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Rapid Communication

First record of the marine alien amphipod *Caprella mutica* (Schurin, 1935) in South Africa

Koebraa Peters and Tamara B. Robinson*
Centre for Invasion Biology, Department of Botany and Zoology, Stellenbosch University, Matieland, 7602, South Africa
E-mail addresses: koebraapeters@yahoo.com (KP), trobins@sun.ac.za (TBR)
**Corresponding author*

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Abstract

We report the first discovery of the marine amphipod *Caprella mutica* (Schurin, 1935), commonly known as the Japanese skeleton shrimp, in South African waters. This amphipod is indigenous to north-east Asia and has invaded several regions, including Europe, North America, New Zealand and now South Africa. *C. mutica* was detected in scrape samples from the hulls and niche areas of four yachts resident to False Bay Marina, Simon's Town, on South Africa's South Coast. A total of 2,157 individuals were recorded, comprising 512 males, 966 females (20% of which were gravid) and 679 juveniles. The yachts upon which this amphipod was found were not alongside each other, suggesting that the species is widely distributed within the marina. The presence of *C. mutica* in South Africa has been anticipated, as previous work highlighted the climatic suitability of the region and the presence of vectors between South Africa and other invaded areas. The fast reproductive cycle of *C. mutica,* along with its high reproductive output, have important implications for its invasiveness in South Africa. Although it has already reached substantial densities in the marina environment, the extent to which it may invade natural habitats along the South African coast remains unclear. This paper comprises the first record of this amphipod from the African continent.

Key words: Japanese skeleton shrimp, hull fouling, Amphipoda, yacht vector

Introduction

The caprellid amphipod *Caprella mutica* (Schurin, 1935), commonly known as the Japanese skeleton shrimp, is a marine epifaunal crustacean native to sub-boreal coastal waters of north-east Asia (Vassilenko 1967; Arimoto 1976). It has become invasive in numerous regions, becoming particularly successful in North American and European waters, where it predominates in artificial habitats (Ashton et al. 2007; Cook et al. 2007a). Despite occurring widely in the north, to date the only region in the southern hemisphere from which it has been recorded is New Zealand (Ashton et al. 2007). The mode of spread of this amphipod over long distances is thought to be via shipping, while short distance spread has been attributed to hull fouling, the movement of aquaculture species and infrastructure, and "natural" spread via drifting macroalgae (Ashton et al. 2007; Cook et al. 2007a).

Although few studies have considered the impacts of *C. mutica* on native species in its invaded ranges, it is known to cause extensive fouling in artificial habitats (Willis et al. 2004). As one of the larger caprellid species it is known to display aggressive behaviour towards other amphipods (Shucksmith 2007). The literature on this species is dominated by detailed accounts of its morphology (Arimoto 1976; Daneliya and Laakkonen 2012), biology, survivorship (Cook et al. 2007b; Cook et al. 2009) and distribution (Ashton et al. 2007; Frey et al. 2009) but, as with many other marine alien species (Alexander et al. 2016), studies on its impacts are almost entirely lacking. Experimental laboratory research has, however, demonstrated that *C. mutica* has a competitive advantage over the native European *Caprella linearis* (Linnaeus, 1767) and *Pseudoprotella phasma* (Montagu, 1804), enabling it to displace both species from artificial habitat patches (Shucksmith et al. 2009). While suggestions have been made that *C. mutica* may have detrimental impacts on mariculture operations,

