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ARTICLE

Coastal and Marine Ecology

The invasive species *Rangia cuneata*: A new food source for herring gull (*Larus argentatus*)?

Jean-Philippe Pezy[1] | **Ambre Pezy**[2] | **Aurore Raoux**[1]

[1]Normandie Université, UNICAEN, UNIROUEN, Laboratoire Morphodynamique Continentale et Côtière, Caen, France

[2]Independent Researcher, Caen, France

Correspondence
Jean-Philippe Pezy
Email: jean-philippe.pezy@unicaen.fr

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Abstract

Continued human population growth and the associated development of coasts lead to dramatic effects on marine coastal ecosystems altering food resources and habitats for several species and resulting in novel species interactions. The Bay of the Seine, located in the eastern part of the English Channel, is one of the most anthropized sea in the world. Here, we report an observation of the European herring gulls (*Larus argentatus*) feeding on the nonindigenous species (NIS) *Rangia cuneata* in the Bay of the Seine. Observations of otter prints (*Lutra lutra*) and excrements were also found near the bivalves, suggesting that this species also feed on the NIS bivalve. Our study suggests that the spread of NIS in coastal marine ecosystem is expected to drive changes in the foraging behavior of top predators.

KEYWORDS

brackish, ecosystem, English Channel, foraging innovation, non-indigenous species, prey–predator relations

INTRODUCTION

Intentional or unintentional species introductions by human activities to regions outside their native ranges have been ongoing for thousands of years (Carlton & Geller, 1993). However, these ecosystem invasions by nonindigenous species (NIS) are considered nowadays as one of the greatest threats to biodiversity worldwide (Mack et al., 2000; Vitousek et al., 1996). NIS introductions into coastal zones have been accelerated through the world in recent decades mainly due to increased human activities such as shipping, aquaculture, maritime traffic, and tourism (Boudouresque & Verlaque, 2002). This increase in NIS introduction occurring in the context of global climate change leads to modifications in the ecosystem structure and function (Vitousek et al., 1996) with potential repercussions on their ability to provide goods and services to humans (Pimentel et al., 2000; Williamson & Fitter, 1996). In fact, NIS present a wide range of threats to native ecosystems and can be responsible for the decline in native species by competition and predation, and thus can lead to a loss of biodiversity (Sax & Gaines, 2008; Wilcove et al., 1998). Moreover, NIS can also cause direct economic impacts on human activity structure and aquaculture. Invasive species can also cause disappearance of the original communities. A famous example is the invasion of the ctenophore *Mnemiopsis leidyi* in the Black Sea, which led to a collapse of pelagic fisheries (GESAMP, 1997). Finally, it is worth to note that in the marine environment, these introductions are most of the time irreversible.

Apart from these negative effects, NIS may harmlessly be integrated into ecosystems and even

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contribute to enrich the biodiversity (Goulletquer, 2016). Recently, studies have highlighted the potential positive role of NIS to regional species richness and conservation goals (Sax & Gaines, 2008). In fact, NIS can provide shelter (Wonham et al., 2005) and be responsible for an increase in habitat leading to an increase in abundance and species richness (Crooks, 2002). They can also provide a new source of food for native species (Bulleri et al. 2006). For instance, Cadée (2000, 2001, 2008) reported that the native European herring gulls (*Larus argentatus*) fed both on the NIS Pacific oysters (*Crassostrea gigas*) and on the NIS *Ensis directus* in the Wadden Sea. Finally, Holman et al. (2019) highlighted a novel herring gull's foraging behavior on the widespread sea squirt *Ciona intestinalis* from under floating pontoons in a recreational marina in Ireland.

