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Crustacea Decapoda of Glorieuses Islands, with notes on the distribution of the coconut crab (*Birgus latro*) in the western Indian Ocean

JOSEPH POUPIN[1], MAYALEN ZUBIA[2], NICOLE GRAVIER-BONNET[3], PASCALE CHABANET[4] AND AURÉLIE DUHEC[5]

[1]IRENAV, Institut de Recherche de l'École navale, Groupe des Écoles du Poulmic, CC 600, 29240 Brest, France, [2]Université Polynésie française, UMR-EIO, BP 6570, 98704 Faa'a, Tahiti, French Polynesia, [3]ECOMAR, Faculté des Sciences et Technologies, Université de La Réunion, 15 Avenue René Casin, BP 7151, 97715 Saint Denis, La Réunion, France, [4]IRD, BP 50 172, 97492 Sainte Clotilde, La Réunion, [5]Conservation Officer for Alphonse Group, Island Conservation Society, PO 775, Pointe Larue, Mahé, Seychelles

An inventory has been made of the decapod fauna of the Glorieuses Islands, western Indian Ocean (WIO), following the BIORECIE 2 Expedition to the Islands, 5–17 December 2012. Field data are complemented by a review of taxonomic studies for these islands. Overall 157 species are now reported from the Glorieuses Islands, including 61 new records. The presence of the coconut crab, Birgus latro*, is confirmed from these islands, for the first time since 1884, and the WIO distribution of this endangered species is updated, based on observations made in the region since 2006.*

Keywords: Crustacea, Decapoda, Glorieuses Islands, western Indian Ocean, inventory, distribution, Coenobitidae, *Birgus*, endangered species

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INTRODUCTION

The Glorieuses Islands, with Europa, Bassas da Indian, Juan de Nova, and Tromelin belong to the Scattered Islands in the Indian Ocean administered by the French Terres Australes et Antarctiques Françaises (TAAF). It is a small archipelago, about 7 km² in area, located at 11°35′S 47°18′E, 222 km from Nosy-Bé, in the north of Madagascar, and 253 km from Mayotte (Figure 1). Caceres (2003) has given a detailed historical account of this archipelago including its discovery, political status, geomorphology and natural history.

The archipelago is composed of two main islands. Grande Glorieuse, the largest, is sub-circular and has a maximum diameter of 2.3 km. Ile du Lys is much smaller and 0.6 km in length (Figure 1). These two islands are separated by 10 km of shallow reefs. There are also two groups of islets, the Ile aux Crabes, in the south of Grande Glorieuse, and the Roches Vertes, between the two main islands. A military detachment is stationed permanently on Grande Glorieuse and there is an airstrip for services supply and staff turnover. Grande Glorieuse is mostly occupied by a dense forest of coconut trees, crossed by a network of footpaths (Figure 2). There are neither rivers nor a lagoon but there is a small salty marsh that is flooded at high tide only. The sand beaches around the island are used as nesting grounds for sea turtles (*Chelonia mydas*). Ile du Lys is a rocky island with reduced vegetation coverage. It is colonized by seabirds (*Anous stolidus* and *Sterna fuscata*) so numerous during this study that it was difficult to explore the interior of the island. A central marshy depression, linked to the sea by a

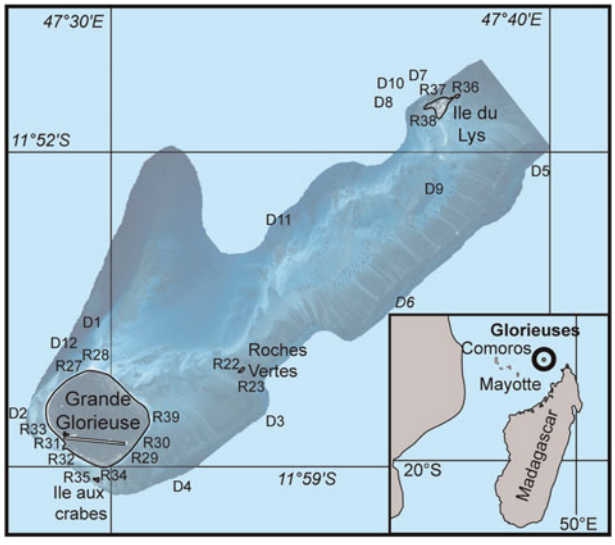

Fig. 1. Map of the Glorieuses Islands with indication of stations investigated during the BIORECIE 2 Expedition, including SCUBA dives (D1–12) and intertidal collection or snorkelling along the reef (R22–39). Adapted from ® Google Earth map at http://crustiesfroverseas.free.fr/pdf/Glorieuses-st-mbr.kmz.

