

Establishment of the invasive Asian shore crab *Hemigrapsus sanguineus* (De Haan, 1835) (Crustacea: Brachyura: Grapsoidea) from the Cotentin Peninsular, Normandy, France

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Abstract

The occurrence of the invasive Asian shore crab *Hemigrapsus sanguineus* (de Haan, 1835), around the Cotentin Peninsular, Normandy, France, is reported. The northern and eastern Cotentin coasts are more densely colonised (maximum density $\cong 10$ ind.m⁻²) than western shore, where the crab remains rare. These colonisation and establishment demonstrate probably the western progression of the species from its initial introduction into the Le Havre harbour during 1999.

Key words: marine invasive species, English Channel, Cotentin coasts, *Hemigrapsus sanguineus*, *Hemigrapsus takanoi*

Introduction

Two species of Asian crabs of the genus *Hemigrapsus* have recently colonised the French Atlantic coast. The first was the brush-clawed shore crab *H. takanoi* Asakura & Watanabe, 2005 initially identified as *H. penicillatus* (de Haan, 1835) and was reported for the first time from La Rochelle, on the Atlantic coast of France in 1994 (Noël et al. 1997). Then the second species *H. sanguineus* (de Haan, 1835) was discovered in the Le Havre harbour in 1999 (Breton et al. 2002). Both species are now known from along the Opal Coast (French side of the Dover Strait), and form abundant populations: *H. sanguineus* occurs in large numbers on the rocky shore of the open sea while *H. takanoi* is abundant in sheltered harbours (Dauvin et al. 2009).

The aim of this study is to record the distribution the status of both Asian species in July-August 2008 in Cotentin, a peninsula that divides the English Channel (north-eastern Atlantic) in two basins (west and east).

Material and Methods

Field site

The Cotentin Peninsular comprises the northern sector of the 'Manche Department', delimited on the west coast from Saint-Jean-le-Thomas to The Hague Cape (Goury), in the north it includes Cherbourg harbour and the east coast from Gatteville-Phare to the Bay of Veys (Figure 1). From Carteret Cape to Saint-Vaast-la-Houge the coastline alternates between sand dunes and rocky shore. Furthermore, some rocky outcrops occur in the mid-littoral zone of a sand dune habitat. A total of fifteen sites were sampled from 12 July to 22 August 2008 including two harbours; i.e. Granville and Carteret, three protected sites, i.e. Querqueville, Salines and Saint-Vaast, and ten other sites located in relatively high hydrodynamic areas (Table 1, Annex 1).

Sampling procedure

At each of the 15 sampling sites (Figure 1, Annex 1), *Hemigrapsus* was present under three