Actually, a recent inventory of NIS along the Normandy coast concludes with a total of 152 NIS (Pezy, Baffreau, et al., 2021). Between Caen and Ouistreham was constructed between 1844 and 1857 the Canal de Caen à la Mer, a navigational channel of 14 km. Two NIS was reported in 1886 (*Amphibalanus amphitrite*) and in 1898 (*Mytilopsis leucophaeata*) (Pezy, Baffreau, et al., 2021). Recently, on 9 August 2017 for the first time *Rangia cuneata* was observed in the Canal de Caen à la Mer by fresh valves collected on the banks (Kerckhof et al., 2018). Since this observation, several dead shells were observed near the sea bottom with some barnacles fixed (personal observations). This brackish-water, suspension-feeding bivalve *R. cuneata* (G. B. Sowerby I, 1832) is native to the Gulf of Mexico (Carlton, 1992) and extended its range northward to the Chesapeake Bay (Hopkins & Andrews, 1970) and to the Hudson River (Carlton, 1992). In Europe, this species was observed for the first time in the Antwerp harbor, in Belgium in 2005 (Verween et al., 2006) and has since spread to estuaries in southern regions of the North Sea (Wiese et al., 2016). In its native range (Gulf of Mexico), *R. cuneata* is typically found in estuaries in salinities ranging between 5‰ and 15‰ (Swingle & Bland, 1974). *Rangia cuneata* is a bivalve with a remarkable salinity tolerance, being able to adapt to salinities varying from 0‰ to 33‰ (Cooper, 1981; Hopkins et al., 1974). The conditions of the Canal de Caen à la Mer are optimum to establish *R. cuneata* population (Faillettaz et al., 2020).

In this study, we report an observation of the European herring gulls feeding on the NIS *R. cuneata* in the Bay of the Seine (eastern part of the English Channel). Observations of otter prints and excrements were also found near the *Rangia* shells, suggesting that this species also feed on the NIS bivalve.

MATERIALS AND METHODS

Observations on herring gulls consuming *R. cuneata* at the Ouistreham harbor were made on August 2019. In fact, observations of herring gulls breaking the bivalve by shell dropped on a hard area were recorded at the Ouistreham harbor and along the bike path bordering the Canal de Caen à la Mer. *Rangia cuneata* shells that accumulated at the Ouistreham harbor along the bike path were collected between 12 and 23 August 2020 (Figures 1, 2a–c, 3, and 4). Only the right valves (the most abundant) were counted and measured. A total of 156 *R. cuneata* specimens were collected among them, 89 were used for length measurements (the 67 other valves were broken). The second site corresponds to the Herouville basin near the Caen City (Figures 1 and 2d). These observations were made along the banks and at the level of an old port structure on 25 August 2020. On this site, a lot of rubble (e.g., concrete block, wooden planks) are present. On a wooden board, located at the level of a path frequented by animals (traces of hair), paw prints were found. Empty shells of *R. cuneata* (29 individuals) have been found near the concrete banks of the Canal de Caen à la Mer. The two valves were still connected to each other by the ligament, but the commissure was chipped. Observations of otter excrements were also found during the same period near the Herouville basin (Figure 2e).

RESULTS

Of the 156 bivalves collected at Ouistreham from the pavement, 42.9% were broken and 57.1% were intact (two valves). The average length of 89 specimens of *R. cuneata* dropped and consumed by herring gulls was 35.3 mm (SD 4.6 mm); the range was 24–45 mm. During the different samplings, the herring gulls were observed to collect *R. cuneata* specimen by diving. Once the specimen collected, the herring gull flies to a high altitude and drop it onto a hard surface near the capture location (Figure 4).

The 29 shells of *R. cuneata* collected close to the Herouville basin were all intact. The average length of 29 specimens of *R. cuneata* was 37.0 mm (SD = 3.9 mm); the range was 31–47 mm. Observations of otter prints (*Lutra lutra*) and excrements were also found near the *Rangia* shells at the Herouville basin (Figure 2e). Further surveys carried out on Canal de Caen à la Mer did not result in the observation of other shells of *R. cuneata* without the presence of *L. lutra* excrements near them (Table 1).

