

## First record of the invasive oriental shrimp *Palaemon macrodactylus* Rathbun, 1902 in France (Gironde Estuary)

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### Abstract

During summer 2006, the first specimens of the oriental shrimp *Palaemon macrodactylus* Rathbun, 1902 were identified in the Gironde Estuary (France). These specimens, which included ovigerous females, are confirmed present throughout a large part of the estuary, in large numbers compared to the local resident shrimp *Palaemon longirostris* Milne Edwards, 1837. Native to Asia, *P. macrodactylus* was first introduced in California (USA) in the 1950s, before being detected recently within several European estuaries, e.g. the Guadalquivir Estuary (Spain) and the Orwell Estuary (England). According to these records, *P. macrodactylus* appears to be a strong invader, able to colonise a wide geographical range.

Key words: France, Gironde Estuary, introduced species, *Palaemon macrodactylus*, Palaemonidae, shrimp

### Introduction

The oriental shrimp *Palaemon macrodactylus* Rathbun, 1902 is native to Japan, Korea and China (Kubo 1942, Rathbun 1902). In the 1950s, this shrimp was first recorded in San Francisco Bay, California (Newman 1963) where it is now a common and well-established species (Central Valley Bay Delta Branch 2006). It has also been found in Australia (Poore 2004). Since the end of the 1990s, *P. macrodactylus* has been found in several European waters: in Spain (Guadalquivir and Guadalete Estuaries, Salado River, San

Pedro River) (Cuesta et al. 2004), in England (Orwell Estuary, Suffolk) (Ashelby et al. 2004) and in the Southern Bight of the North Sea (d'Udekem d'Acoz 2005). During the same period, a first specimen was recorded in southern Atlantic waters in Mar del Plata Harbor (Argentina) (Spivak et al. 2006). According to all these studies, *P. macrodactylus* appears to be a very successful invader, able to colonise a wide geographical range.

In the Gironde Estuary, several invasive crustacean species have already been reported, such as the spiny-cheeked crayfish *Orconectes*

*limosus* Rafinesque, 1817 at the beginning of the 20th Century from North America (Laurent 1997, Souty-Grosset et al. 2006), the Chinese mitten crab, *Eriocheir sinensis* Milne-Edwards, 1853 in the 1930s from South-eastern Asia (Hoestlandt 1959), the isopod *Synodotea laticauda* Benedict, 1897 during the 20th Century from East Asia (Mees and Fockedey 1993, Poore 1996), the copepod *Acartia tonsa* Dana, 1848 in the 1970s from North and South America (Brylinsky 1981, Castel 1981) and the red swamp crayfish *Procambarus clarkii* Girard, 1852 in the 1980s from Louisiana, USA (Laurent 1997, Noël 1993, Souty-Grosset et al. 2006).

In this short communication, we report for the first time the presence of *P. macrodactylus* in French waters, specifically in the Gironde Estuary.

### Study area, Materials and Methods

The Gironde Estuary (45°20'N, 0°45'W), with an area of 635 km<sup>2</sup>, is the largest estuary in Western Europe (Figure 1). About 20 species of Decapoda have been inventoried in this estuary (Mauvais and Guillaud 1994) and the genus *Palaemon* is well represented with four species. Among these, the white shrimp *Palaemon longirostris* Milne Edwards, 1837, a resident species, represents large population throughout the estuary (Aurousseau 1984, Girardin et al. 2005, Sorbe 1983) and supports a traditional fishing industry.

Since 1979, a large part of the estuary (Figure 1) within a 20 km area around the nuclear power plant had been sampled monthly for fauna survey (mainly fishes and crustaceans) (Girardin et al. 2005). The water surface was sampled using two pushnets located on either side of the boat (section 4m x 1m, stretched mesh of 2.8mm at the end). The bottom was sampled using an Agassiz trawl consisting of a metal frame 2m x 1.2m kept at 0.2m from the bottom by skates with similar mesh size. Samplings were carried out only in daytime between the mid-flow and the slack period of the high tide. Each tow lasted about seven minutes.