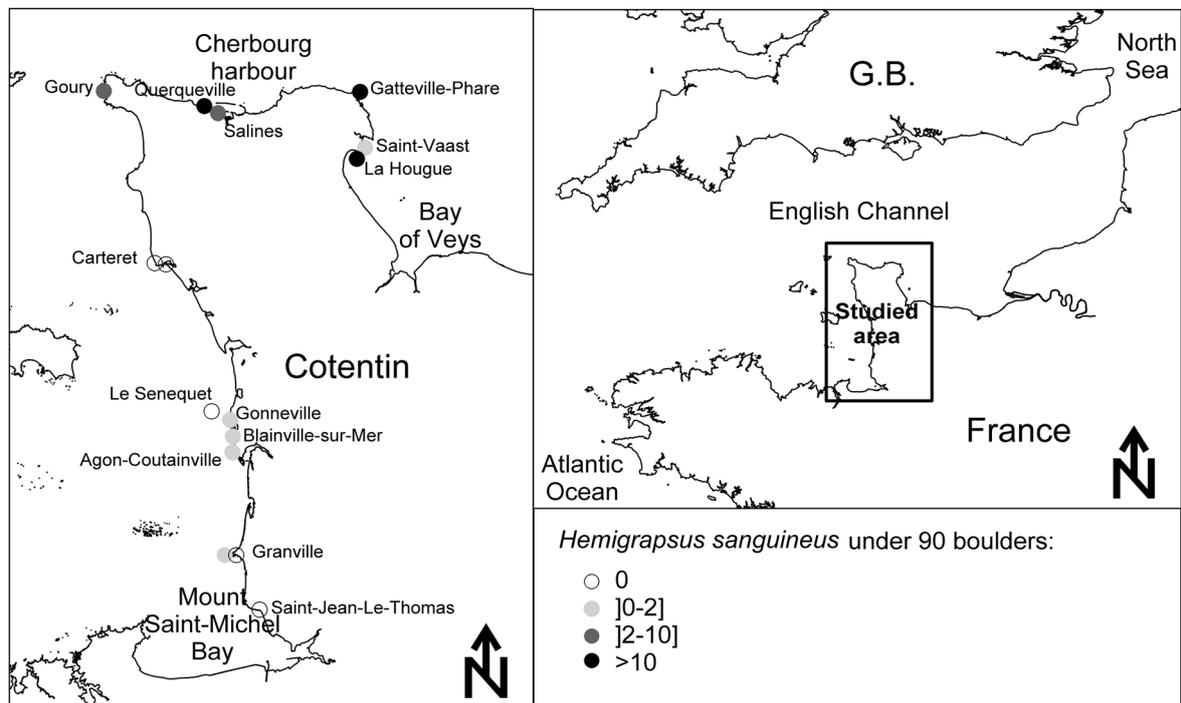


Figure 1. Four categories of colonisation (mean number of individuals sampled under 30 boulders) were established for *Hemigrapsus sanguineus* from the 15 sites sampled around the Cotentin Peninsular during the summer 2008

groups of 30 boulders sampled in the mid-littoral zone of a total of 90 boulders per site. At one site, Querqueville in Cherbourg harbour, corresponding to a high colonised zone, an estimation of the density of *H. sanguineus* was made with a quadrat of 1 m² (three replicates) (Table 1).

Laboratory observations

Hemigrapsus crabs were collected, identified, counted, measured (carapace width taken across the first pair of anterior lateral teeth) and sexed. The class-size histograms were constructed according 2 mm classes.

Results

Abundance and density

The results of the summer 2008 sampling are presented in Table 1 (see also Annex 1). *Hemigrapsus sanguineus* has colonised the whole of the Cotentin peninsular. However its abundance is low along the western coastline

where only one to five individuals were collected under 90 boulders at four sites and at five localities no Asian shore crabs were recorded. Furthermore, one ovigerous female (19 mm) was collected at Granville and one male juvenile at Agon-Coutainville (10 mm) demonstrating that *H. sanguineus* is able to reproduce and recruit along this western coastline. Along the northern and eastern Cotentin coastline the Asian shore crab is relatively abundant especially at Querqueville, Gatteville-Phare and La Hougue with respectively 93, 83 and 77 individuals found under 90 boulders. These abundances are similar to those that were estimated for sites along the Opal coast during the spring 2008, i.e. 87 at Wimereux and 95 at Dunkirk outside the harbour site (Dauvin et al. 2009). The single density measured at Querqueville, Cotentin (9.7 ind.m⁻²) is also comparable to those measured at Wimereux and Dunkirk outside harbour, 11.2 and 12.0 ind.m⁻² respectively. The expected density of other invaded sites such as Gatteville-Phare and La Hougue remain probably lower than 10 individuals per square meter.

Table 1. *Hemigrapsus sanguineus* data collected from the 15 sites during the summer of 2008. Abbreviations used = G1, G2, and G3: group of 30 boulders; S.D.: Standard Deviation of the mean; N: number; % of ovigerous female= number of ovigerous female/total number of females

