



Crossing the Indian Ocean: a range extension for *Goreopagurus poorei* Lemaitre & McLaughlin, 2003 (Crustacea: Decapoda: Paguridae)

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Abstract

Goreopagurus poorei Lemaitre & McLaughlin, 2003, a hermit crab of the family Paguridae previously known only from off eastern Tasmania in the Tasman Sea, has been discovered in the western Indian Ocean off the coast of South Africa, extending considerably the range of this species by 10,100 km to the west. While this finding represents a large range extension, similar wide ranges are frequent and well known in other deep-water decapods including paguroids. Colour information and minor morphological variations are presented to complement the morphological information provided in the original description. Genetic sequence data is also provided for future use in phylogenetic and biogeographic studies.

Key words: deep sea, hermit crab, South Africa, Agulhas Shelf, range extension

Introduction

The four species currently in the genus *Goreopagurus* McLaughlin, 1988, stand out by the unusually large and sexually dimorphic right cheliped. The morphology of the carpus in particular, is quite striking in having an unusually expanded ventral portion and a flared dorsomesial margin armed with spines, both features being much more pronounced in males than in females. Among other diagnostic characters, the females of species of *Goreopagurus* have well developed, paired first pleopods modified as gonopods, whereas males may or may not have paired short sexual tubes emanating from the gonopores on the coxae of the fifth pereopods. The genus was established by McLaughlin (1988) for *Pagurus piercei* Wass, 1963, a western Atlantic species now known to range in the Gulf of Mexico and southeastern coast of the United States (Felder *et al.* 2009). Subsequently, two more species were described from the coast of the Americas: *G. garthi* McLaughlin & Haig, 1995, from the eastern Pacific, off Baja California; and *G. lemaitrei* Nucci & Melo, 2007, from the southwestern Atlantic, off Fortaleza, Brazil. A fourth species of this genus, *G. poorei* Lemaitre & McLaughlin, 2003, was surprisingly discovered in the western Pacific, off the coast of eastern Tasmania, considerably expanding the distribution of *Goreopagurus*.

Herein we report the presence of *Goreopagurus poorei* on the western side of the Indian Ocean, off the coast of South Africa, based on specimens collected during studies sponsored by the Republic of South Africa, Department of Agriculture, Forestry and Fisheries (DAFF) and the Department of Environmental Affairs (DEA). During the spring 2015 DAFF demersal research survey the senior author collected a single specimen from a trawl on board the *RS Africana*. At the same time numerous specimens were dredged on board the *RV Algoa* during the 2016 Deep Secrets Cruise, a collaborative project enabled through the African Coelacanth Ecosystem Program (ACEP). All specimens were collected along the edge of the Agulhas Shelf, from south of the Cape Agulhas to off the coast of Jeffreys Bay. The discovery of *G. poorei* in South African waters represents a large and significant range extension for this species. Furthermore, the colour photographs obtained of live specimens provide the opportunity to describe complete and accurate information on the colouration of *G. poorei*. Some morphological variations observed in the South African specimens are also described. Genetic data has been obtained as part of the South

African SeaKeys project and is reported, in order to make it available for subsequent studies of phylogenetic relationships or genetic exchange among populations across the wide range of distribution of *G. poorei*.