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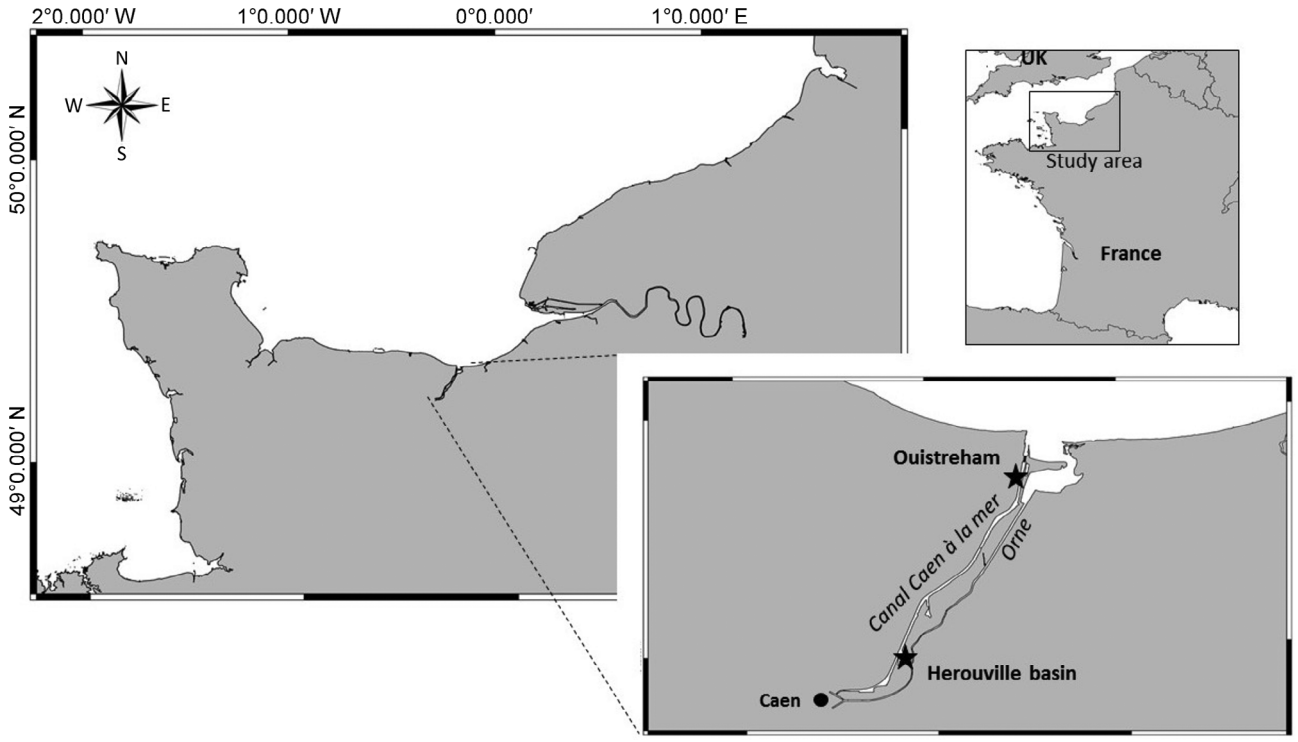


FIGURE 1 Sampling sites of *Rangia cuneata* shell observation in Normandy, at Ouistreham harbor and Herouville basin in 2020



FIGURE 2 Individuals of *Rangia cuneata* from Ouistreham harbor (a, b, c) and individuals of *R. cuneata* from Herouville basin (d), and otter excrements (e)