Sites	Date	N G1	N G2	N G3	Total N	Mean N± S.D.	Males N (M)	Females N (F)	Sex- ratio M/F	% of ovigerous females
Saint-Jean-Le-Thomas	22/08	0	0	0	0	-	-	-	-	-
Granville harbour	29/07	0	0	0	0	-	-	-	-	-
Granville outside harbour	29/07	1	0	0	1	0.33±0.58	-	-	-	-
Agon-Coutainville	17/08	0	1	0	1	0.33±0.58	1	0	-	0
Blainville sur mer	12/07	2	0	0	2	0.66±1.15	1	1	1	100
Gonneville	02/08	2	1	2	5	1.66±0.58	3	2	1.5	100
Le Senequet	16/08	0	0	0	0	-	-	-	-	-
Carteret harbour	30/07	0	0	0	0	-	-	-	-	-
Carteret outside harbour	30/07	0	0	0	0	-	-	-	-	-
Goury	05/08	4	4	5	13	4.33±0.58	5	8	0.625	62.5
Querqueville	12/08	27	33	33	93	31±3.46	46	47	0.98	61.7
Salines	05/08	8	7	8	23	7.66±0.58	9	14	0.64	92.9
Gatteville-Phare	11/08	16	20	47	83	27.66±16.86	34	49	0.70	75.5
Saint-Vaast	11/08	0	0	3	3	1.00±1.73	1	2	0.50	100
La Hougue	11/08	27	22	28	77	25.66±3.21	32	45	0.71	75.5
Querqueville (m ²)	12/08	8	9	12	29	9.66±2.08	15	14	1.07	64.3

Size class frequency and sex ratio

The size of sampled individuals ranged from 5 to 34 mm for the largest. At Querqueville, Gatteville-Phare and La Hougue size class frequencies showed similar pattern of individual distribution (Figure 2). Three modes could be identified, young individuals < 10 mm at 6-8 mm (these being probably crabs in their first year), the 16-18 mm at Querqueville, 18-20 mm at Gatteville-Phare and 20-22 mm at La Hougue. The third mode at La Hougue, represents the largest individuals with a range 30-32 mm and these probably correspond to individuals older than 2 years. The high proportion of ovigerous female (from 64.3 to 100 %; table 1) found along the north-eastern coastline of the peninsular show that the reproductive period occurs during the summer in the Cotentin region. Among the 182 females, 132 (72.5 %), were ovigerous showing that this population is successfully breeding and is probably be able to increasing its density in this part of the Channel. But, it is not sure that *H. sanguineus* will be as successful in Europe as in the United States of America (C. d’Udekem d’Acoz, personal communication). In the USA, *Carcinus maenas* is itself an alien species; hence it probably has a reduced genetic variability; hence its potential of adaptability is reduced. In Europe *Carcinus maenas* is a native species and it is more genetically variable (at the individual and population level). Hence, it could be more

resistant to the competition with *H. sanguineus*. It should also be noticed that no ovigerous female was observed in the Dover Strait in spring (April-May 2008) (Dauvin et al. 2009).

Figure 3 shows the size class frequency of the 330 individuals collected during the summer of 2008 from the Cotentin, with the presence of three modes, young individuals measuring 6-8 mm, one-year individuals measuring 18-20 mm and > 2 years individuals 30-32 mm respectively. The presence of juvenile < 10 mm indicates that the first cohort was recruited at the start of the reproductive period, probably at the beginning of June 2008, after a planktonic phase of about six weeks for a sea surface temperature in the Channel \cong 15°C during this period. The smallest ovigerous was 13 mm and the largest 31 mm in carapace width. The largest male was 34 mm.

The sex-ratio, males/females for all the specimens collected, was 0.81 indicating that the number of females was higher than males. However the sex-ratio at Querqueville was 1 (71 females and 71 males) while at Gatteville-Phare it was 0.7 and at La Hougue, 0.71 the two other high colonised sites in the north-east Cotentin.

During the field sampling, two other non-indigenous crabs were collected (Annex 1). The first of these was the marbled crab *Pachygrapsus marmoratus* (J.C. Fabricius, 1787) from the Mediterranean Sea and the Atlantic warm temperate zone (Ingle and Clark 2006). Three specimens were sampled at Blainville sur mer on