Taxonomic knowledge of the Paguroidea (sensu McLaughlin *et al.* 2007) from South Africa remains inadequate. A summary of the history of decapod collecting and research from the 19th to the late 20th century was provided by Kensley (1981), and to recent times by Emmerson (2016a). The most prominent earlier attempts at comprehensive treatments of the South African paguroid fauna are in the catalogues by Stebbing (1910) on the Crustacea, and Barnard (1950) on the Decapoda, although hermit crab classification and nomenclature used in both these works is now severely outdated. Forest (1954) included specimens from the South African coast in his detailed report on the species of the diogenid genus *Paguristes* Dana, 1851, and remarked on the scarcity of samples and poor knowledge of the hermit crabs from this region. Kensley (1969) provided taxonomic information on a few hermit crab species from the South African region, although subsequently in his study on the zoogeography of decapods from the region he (Kensley 1981) presented a long list of hermit crab species. Recently, Emmerson (2016a–c) published a multi-volume guide to the decapods from South Africa and Mozambique, in which 70 paguroid species are included. Among the diverse family Paguridae, a number of species from South Africa have been discussed in various taxonomic studies: McLaughlin & Haig (1989) reexamined the only known South African specimen of *Pylopaguropsis zebra* (Henderson, 1893); García-Gómez (1994) redescribed the South African endemic *Anapagurus hendersoni* Barnard, 1947; Lemaitre & McLaughlin (1996) discussed the type specimens from South Africa of *Manucomplanus ungulatus* (Studer, 1883); McLaughlin (1998) described three new species of *Nematopagurus* that occur in South Africa, *N. crosnieri*, *N. kosiensis*, and *N. meringae*; and McLaughlin & Forest (1999) revised six species of *Pagurus* from South African waters, and redescribed *Propagurus deprofundis* (Stebbing, 1924). Despite all these studies, however, the fact remains that the South African hermit crab fauna remains woefully understudied and undersampled, with many species still known based on a few specimens. Recent sampling efforts and ongoing studies of paguroid specimens collected in shallow to moderately deep waters, are revealing many previously unreported or undescribed species from the South African coast (J. Landschoff & R. Lemaitre, pers. obs.). As surmised by Griffiths *et al.* (2010), many discoveries are still to be made in the marine invertebrate communities of South Africa, particularly in deep-sea habitats that are notoriously under-sampled.

Specimens used in this report are deposited in the South African Museum, Cape Town, South Africa (SAMC), with duplicates at the National Museum of Natural History, Smithsonian Institution, Washington DC (USNM). Morphological terminology follows Lemaitre & McLaughlin (2003). Measurements in millimetres (mm) of specimens listed in the material examined sections are for shield length (SL), taken from the tip of the rostrum to the midpoint of the posterior margin of the shield. Station coordinates are given using the Degrees Decimal Minutes system.

Systematics

Family Paguridae Latreille, 1802


Genus *Goreopagurus* McLaughlin, 1988

Goreopagurus poorei Lemaitre & McLaughlin, 2003

(Figs. 1–4)

Goreopagurus poorei Lemaitre & McLaughlin, 2003: 222, figs 1–3.—McLaughlin *et al.*, 2010: 29.

New material. Agulhas Shelf. South Coast Survey spring 2016, AFR289: 1 male 4.5 mm, sta A32823–076, 35°14.94'S, 22°50.82'E, 520 m, 5 Oct 2016 (USNM 1292090). Deep Secrets Cruise, ALG230: 1 male 3.9 mm, sta DSC027 DSCS-INV-422, 34°43.74'S, 25°09.06'E, 622 m, 15 Oct 2016 (USNM 1292091); 1 female 3.7 mm (USNM 1292088), 1 female 4.5 mm (USNM 1292089), sta DSC006 DSCS-INV-154, 36°45.54'S, 21°12.72'E, 516 m, 1 Oct 2016; 1 female 2.8 mm (damaged), sta DSC012 DSCS-INV-280, 35°07.20'S, 23°02.76'E, 334 m, 6 Oct 2016 (USNM 1292093); 1 female 5.7 mm (USNM 1292087), 1 female 4.0 mm (SAMC MB-A066772), sta DSC003 DSCS-INV-97, 36°01.92'S, 19°42.24'E, 463 m, 30 Sep 2016; 2 males 4.1–4.7 (SAMC MB-A066784),

sta DSC003 DSCS-INV-98, 36°01.92'S, 19°42.24'  463 m, 30 Sep 2016; 1 male 3.5 mm, 2 ovig. females 2.6–3.1 mm (USNM 1292092), 2 ovig. females 2.6–2.9 mm (SAMC MB-A066771), sta DSC057 DSCS-INV-568, 24°47.10'S, 24°45.60'E, 388 m, 22 Oct 2016.

Description. See Lemaitre & McLaughlin (2003).