Corresponding author:
J. Poupin
Email: joseph.poupin@ecole-navale.fr

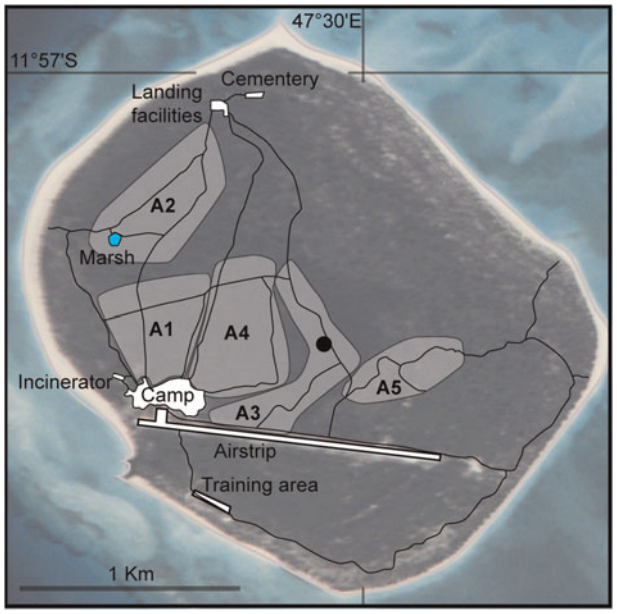

Fig. 2. Map of Grande Glorieuse Island with indication of the terrestrial areas (A1–5) searched at night looking for the coconut crab (*Birgus latro*). The black spot in A3, 11°34.767′S 47°17.779′E, indicates the place where the crabs were observed.

narrow passage in the north of the island, is flooded at high tide.

The fauna and flora of the archipelago are protected by the TAAF. In Grande Glorieuse, with a permanent military detachment, the anthropogenic influence is strictly controlled, but illegal visits by foreign fishermen are still regularly noted at the Ile du Lys.

Terres Australes et Antarctiques Françaises is strongly committed to making the Scattered Islands a Marine Protected Area. To this end several studies have been undertaken in a research program called Biodiversité, ressources et conservation des récifs coralliens des Iles Eparses (BIORECIE, 2011–2013) which aims to update the inventories of the fauna and flora of these islands. The study presented herein is a part of this BIORECIE programme. It focuses on the results obtained for the Crustacea Decapoda during the BIORECIE 2 Expedition to the Glorieuses Islands, 5–17 December 2012. Field data are complemented by a review of the taxonomic studies for these islands, published between 1884 and 2006, with an updated list of the species presented for the Glorieuses Islands. A comparison is made with the results obtained in the Mozambique Channel for Europa Island after the BIORECIE 1 Expedition, 7–12 November 2011 (Poupin *et al.*, 2013). Special attention is paid to the coconut (or robber) crab, *Birgus latro* (Linnaeus, 1767) as this is an endangered species very vulnerable to human predation. Its presence in the Glorieuse Islands is confirmed herein, for the first time since 1882, and its distribution in the western Indian Ocean (WIO) is updated based on recent observations made in the region between 2006 and 2013.