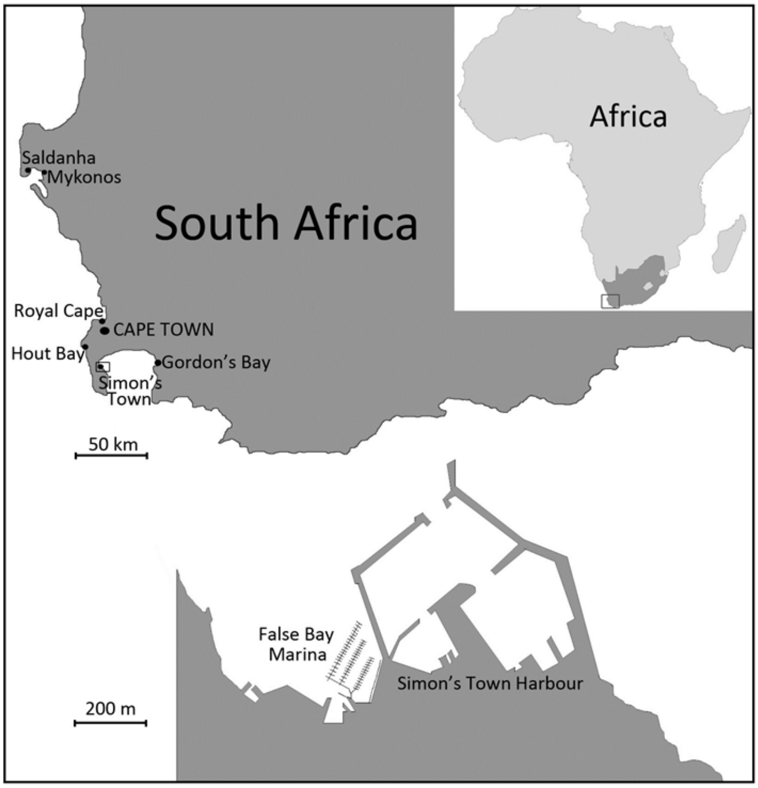

Figure 1. False Bay Marina in Simon's Town, where *Caprella mutica* was recorded. Other marinas mentioned in the text are also indicated.

leading to negative socio-economic consequences (Almón et al. 2014), these purported impacts remain untested.

The present study documents the first record of *C. mutica* in South African waters, provides abundance and demographic details of the population, and discusses its potential spread within the region.

Material and methods

Study site

The False Bay Marina (34º11′32.99″S; 18º26′02.20″E) is situated adjacent to Simon's Town harbour (Figure 1) in the SW Cape, South Africa. The marina is less than 1km^2 in area and berths up to 250 recreational vessels. The marina is situated adjacent to the main Simon's Town Naval Base, but is not enclosed in the harbour as are most other South African marinas. On average, it experiences temperatures of 14 °C in winter and 18 °C in summer (Smit et al. 2013) and is fully marine in nature.

Data collection

As part of an ongoing study, 13 yachts were sampled for hull-fouling organisms during December 2015 and March 2016, with six 15 × 15 cm subtidal scrape samples randomly collected from the hull of each yacht. Samples were preserved in 70% ethanol upon collection. Additional specimens were collected from niche areas including the propeller, rudder, shaft, keel, vents, and water intakes. During processing of samples in the laboratory, a distinctive caprellid was noted, and it was identified as *Caprella mutica* (Schurin, 1935). All *C. mutica* individuals were then extracted from the samples and the number of 1) males, 2) ovigerous females, 3) non-ovigerous females and 4) juveniles were counted. Those individuals for which we could not clearly distinguish sexes were considered as juveniles. These were characterised by absence of dense setae on pereonites 1–2 and gnathopod 2, and of oostegites that form the brood pouch (Cook et al. 2007b; Daneliya and Laakkonen 2012).

Results

Caprella mutica were detected on 4 of the 13 yachts sampled and were recorded in both December 2015 and March 2016 and on both hull and niche areas of the yachts. Mature males demonstrated the distinctive features of *Caprella mutica* where segments 1–2 of