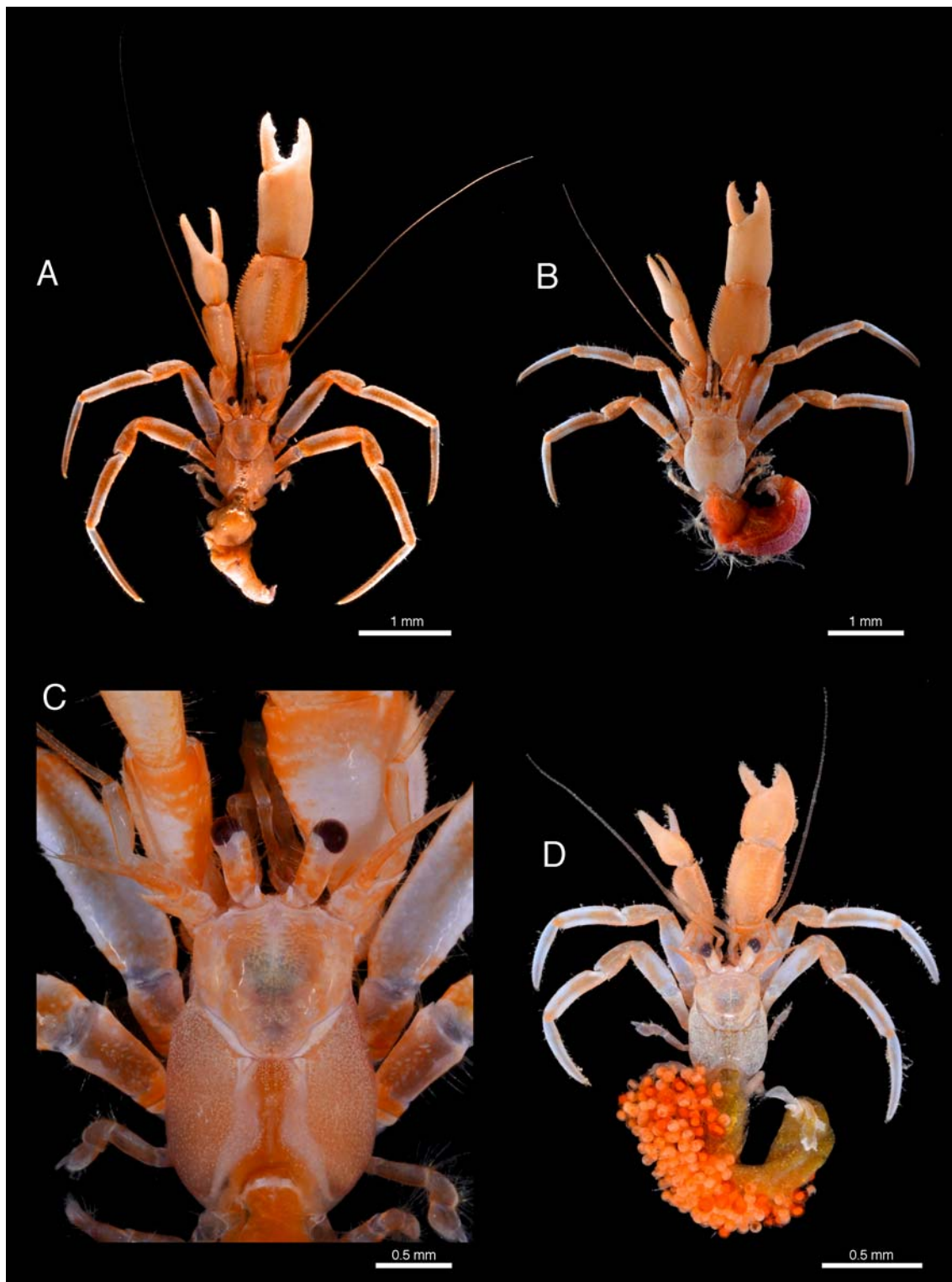



FIGURE 1. *Goreopagurus poorei* Lemaitre & McLaughlin, 2003, Agulhas Shelf, fresh specimens after capture, dorsal view. A, male 4.5 mm, South Coast Survey spring 2016, sta A32823–076 (USNM 1292090); B, female 5.7 mm, Deep Secrets Cruise, ALG230, sta DSC003 DSCS-INV-98 (USNM 1292087); C, same male as A, shield and cephalic appendages, and posterior carapace; D, ovigerous female 3.1 mm, Deep Secrets Cruise, ALG230, sta DSC057 DSCS-INV-568 (USNM 1292092).