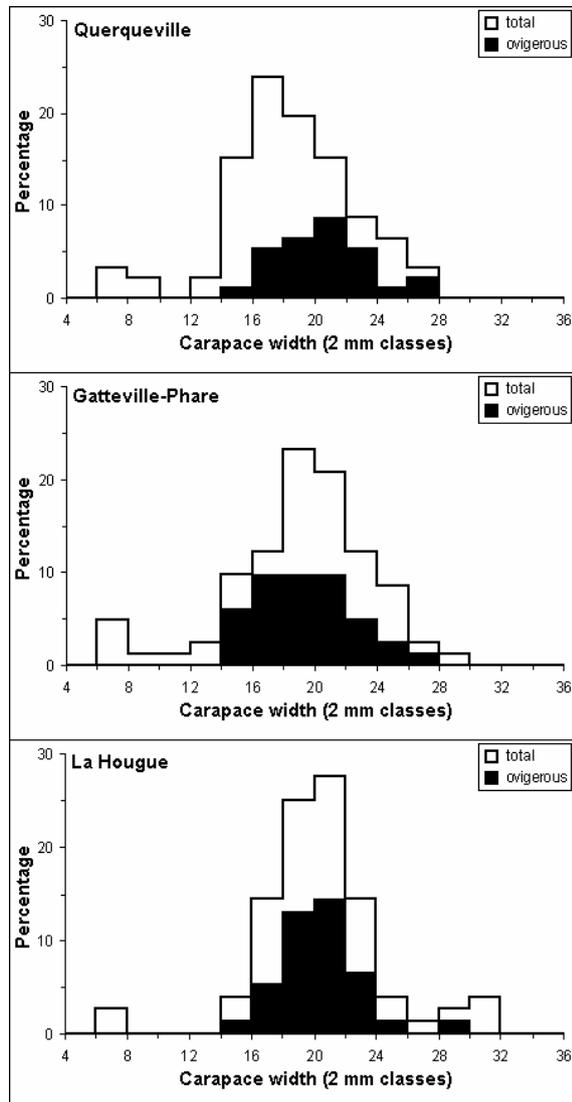


Figure 2. Frequency distribution of carapace-width classes of *Hemigrapsus sanguineus* collected at Querqueville (93 individuals), Gatteville-Phare (83 individuals) and La Hougue (77 individuals) from August 2008

12 July and two at Gonnevillle on 2 August (two specimens). No ovigerous females were observed (Dauvin 2009). The other species was a single male of the brush crab, *Hemigrapsus takanoi* collected at Saint-Vaast on 8 August (Annex 1). This species is abundant in the Le Havre harbour (Breton et al. 2002) and along the Opal coast with densities $> 60 \text{ ind.m}^{-2}$ in Dunkirk harbour (Dauvin et al. 2009).

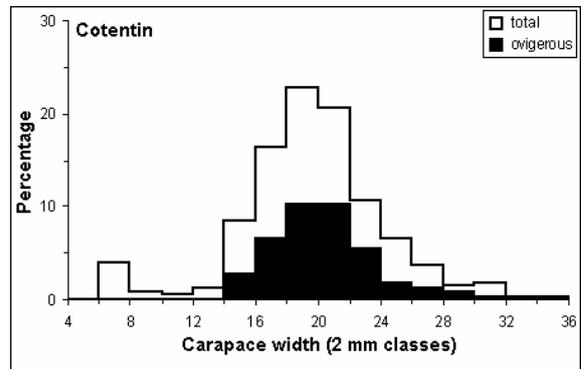


Figure 3. Frequency distribution of carapace-width classes of the 330 *Hemigrapsus sanguineus* collected at 10 sites sampled during the summer 2008

Discussion

These observations suggest that there is a general change of the intertidal crab population along the French coast of the English Channel. These invasions may generate competition for space and food with the indigenous crabs especially the common shore crab *Carcinus maenas* (Linnaeus, 1758) (McDonald et al. 2007) which remains common in protected areas such as in harbours.

The *Hemigrapsus sanguineus* densities observed in 2008 along the English Channel coasts ($\cong 10 \text{ ind.m}^{-2}$) appear low compared to those along the eastern coast of the United States where *H. sanguineus* was originally introduced and observed at Cape May, New Jersey, in 1988 (Williams and Mc Dermott 1990). To date, the species has colonised the temperate zone of the east US coast from North Carolina to Maine (Mc Dermott 1998; Delaney et al. 2008). The maximum density observed in this area was reported by Mc Dermott (1998) for a site at 'Townsend and Hereford Inlets', New Jersey; 320 ind.m^{-2} . In August 2005, across 52 sites along a 725-km coastal transect from New Jersey to Maine, Delaney et al. (2008) reported lower density with a maximum of 43.83 ind.m^{-2} in the south. These American figures may suggest that the *H. sanguineus* populations in France are still in the colonisation and expansion phase and those maximum densities are yet to be established. This hypothesis is possible but not

sure (C. d'Udekem d'Acoz, personal communication). In Belgium, the species is already present for some years but the density of *H. sanguineus* remains moderate or low, depending on the shore. Also in the Netherlands, *H. sanguineus* has not become very abundant. On the other hand, in some parts of the Netherlands (eastern Scheldt) the populations of the related species *H. takanoi* exploded in a few years and it has locally almost completely replaced *Carcinus maenas* (C. d'Udekem d'Acoz, personal communication).