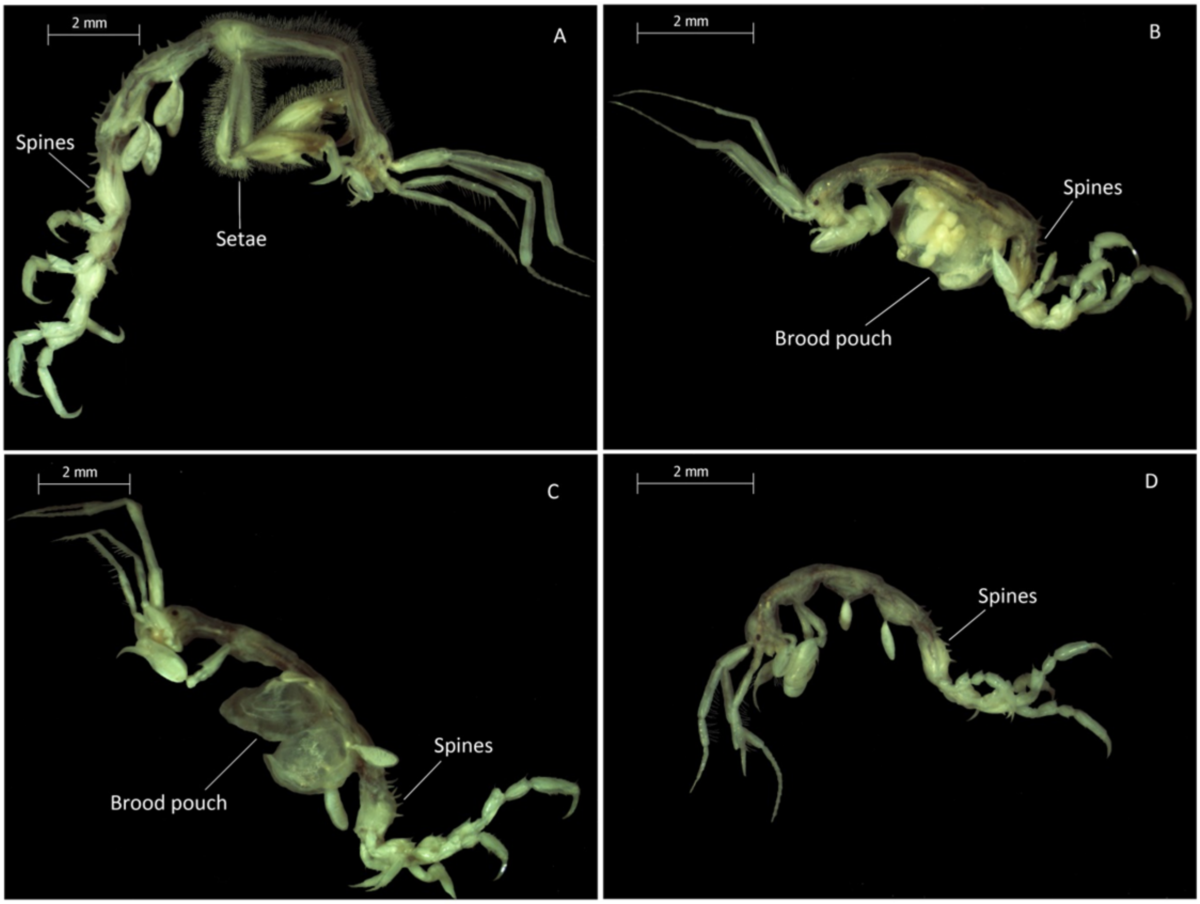

Figure 2. Mature male (A), ovigerous female (B), non-ovigerous female (C) and juvenile male (D) *Caprella mutica* individuals. Note that these specimens were preserved and therefore do not display their distinctive orange colour. Photomicrograph by Koebraa Peters.

the pereon (thorax) and gnathopod 2 were covered in varying densities of setae (Figure 2A). Additionally, both males and females had the distinctive spination on the hind section of the pereon. For mature males spines were visible on the third to seventh segment of the pereon (Figure 2A) and for females these spines were visible from the fifth to seventh segment of the pereon (Figures 2B and C). Juveniles also displayed varying levels of spination, mostly from the fourth to seventh segments of the pereon (Figure 2D). These are the main characteristics that distinguish *C. mutica* from other native caprellids in the region. Only one other caprellid was found amongst *C. mutica* individuals on two of the yachts and this was *Caprella triodous,* which lacks the dense setation and spination observed in *C. mutica*.