Live colouration (Fig. 1). General background orange. Shield light orange fading to white medially and near rostrum, anterior and anterolateral margins. Carapace lateral lobes adjacent to posterolateral margins white. Posterior carapace with branchiostegites orange with numerous minute white punctae; posteromedian plate orange; posterolateral plates white. Ocular acicles white with small orange portion basally on mesial side. Ocular peduncles mottled orange and white on proximal half, distal half mostly white distally except for two orange patches mesially. Chelipeds mostly orange on dorsal, lateral and mesial surfaces, and much lighter orange tone on chela and even lighter on fingers; ventral surfaces nearly white; carpus with light orange tone dorsomedially; merus dorsal surface, lateral and mesial surfaces light orange to white medially, and darker orange distally and proximally. Ambulatory legs each with dactyl white dorsally and light orange ventrally; propodus with weakly defined orange stripe on lateral and mesial faces, otherwise white dorsally and ventrally; carpus mostly orange with undefined white areas dorsally; merus with weakly defined orange stripe on lateral and mesial faces, orange all around distally end mesially, otherwise white dorsally and ventrally; ischium orange.

Distribution. From off eastern Tasmania, Australia, in the western Tasman Sea, and the Agulhas Shelf, off South Africa (see Fig. 4 for South African distribution). Depth range: 334–1,300 m.

Genetic data. Sta DSC006 DSCS-INV-154, 36°45.54'S, 21°12.72'E, 516 m, female 3.7 mm, BOLD: SEAKY1190–17 (USNM 1292088), female 4.5 mm, BOLD: SEAKY1189–17 (USNM 1292089). Sta A32823–076, 35°14.94'S, 22°50.82'E, 520 m, male 4.5 mm, BOLD: SEAKY1187–17 (USNM 1292090). Sta DSC027 DSCS-INV-422, 34°74'S, 25°09.06'E, 622 m, male 3.9 mm, BOLD: SEAKY1188–17 (USNM 1202091). Sta DSC012 DSCS-INV-280, 35°07.20'S, 23°02.76'E, 334 m, female 2.8 mm, BOLD: SEAKY1191–17 (USNM 1292093).

Remarks. *Goreopagurus poorei* had not been reported since its original description by Lemaitre & McLaughlin (2003), which was based exclusively on specimens collected off the Freycinet Peninsula and seamounts of the Southeast Cape, eastern Tasmania. Thus, the presence of this species in South African waters represents a huge range extension to the west and across the Indian Ocean, of approximately 10,100 km (5,400 nautical miles). The specimens in the original description were collected at a depth range of 500–1,300 m, whereas the new specimens herein reported from South Africa were collected at a shallower depth range of 334–622 m. The broad distribution of this species across such an immense expanse of oceans, covering from the western Indian Ocean to the Tasman Sea in the western Pacific, might appear to be unusual. However, a good number of deep-water paguroids, such as various species in genera of the families Paguridae and Parapaguridae that live at similar depth ranges along the continental slopes, are known to also have the same or even wider distributions in the Indo-West Pacific region (*e.g.*, McLaughlin 1997, 2002, 2004; Lemaitre 1999, 2004a, 2004b, 2013, 2014). Moreover, parallel distribution patterns from southern Australia to southeastern Africa were recently recorded for the caridean shrimp *Leontocaris bulga* Taylor & Poore, 1998, and the squat lobster *Munidopsis pyrochela* Ahyong, 2013. Whether or not *G. poorei* will be found between Tasmania and South Africa, across the vast Indian Ocean, can only be determined by more sampling of the varied deep-water habitats that exist in this oceanic region.

Morphological variations of species of *Goreopagurus* have been sufficiently documented in each of the original descriptions of the four species currently known of this genus (McLaughlin 1988; McLaughlin & Haig 1995; Lemaitre & McLaughlin 2003; Nucci & Melo 2007). Variations are particularly visible on the expansion of the carpus and length of the chela of right cheliped, which in some species can be attributable to sexual dimorphism (*G. piercei*, *G. garthi*) or allometric growth (*G. poorei*). In the specimens herein reported from South Africa of *G. poorei*, we have noticed variations in the ambulatory legs (pereopods 2 and 3) related to sex that do not occur in other congeners or at least have not been discussed in the descriptions of species of *Goreopagurus*. In *G. poorei*, males tend to develop distinctly more slender ambulatory legs and longer dactyls than females (Figs 1, 2), and some females can have distinctly stout segments on the ambulatory legs (Fig. 2). The dactyls in males can be up to nine times as long as wide, whereas in females the dactyls can be short and wide, only about six times as long as wide.