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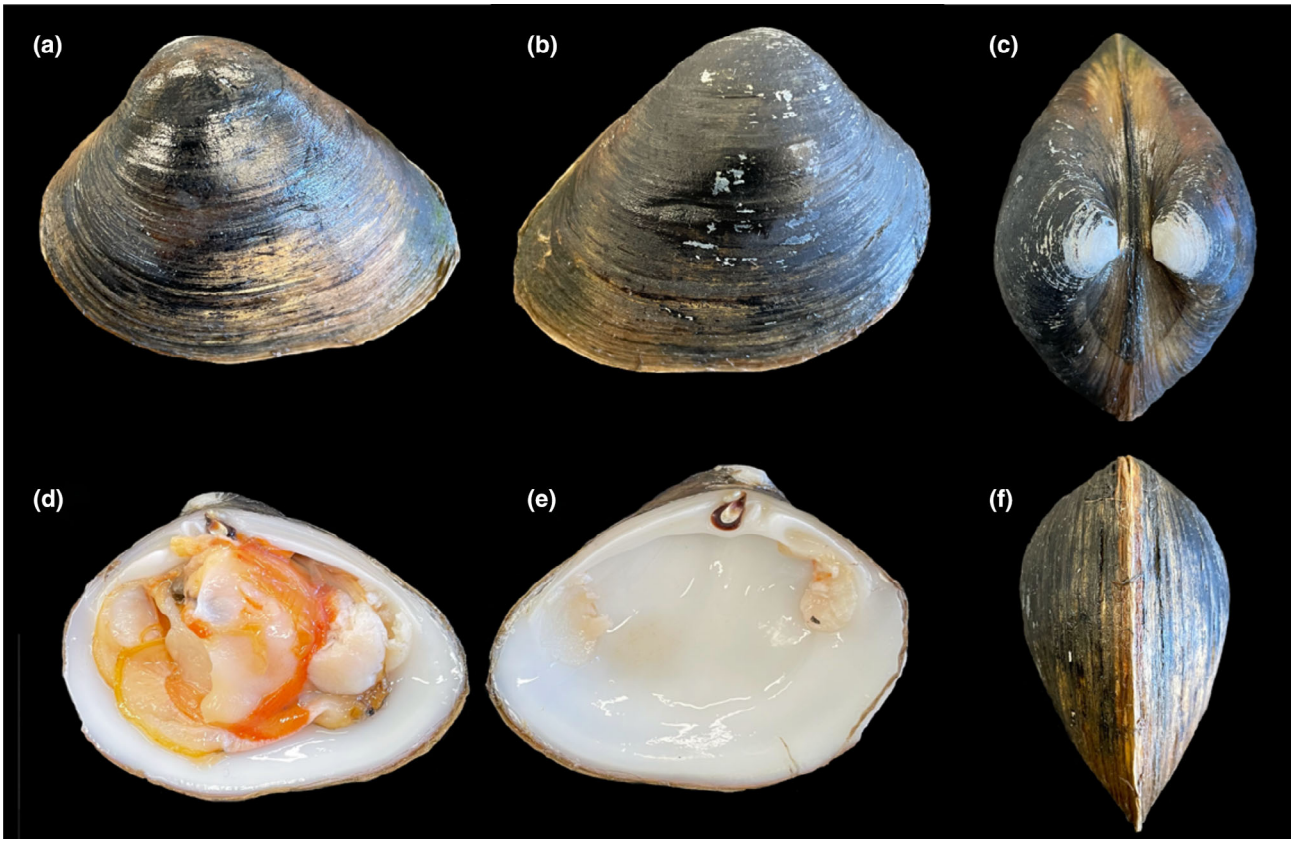


FIGURE 3 *Rangia cuneata* (G. B. Sowerby I, 1832) from Herouville basin, 0.80 m depth. (a) Left valve 77.4 mm long. (b) Right valve. (c) Same specimen, viewed from the dorsal region of the two valves. (d) View of the inside of the right valve. (e) View of the inside of the left valve. (f) View of the frontal region of the two valves



FIGURE 4 Individuals of *Rangia cuneata* broken by herring gulls from Ouistreham harbor

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TABLE 1 Number and min, max, and mean size (± SD; in centimeters) of *Rangia cuneata* specimens recorded at Ouistreham and Herouville basin between 12 and 25 August 2020

Rangia cuneata specimens	Ouistreham	Herouville basin
Number	156	29
Min size	2.4	3.1
Max size	4.5	4.7
Mean size	3.5 ± 0.5	3.7 ± 0.4