It is hypothesized that both *Hemigrapsus* species have dispersed from Le Havre Harbour where the crabs were observed in 1999, probably being introduced with ballast water (Breton et al. 2002). From this starting point, both species extended the range of their western and eastern distributions along the French coast in relation with the coastal residual circulation in the bay of Seine (Le Hir et al. 1986). Both species have subsequently extended their ranges along the French coast. *Hemigrapsus sanguineus* is today known from the west coast of Cotentin to the Lower Saxony, Germany i.e. more than 1100 km of coast (d'Udekem d'Acoz and Faasse 2002; Kerkhof et al. 2007; Obert et al. 2007; Dauvin et al. 2009), and form more or less abundant populations on the rocky intertidal shore. As yet, neither *Hemigrapsus* species have been reported from the British Isles.

A regular survey, perhaps once a year, of the colonisation by these two species of *Hemigrapsus* crabs is recommended to evaluate their impact, densities and expansion of range. This is especially relevant for *H. sanguineus* as it is known as omnivorous predator capable of opening mussel up to 48 mm in length (McDermott 1999) and probably young oysters. This predation is of concern because the Cotentin is known for its cultivation of mussels and oyster, being an important centre of French production. The fact that *H. sanguineus* inhabit the upper part of the mid-littoral zone during the spring-summer period may restrict this predation but this species is known to migrate to the shallow subtidal zone during winter (Williams and McDermott 1990; Lohrer et al. 2000). Consequently, during this phase the crab could be a problem for shellfish production. Observations are required to test this hypothesis.

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Annex 1

Location for samples of invasive species crabs in the Cotentin, total numbers of collected specimens at each site.
HS - *Hemigrapsus sanguineus*, HT - *Hemigrapsus takanoi*, PM- *Pachygrapsus marmoratus*

Location	Geographic coordinates		Sampling Date	Habitat characteristics	HS	HT	PM
	Latitude	Longitude					
Saint-Jean-Le-Thomas	48°43'56"N	1°33'05"W	22/08/08	Boulders on sandy mud	0	0	0
Granville harbour	48°50'04"N	1°36'20"W	29/07/08	Boulders on muddy gravel	0	0	0
Granville outside harbour	48°49'58"N	1°36'28"W	29/07/08	Boulders on rock	1	0	0
Agon-Coutainville	49°01'29"N	1°36'01"W	17/08/08	Boulders on rock	1	0	0
Blainville sur mer	49°03'33"N	1°36'47"W	12/07/08	Boulders on rock	2	0	3
Gonneville	49°04'57"N	1°36'43"W	02/08/08	Boulders on rock	5	0	2
Le Senequet	49°05'30"N	1°39'42"W	16/08/08	Boulders on rock	0	0	0
Carteret harbour	49°22'40"N	1°47'06"W	30/07/08	Boulders on muddy gravel	0	0	0
Carteret outside harbour	49°22'20"N	1°48'29"W	30/07/08	Boulders on rock	0	0	0
Goury	49°42'53"N	1°56'45"W	05/08/08	Boulders on rock	13	0	0
Querqueville	49°40'08"N	1°40'47"W	12/08/08	Boulders on rock	93	0	0
Salines	49°39'28"N	1°38'45"W	05/08/08	Boulders on gravel and rock	23	0	0
Gatteville-Phare	49°41'44"N	1°15'56"W	11/08/08	Boulders on gravel and rock	83	0	0
Saint-Vaast	49°35'34"N	1°15'48"W	11/08/08	Boulders on muddy gravel	3	1	0
La Hougue	49°34'30"N	1°16'18"W	11/08/08	Boulders on rock	77	0	0
Querqueville (m ²)	49°40'08"N	1°40'47"W	12/08/08	Boulders on sand	29	0	0