The only appreciable morphological difference between the South African specimens of *G. poorei* and those from Tasmania used in the original description by Lemaitre & McLaughlin (2003), is in the armature of the dactyls of the ambulatory legs. The dactyls were described by Lemaitre & McLaughlin (2003) as having ventral margins armed with a range of 10–13 corneous spines, whereas the South African specimens reported herein have a range of 12–23 corneous spines. In addition, the preungual process on the dactyl of pereopod 4 is in some specimens obsolete.

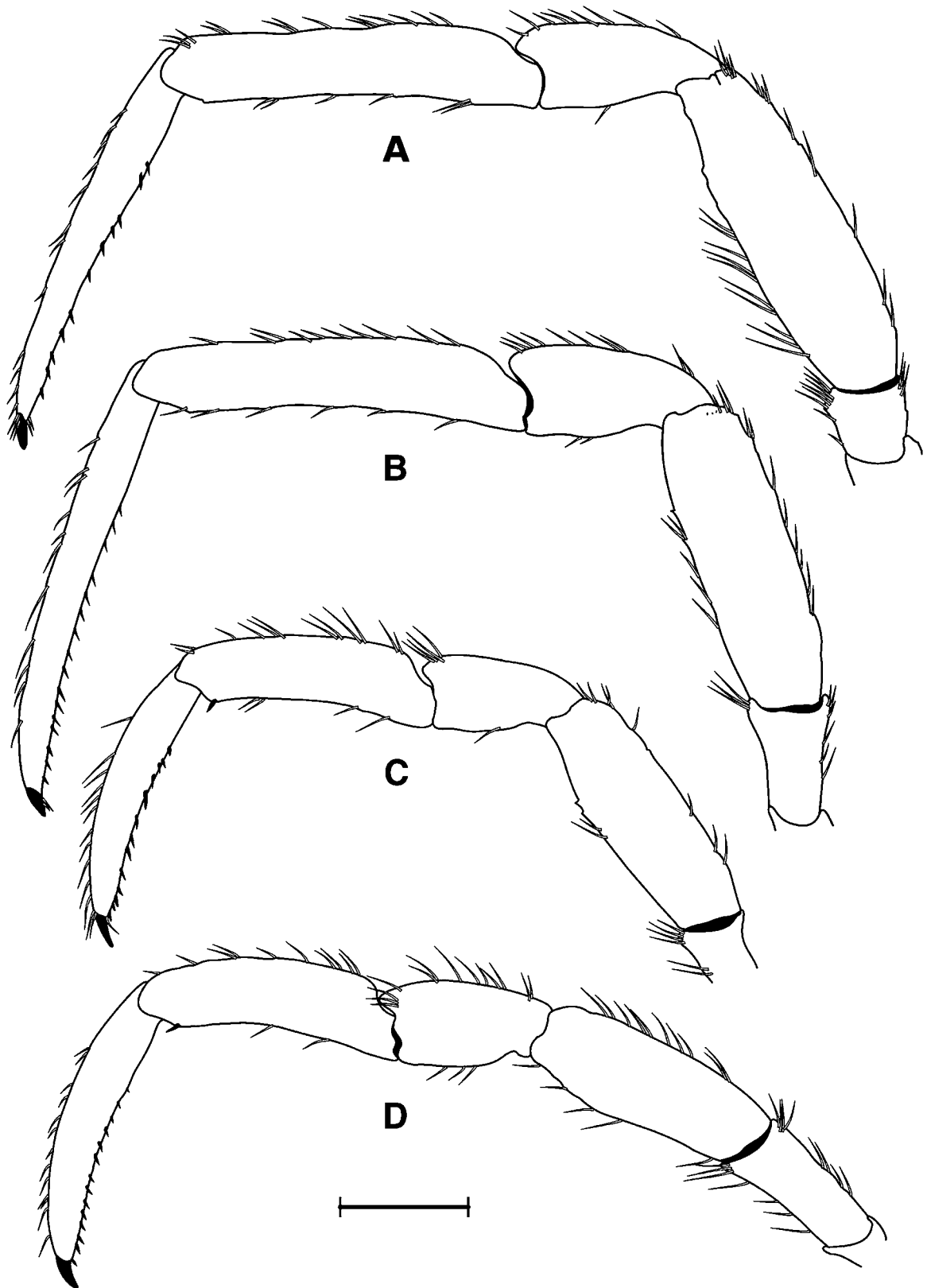


FIGURE 2. *Goreopagurus poorei* Lemaitre & McLaughlin, 2003, left ambulatory legs (pereopods 2 and 3), lateral view: A, B, male 4.5 mm, South Coast Survey spring 2016, sta A32823–076 (USNM 1292090); C, D, female 2.8 mm, Deep Secrets Cruise, ALG230, sta DSC012 DSCS-INV-280 (USNM 1292093). A, C, pereopod 2; B, D, pereopod 3. Scale = 2 mm (A, B), and 1 mm (C, D).