We recorded 2,157 individuals, comprising 512 males, 966 females (196, 20%, were carrying eggs), and 679 juveniles (Table 1). On three of the four yachts supporting *C. mutica*, populations were dominated by females, while juveniles were the most abundant demographic group on the remaining yacht (Table 1) All but one yacht had ovigerous females accounting for 9–25% of the population, with no egg-bearing females on the fourth yacht. Of the ovigerous females, some had juveniles in their brood pouches that were ready to emerge. It is notable that juveniles were the most abundant demographic group on the yacht on which no ovigerous females were detected.

Table 1. The numbers of males, females (including ovigerous females) and juvenile *Caprella mutica* individuals detected on four yachts in False Bay Marina, Simon's Town.

	N	Males	Females (ovigerous)	Juveniles
Yacht 1	2122	501	956 (194)	665
Yacht 2	4	1	3 (1)	0
Yacht 3	10	3	4 (1)	3
Yacht 4	21	7	3 (0)	11
TOTAL	2157	512	966 (196)	679

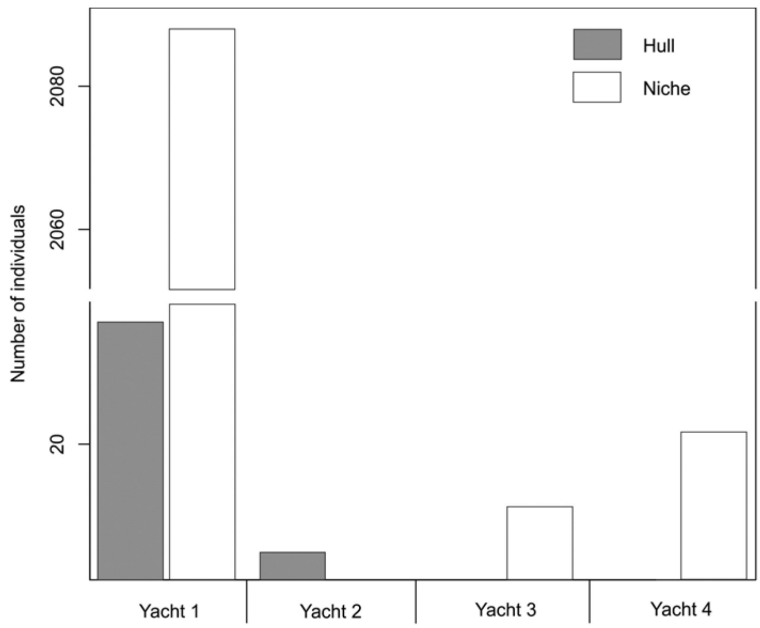

Figure 3. Number of *Caprella mutica* individuals detected on hull and niche areas of yachts in False Bay Marina, South Africa.

Number of individuals recorded per hull sample varied from 4–22, but a staggering 2,088 individuals were detected on the niche area of one yacht (Figure 3). Interestingly, prior to sampling, three of the yachts on which this amphipod was recorded were rated from the dockside as having 0% fouling, aside from a slime layer, while one was rated as being highly (> 50%) fouled. Notably, the yacht supporting the highest densities of *C. mutica* was one of those supporting little visible fouling.

Discussion

The presence of *Caprella mutica* in South Africa has been anticipated after a previous study (Ashton 2006) highlighted the similarity in climatic conditions and the presence of vectors between this and other invaded areas. Thus we were not surprised to detect this amphipod in our waters, but the high abundances in which it was first recorded were unexpected. Likely vectors responsible for the introduction of *C. mutica* include ballast water and hull fouling from naval vessels, or hull fouling from international yachts. Since it was not possible to sample naval vessels during this study, it is unknown if *C. mutica* is present in that part of the Simon's Town harbour. This is unfortunate, as the pattern of distribution within the harbour could provide insight into the most likely vector(s) of introduction.