The first specimens of *P. macrodactylus* were identified during the summer 2006. They were initially recognised by their colour pattern, especially their orange/pink coloration, which is not observed in *P. longirostris* in this estuary, and by the presence of a whitish longitudinal dorsal stripe running all along the back, which is

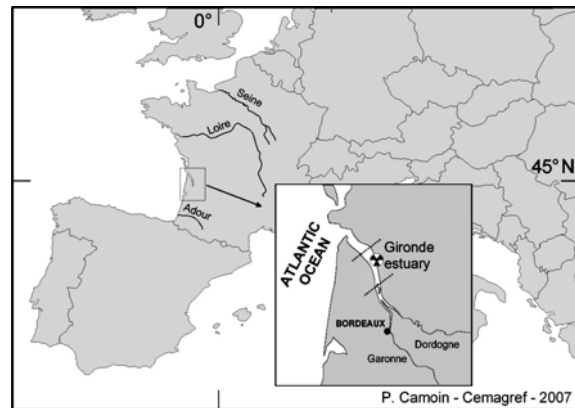


Figure 1. The Gironde Estuary and the sampling area (between dotted lines)

absent in European native Palaemonidae (d'Udekem d'Acoz et al 2005). A microscopic examination enabled us to confirm the finding. Indeed, *P. macrodactylus* can be identified with their rostrum which has 9 to 15 dorsal teeth and ventral margin with a double row of setae, with the shorter ramus of antennular flagellum fused for a quarter of its length to longer ramus and with the absence of protuberance above spine of the posterolateral margin of the sixth abdominal segment (Ashelby et al. 2004, Gonzalez-Ortegon and Cuesta 2006).

Additional samples collected during summer 1992, 1996, 1997, 1998, 1999 and 2002 in the same conditions have been examined in order to look for *P. macrodactylus*.

### Results and Discussion

Specimens of *P. macrodactylus* were first recorded in the Gironde Estuary during summer 2006 (Annex). Their presence was confirmed in all sampling stations, surface and bottom water, within a salinity range from 8 to 20 psu and representing 8 to 71% of the collected shrimps (*P. macrodactylus* and *P. longirostris*). Similarly to *P. longirostris*, *P. macrodactylus* was more abundant in the bottom samples.

Therefore, according to these first observations, it appears that *P. macrodactylus* already make up a major proportion of the estuarine shrimp population during summer 2006. Several ovigerous females were identified in the August samples (Figures 2 and 3), indicating that the population of *P. macrodactylus* might be established in the area, with reproducing specimens.

Due to their similar morphologies, it is not easy to distinguish between the exotic species (*P. macrodactylus*) and the local species *P. longirostris*. The coloration criterion, which helps for initial identification, is useless within the Gironde Estuary due to the high turbidity (1g/l to 10g/l, exceptionally 400g/l) (Sottolichio and Castaing 1999) which tends to enhance a loss of coloration in all organisms (Figures 2 and 3). The specimens observed had almost no coloration compared with specimens found in the Netherlands for example. This might explain the fact that *P. macrodactylus* has not previously been identified.

The examination of several samples from 1992, 1996 and 1997 revealed no *P. macrodactylus* specimens. One specimen was found in a sample from 1998, followed by several in 1999 and 2000 samples, suggesting the presence of *P. macrodactylus* in the Gironde Estuary since at least 1998. Since it cannot be excluded that the species was already present, further anterior samples will have to be examined.

We found several specimens in the Adour Estuary in September 2006 (Annex). No *P. macrodactylus* specimens were found in samples from the Loire (2004 and 2006 samples) and Seine estuaries (2004 samples). More samples must be examined to determine whether this species has already invaded these estuaries.

The most probable cause of introduction may be the accidental transport of pelagic larvae in the ballast water of ships, as shown in previous cases (e.g. Carlton 1985). Inter-regional traffic is indeed well developed in the Gironde Estuary (Allain et al. 2006).

*P. macrodactylus* is very similar to the resident species *P. longirostris*. Both are strong osmoregulators (Born 1968, Campbell and Jones 1989) and are typical estuarine species with similar diets, consisting mainly of mysids and copepods (Siegfried 1982, Sitts and Knight 1979, Sorbe 1983). We can assume that food competition will take place between the two species and even with another common species, *Crangon crangon* Linnaeus, 1758. There is also evidence of cannibalism when individuals are kept in crowded laboratory conditions (Newman 1963), so the species could prey on other carideans in the estuaries. Moreover, each age group of *P. macrodactylus* produces at least two cohorts compared with only one or two for *P. longirostris* (Aurousseau 1984, Omori and Chida 1988).



Figure 2. *Palaemon macrodactylus*, ovigerous female, 50 mm, Gironde Estuary, France (Photography by M. Béguer)



Figure 3. *Palaemon macrodactylus*, ovigerous female, 45 mm, Gironde Estuary, France (Photography by M. Béguer)

We can assume that interactions between the two species could be considerable and could perhaps lead to a decrease in the native shrimp population abundance. In California, Ricketts et al. (1968) observed that *P. macrodactylus* was responsible for the disappearance of the native *Crangon* spp. Furthermore, Gil-Turnes et al (1989) found fungi associated with *P. macrodactylus* which, if confirmed in the Gironde, raises the possibility of new diseases being introduced that may affect the native shrimps.