DISCUSSION

The herring gull is considered as an apex predator and is known to be an opportunistic species with a wide trophic range. This species is also known to easily adapt to a new source of food (Burger & Gochfeld, 1996) such as anthropogenic food sources (rubbish dumps and bins) (Horton et al., 1983). In this paper, the NIS bivalve *R. cuneata* have been reported to be preyed upon by herring gulls in the Bay of the Seine, one of the most anthropized sea in the world (Halpern et al., 2008). Indeed, herring gull observations capturing the bivalve *R. cuneata* and taken it into the air and dropped from a certain height to break were recorded at the Ouistreham harbor along the bike path. This herring gull consumption of NIS can be explained in part by the fact that coastal habitats have been profoundly altered by human activities where most gull species commonly reside (Firth et al., 2016) and have led to dramatic effects on marine coastal ecosystems altering food resources and habitats for several species and resulting in novel species interactions. Thus, this new behavior in the Bay of the Seine seems to have developed as a consequence of these changes with, especially, the construction of the Canal de Caen la Mer. This herring gulls drop catch behavior on clams and more particularly on the bivalve *R. cuneata* has already been observed at a coastal estuary in Virginia, USA (Cristol et al., 2017; Gamble & Cristol, 2002). In addition, this smashing method is known for a long time (Oldham, 1930) and occurs worldwide (Cadée, 2001). Moreover, it is worth to note that observation of gulls feeding on NIS species has been already recorded in the literature (Cadée, 2000, 2001, 2008; Holman et al., 2019). For instance, Cadée (2000, 2001, 2008) reported herring gulls carrying the NIS Pacific oysters (*C. gigas*) or the NIS *E. directus* to high altitude and drop them onto rocks to crack them open and to feed them. Similarly, in 2018, Holman et al. (2019) observed a new behavior of herring gull feeding on *C. intestinalis* in a recreational marina in Ireland. In this study, the authors observed a gull diving down below the pontoons and emerging with a sea squirt of the nonnative species *C. intestinalis*. All these studies highlighted that in these last decades, herring gulls have learned to prey on several NIS and thus that the spread of NIS in coastal marine ecosystem is expected to drive changes in the foraging behavior of top predators. In addition that Faillettaz et al. (2020) found that the densities of *R. cuneata* (110.45 ± 86.08 individuals m^{-2}) in the Ouistreham marina largely dominating the benthos community and was similar to thus found in northern Europe. The authors also stated that a population of *R. cuneata* is now consistently established in Normandy (Ouistreham marina). Thus, these densities of *R. cuneata* could represent a large proportion of the herring gull diet (Faillettaz et al., 2020).

In Normandy, the otter lives in the catchment areas of the Orne, la Vire, l'Aure, and La Seulles, and so, it can be met in the Canal de Caen la Mer. This species is also known to be a potential native predator of NIS (Miranda et al., 2008). Observations of otter prints and excrements were found near the *Rangia* shells; this observation may suggest that the otter could feed on the NIS bivalve. As this species is a nocturnal species, its diet composition can be studied mainly by indirect methods such as the analyses of the fecal samples (Kruuk, 2006). In fact, several authors highlighted that in fecal samples, it is most common to find remains, which can be used for the identification of prey possibly to species level (Mason & Macdonald, 1986; Reynolds & Aebischer, 1991). However, as pointed out by Carss and Parkinson (1996), this method cannot be appropriate for detecting some food taxa, such as mollusks, or when only the prey soft parts are eaten. Thus, nocturnal observations with photographic evidence are needed in order to analyze the potential proportion of *Rangia* consumed by this species. In addition, it will be interesting to repeat this kind of study after some years in order to analyze whether the herring gulls improve their foraging method as suggested by Barash et al. (1975).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data (Pezy, Pezy, & Raoux, 2021) are available from Dryad: https://doi.org/10.6084/m9.figshare.17152145.

ORCID

Jean-Philippe Pezy https://orcid.org/0000-0002-8293-5090

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