As over 2,000 individuals were detected, including mature males, egg-bearing females, and juveniles, together with their presence on multiple yachts, we assume that this is an established population with the potential to spread and become invasive in the region. The presence of juveniles at various stages of development at both sampling periods suggests that the species has already undergone at least one reproductive cycle at this location. This suggests that it was present in the marina for at least 8–40 days before being detected (Boos 2009). However, as the yachts on which this amphipod was recorded have not left South African waters, the high densities detected on these boats suggests the introduction occurred earlier, enabling *C. mutica* to spread among yachts in the marina. Further evidence for a fairly recent introduction comes from the fact that this species was not recorded during an earlier survey of the fouling community of the marina and harbour in 2013 (Peters et al. 2014).

The fast reproductive cycle and high reproductive output of *C. mutica* have important implications for its invasiveness in South Africa. Females produce up to 82 hatchlings in a single brood and on average produced at least 2 broods when they were monitored throughout their lifecycle in a European study (Cook et al. 2007b). In Scotland, ovigerous females were found throughout the year (Ashton 2006) suggesting a non-seasonal reproductive pattern. Based on these findings, along with the number of mature females (966) found in the current study, abundances of this species could rise very rapidly in Simon's Town. These high abundances, together with the competitive advantage displayed by *C. mutica* over native amphipods in other regions (Shucksmith et al. 2009), suggests that this invasion could pose a threat, at least to native South African amphipods, including co-occurring caprellids. Only one individual of another caprellid species (*Caprella triodous*) was detected amongst *C. mutica* individuals. As such, we can infer a potential interaction between these species. However, a dedicated study is needed to clarify the nature of this interaction and the risk posed by *C. mutica* to native congeners. Interestingly, *C. triodous* is known to be endemic to the region from Port Elizabeth to Mossel Bay along the South African South coast (Griffiths 1976). Thus, detecting it outside this range in False Bay suggests that it may also have been spread by human vectors. However, as knowledge on the distribution of local caprellids is limited, this conclusion is tenuous.

Considering that the first record of *C. mutica* along the South African coast was associated with yachts, it is important to consider connectivity between this marina and others in the region. The number of yachts in harbours has previously been highlighted as an important characteristic associated with harbours supporting high numbers of alien species in South African waters (Peters et al. 2017). Although this does not empirically link yachts with the spread of marine aliens, it does suggest that they are an important transport mechanism. As such, the detection of *C. mutica* on yachts highlights the risk of intra-regional transfer of this species. False Bay Marina in Simon's Town receives visiting yachts from other South African ports, as well as international destinations. While a detailed analysis of yacht movement patterns is outside the scope of this study, discussions with the marina management revealed that the highest frequency of movement of local yachts occurs amongst False Bay, Royal Cape, Saldanha, Mykonos, Hout Bay and Gordon's Bay marinas. In the ongoing study that led to the discovery of *C. mutica*, yachts from Royal Cape Marina were also sampled and the amphipod was not detected there. In contrast international yachts tend to move with prevailing winds in a westerly direction along the South African coast, visiting Simon's Town near the end of their South African stay. As such, the marinas most at risk of invasion by intra-regional spread of *C. mutica* appear to be those in close proximity to the False Bay Marina.

Due to the high yacht connectivity amongst marinas, it is important for yacht owners and skippers to be aware of the potential consequences of moving vessels fouled with alien species amongst marinas. Therefore, it is important to incorporate education and awareness programmes into alien species management initiatives. Following the discovery of *C. mutica*, yacht owners of affected vessels were informed and encouraged to have their hulls cleaned out of the water prior to travelling to another marina. While South Africa has no regulatory regime to enforce such actions, we found yacht owners eager to protect the marine environment and many were aware of the concept of marine alien species. Since Simon's Town is a naval base, the risk posed by the much less frequent movement of naval vessels to other regional harbours should not be ignored as a potential mode of spread.

We conclude by confirming the first record of *Caprella mutica* on the African continent, now the second southern hemisphere region to be invaded by the amphipod. The potential impact of this amphipod in South Africa (as in other invaded regions), however, remains unclear. A quantitative assessment of *C. mutica*'s impacts could be used to support management decisions regarding this invasion and education and awareness amongst the yachting fraternity in the region could provide a valuable basis for management actions.

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