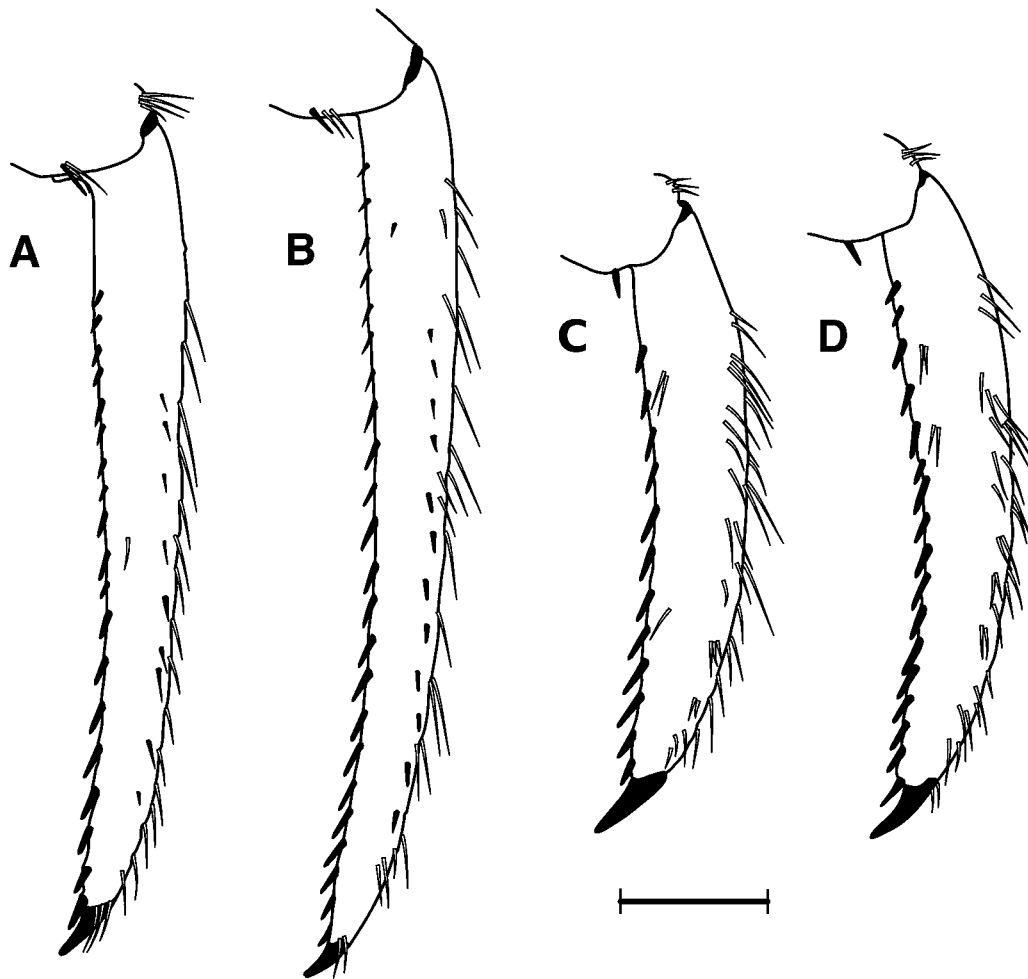


FIGURE 3. *Goreopagurus poorei* Lemaitre & McLaughlin, 2003, dactyls of left ambulatory legs (pereopods 2 and 3), mesial view: A, B, male 4.5 mm, South Coast Survey spring 2016, sta A32823–076 (USNM 1292090); C, D, female 2.8 mm, Deep Secrets Cruise, ALG230, sta DSC012 DSCS-INV-280 (USNM 1292093). A, C, pereopod 2; B, D, pereopod 3. Scale = 1 mm.

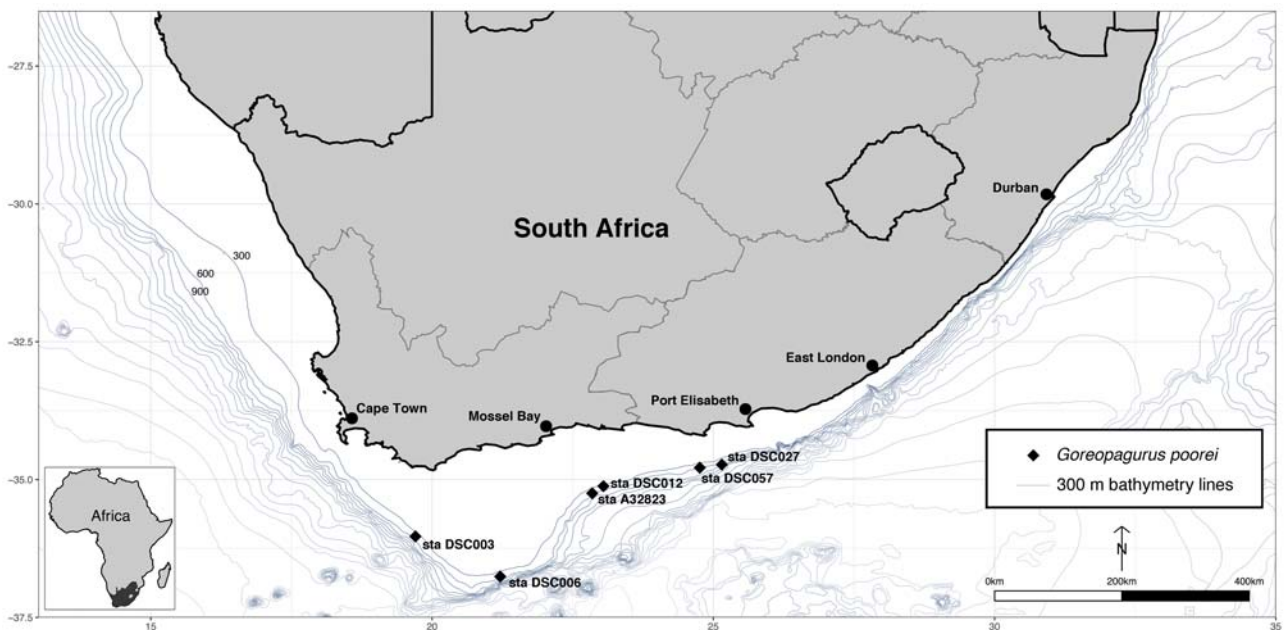


FIGURE 4. Distribution of *Goreopagurus poorei* Lemaitre & McLaughlin, 2003 along the edge of the Agulhas Shelf, South Africa.

The finding in South African waters of numerous specimens of *Goreopagurus poorei* during South African research surveys, suggests that this species is not rare. Individuals can grow to a relatively large size, and it is probably quite abundant. Thus, it seems this species has simply remained overlooked despite the various taxonomic studies and voluminous reports and catalogs on South African decapods spanning 100 years (Stebbing 1910; Barnard 1950; Kensley 1969; Emmerson 2016a-c). This discovery also clearly suggests that, like other invertebrates, the paguroid fauna from South Africa is understudied and requires attention.

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