In the Gironde Estuary, shrimps are an important food resource for many fish species (Pasquaud 2006) and form the basis of fish richness (Lobry 2004, Lobry et al. 2006). Thus, by representing a new or an additional resource for fish species, the spread of the *P. macrodactylus* population could also result in disturbance estuarine functioning.

In order to study the effect of this invasive species, we are currently sampling the estuary once a month (poly- to oligohaline zone). We focus particularly on the interaction between *P. macrodactylus* and the resident species *P. longirostris*, which is traditionally fished in the

Gironde Estuary. Samples collected between 1992 and 1998 will be examined to specify its apparition period and to detail the invasion in the Gironde Estuary. We also plan an extensive survey of the entire tidal estuary to determine its spatial distribution.

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## References

- Allain Y-M, Hellias A, Ribiere G, Genevois R and Le Dore F (2006) La gestion des estuaires dans une approche communautaire. Ministères des transports de l'équipement, du tourisme et de la mer, Ministère de l'écologie et du développement durable, Conseil Général des Ponts et Chaussées Inspection Générale de l'Environnement, 69 pp
- Ashelby CW, Worsfold TM and Franssen CHJM (2004) First records of the oriental prawn *Palaemon macrodactylus* (Decapoda: Caridea), an alien species in European waters, with a revised key to British Palaemonidae. *Journal of the Marine Biological Association of the United Kingdom* 84: 1041-1050
- Aurousseau J-M (1984) Eléments d'écologie de la crevette blanche, *Palaemon longirostris*, dans l'estuaire de la Gironde. Dynamique de la population et production. Thèse de doctorat, Biologie Animale mention Ecologie, Université Paris VI, Paris, 227 pp
- Born JW (1968) Osmoregulatory capacities of two caridean shrimps: *Siniperca kneri* (Atyidae) and *Palaemon macrodactylus* (Palaemonidae). *Biological Bulletin* 134: 235-244
- Brylinsky JM (1981) Report on the presence of *Acartia tonsa* Dana (Copepoda) in the harbour of Dunkirk (France) and its geographical distribution in Europe. *Journal of Plankton Research* 3: 255-260
- Campbell PJ and Jones MB (1989) Osmoregulation of the estuarine prawn *Palaemon longirostris* (Caridea: Palaemonidae). *Journal of the Marine Biological Association* 69: 261-272
- Carlton JT (1985) Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. *Oceanography and Marine Biology* 23: 313-371
- Castel J (1981) Aspects de l'étude écologique du plancton de l'estuaire de la Gironde. *Oceanis* 6: 535-578
- Central Valley Bay Delta Branch (2006) *Palaemon macrodactylus* in San Francisco Bay. Retrieved from <http://www.delta.dfg.ca.gov/baydelta/monitoring/pael.asp>. Cited 18 september 2006
- Cuesta JA, Gonzalez-Ortegon E, Drake P and Rodriguez A (2004) First record of *Palaemon macrodactylus* Rathbun, 1902 (Decapoda, Caridea, Palaemonidae) from European waters. *Crustaceana* 77: 377-380
- Gil-Turnes MS, Hay ME and Fenical W (1989) Symbiotic marine bacteria chemically defend crustacean embryos from a pathogenic fungus. *Science (Washington)* 246: 116-118
- Girardin M, Castelnaud G and Beaulaton L (2005) Surveillance halieutique de l'estuaire de la Gironde - suivi des captures 2003 - étude de la faune circulant 2004. p 195, Cemagref groupement de Bordeaux, Cestas
- Gonzalez-Ortegon E and Cuesta JA (2006) An illustrated key to species of *Palaemon* and *Palaemonetes* (Crustacea: Decapoda: Caridea) from European waters, including the alien species *Palaemon macrodactylus*. *Journal of the Marine Biological Association of the United Kingdom* 86: 93-102
- Hoestlandt H (1959) Répartition actuelle du crabe chinois (*Eriocheir sinensis*, H. Milne Edwards) en France. *Bulletin Français de la Pêche et de la Pisciculture* 194: 5-13
- Kubo I (1942) Studies on Japanese Palaemonoid Shrimps, III. Leander. *Journal of the Imperial Fisheries Institute* 35: 17-85
- Laurent PJ (1997) Introductions d'écrevisses en France et dans le monde, historique et conséquences. *Bulletin Français de la Pêche et de la Pisciculture* 344/345: 345-346
- Lobry J (2004) Quel référentiel de fonctionnement pour les écosystèmes estuariens ? Le cas des cortèges de poissons fréquentant l'estuaire de la Gironde. Thèse de Doctorat, CEMAGREF, Université de Bordeaux I, Bordeaux, 230 pp
- Lobry J, Lepage M and Rochard E (2006) From seasonal patterns to a reference situation in an estuarine environment: Example of the small fish and shrimp fauna of the Gironde estuary (SW France). *Estuarine Coastal and Shelf Science* 70: 239-250
- Mauvais JI and Guillaud JF (1994) Etat des connaissances sur l'estuaire de la Gironde. Agence de l'Eau Adour Garonne, Toulouse, 250 pp
- Mees J and Fockede N (1993) 1st Record of *Synidotea laevidorsalis* (Miers, 1881) (Crustacea, Isopoda) in Europe (Gironde Estuary, France). *Hydrobiologia* 264: 61-63
- Newman WA (1963) On the introduction of an edible oriental shrimp (Caridea, Palaemonidae) to San Francisco Bay. *Crustaceana* 5: 119-132
- Noël P (1993) Atlas des crustacés décapodes de France (espèces marines et d'eaux saumâtres) : état d'avancement du 28-06-1993. SFF et BIMM/MNHN, CSP, Ministère de l'environnement, Paris, 96 pp
- Omori M and Chida Y (1988) Life history of the caridean shrimp *Palaemon macrodactylus* with special reference to the difference in reproductive features among ages. *Nippon Suisan Gakkaishi* 54: 365-375
- Pasquaud S (2006) Les relations trophiques : éléments de structuration des peuplements ichthyologiques en milieu estuarien - Application à l'estuaire de la Gironde. Thèse de doctorat, CEMAGREF, Université de Bordeaux I, Bordeaux, 361 pp

