the United States of America have also baned this species (Faulkes, 2015a). Other forms of prevention and control Monitoring the pet trade to assess the popularity and prevalence of the species has been used to assess the risk of introductions in many countries (Uderbayeve et al., 2017; Patoka et al., 2014; Faulkes, 2015a; Faulkes, 2010). Both Ireland and Italy have introduced programs to raise awareness of invasive species in order to discourage pet owners from seeking out these species (Scalera et al., 2017; Faulkes, 2014). No active eradication programs exist, although control of populations has been attempted in Germany by maintaining stocks of predatory fish in affected lakes (Chucholl et al., 2012).

Pathway
Its popularity in the pet trade makes it difficult to assess the source location. The species is thought to have originated fom the United States.Its popularity in the pet trade makes it difficult to assess the source location. The species is thought to have originated fom the United States.

Principal source: Chucholl, C. (2014). Predicting the risk of introduction and establishment of an exotic aquarium animal in Europe: insights from one decade of Marmorkrebs (Crustacea, Astacida, Cambaridae) releases. Biol. Invasions, 5(4), 309-318. Faulkes, Z. (2015). Marmorkrebs (Procambarus fallax f. virginalis) are the most popular crayfish in the North American pet trade. Knowledge and Management of Aquatic Ecosystems, (416), 20. Lyko, F. (2017). The marbled crayfish (Decapoda: Cambaridae) represents an independent new species. Zootaxa, 4363(4), 544-552. Martin, P., Dorn, N. J., Kawai, T., van der Heiden, C., & Scholtz, G. (2010). The enigmatic Marmorkrebs (marbled crayfish) is the parthenogenetic form of Procambarus fallax (Hagen, 1870). Contributions to Zoology, 79(3). Vogt, G., Tolley, L., & Scholtz, G. (2004). Life stages and reproductive components of the Marmorkrebs (marbled crayfish), the first parthenogenetic decapod crustacean. Journal of Morphology, 261(3), 286-311.

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