- Poore GCB (1996) Species Differentiation in *Synidotea* (Isopoda: Idoteidae) and recognition of introduced marine species: a reply to Chapman and Carlton. *Journal of Crustacean Biology* 16: 384-394
- Poore GCB (2004) Palaemonidae Rafinesque, 1815. In: Poore G (ed) *Marine decapod Crustacea of Southern Australia. A guide to identification. With chapter on Stomatopoda* by Shane Ahyong, p 90, CSIRO Publishing, Collingwood
- Rathbun MJ (1902) Japanese stalk-eyed crustaceans. *Proceedings of the United States National Museum* 26: 23-55
- Ricketts EF, Calvin J and Hedgpeth JW (1968) *Between Pacific tides*. Standfort University Press, California, 614 pp
- Siegfried CA (1982) Trophic relations of *Crangon franciscorum* Stimpson and *Palaemon macrodactylus* Rathbun: predation on the opossum shrimp, *Neomysis mercedis* Holmes. *Hydrobiologia* 89: 129-139
- Sitts RM and Knight AW (1979) Predation by the estuarine shrimps *Crangon franciscorum* Stimpson and *Palaemon macrodactylus* Rathbun. *Biological Bulletin. Marine Biological Laboratory, Woods Hole* 156: 356-368
- Sorbe JC (1983) Les Décapodes natantia de l'estuaire de la Gironde (France). Contribution à l'étude morphologique et biologique de *Palaemon longirostris* H. Milne Edwards, 1837. *Crustaceana* 44: 251-270
- Sottolichio A and Castaing P (1999) A synthesis on seasonal dynamics of highly-concentrated structures in the Gironde estuary. *Comptes rendus de l'Académie des Sciences Série II Fascicule a, Sciences de la Terre et des Planètes*, 329: 795-800
- Souty-Grosset C, Holdich DM, Noël PY, Reynolds JD and Haffner P (2006) *Atlas of Crayfish in Europe*. Muséum national d'Histoire Naturelle, Paris, 187 pp
- Spivak ED, Boschi EE and Martorelli SR (2006) Presence of *Palaemon macrodactylus* Rathbun 1902 (Crustacea: Decapoda: Caridea: Palaemonidae) in Mar del Plata harbor, Argentina: First record from southwestern Atlantic waters. *Biological Invasions* 8: 673-676
- Udekem d'Acoz d' C, Faasse M, Dumoulin E and De Blauwe H (2005) Occurrence of the Asian shrimp, *Palaemon macrodactylus* Rathbun, 1902, in the Southern Bight of the North Sea, with a key to the Palaemonidae of North-West Europe (Crustacea, Decapoda, Caridea). *Nederlandse Faunistische Mededelingen* 22: 95-111

## Annex

### Records of *Palaemon macrodactylus* in France

Location	Record coordinates		Record date	Species abundance	Collector
	Latitude, N	Longitude, E			
Gironde estuary	45°20'	0°45'	2.08.2006	several hundreds included numeros ovigerous female	Béguer M
Adour estuary	43°53'	1°53'	26.09.2006	one ovigerous female	Lepage M