MATERIALS AND METHODS

The Crustacea Decapoda were collected by hand at low tide, in the intertidal zone and by snorkelling in 1–2 m, in 15 reef stations (see Figure 1: R22–23 and R27–39) and Table 1. There were also 12 outer reef stations investigated by SCUBA diving (D1–12) ranging from 0.5–13 m in depth (Figure 1). Land Crustacea were investigated in Grande Glorieuse over eight nights, between 10 and 12 pm, in five areas identified on Figure 2 (A1–A5) with A2 visited twice and A3 visited three times. The Ile du Lys was also prospected during one night (9–12 pm, on 13 December). Crustacea samples were limited to species not identifiable in the field. Overall the collection represents 58 samples that are deposited and registered in the Muséum national d'Histoire naturelle, Paris (MNHN). Almost all the species have been photographed with their live coloration with photographs made available online by Legall & Poupin at http://crustiesfrover-seas.free.fr/glorieuses.php.

Abbreviations used for this work are: coll., collected by; F, female; juv., juvenile; M, male; ov., ovigerous; spec./specs, specimen/s; st., Station.

RESULTS AND DISCUSSION

Historical overview

Before this study, 96 species of Decapoda were reported from the Glorieuses Islands. The oldest records are those of Coppinger (1884) and Miers (1884) after the visit of the British HMS 'Alert', in 1882. These authors report seven common species, including the coconut crab, *Birgus latro* (Linnaeus, 1767). Further crustacean collections were made much later, between 1958 and 1973, by French researchers, such as A. Crosnier, C. Jouannic and J. Millot, working at the 'Institut Français de Recherche Scientifique pour le Développement en Coopération' ORSTOM, Madagascar. Their collections appear sporadically in taxonomic reviews published afterward: Palaemonidae in Bruce (1978); Galatheidae in Baba (1990), Porcellanidae in Haig (1966), Haig & Kropp (1987); Dromiidae in Lewinsohn (1984); Dynomenidae in McLay (1999); Calappidae in Galil (1997); Carpiliidae, Eriphiidae, Oziidae and Pseudoziidae in Crosnier (1984); Parthenopidae in Tan & Ng (2007); Portunidae in Crosnier (1962, 1975), Crosnier & Thomassin (1975); Trapeziidae in Castro (1997); Xanthidae in Serène (1984); and Grapsidae in Crosnier (1965).

In 1977 several deep stations of an expedition called BENTHEDI were investigated off the Glorieuses Islands between 30 and 3000+ m. Nine species of Decapoda have been found in the taxonomic literature as a result of this cruise: 1 Penaeidae in Crosnier (1991); 1 Sicyoniidae in Crosnier (1985); 1 Crangonidae in Komai (2008); 1 Scyllaridae in Holthuis (2002); 1 Diogenidae in Rahayu (2007); 2 Parapaguridae in Lemaitre (2004a, b); 1 Pylochelidae in McLaughlin & Lemaitre (2009); and 1 Dynomenidae in McLay (1999). A deep lobster is also reported by Chan & Yu (1995), 10 km off the Glorieuses Islands, collected in 1983 between 150 and 670 m during an unidentified sampling expedition.

In 2009, a collection of Crustacea was made at the Glorieuses Islands during an international programme called The Southwest Indian Ocean biodiversity hotspot: A biota-level study of diversification on land and sea (BIOTAS). From this campaign Poupin *et al.* (2013a) have already identified 22 anomurans from Mayotte and the Glorieuses

Table 1. Station data for the BIORECIE 2 Expedition in the Glorieuses Islands, 5 – 17 December 2012. MNHN number is the station number indicated on labels for the specimens that are deposited in the Muséum national d'Histoire naturelle, Paris.

MNHN number	Field number	Date	Latitude	Longitude	Depth (m)	Island
R27	27	07/12/2012	11°34 134′S	47°17 384′E	2,5	Grande Glorieuse
R28	28	07/12/2012	11°34 128′S	47°17 560′E	2	Grande Glorieuse
R31	31	07/12/2012	11°34 981′S	47°17 111′E	0,9	Grande Glorieuse
R32	32	07/12/2012	11°35 129′S	47°17 346′E	0,9	Grande Glorieuse
R33	33	07/12/2012	11°34 851′S	47°17 126′E	0,9	Grande Glorieuse
R29	29	08/12/2012	11°35 417′S	47°18 191′E	0,5	Grande Glorieuse
R30	30	08/12/2012	11°35 217′S	47°18 406′E	0,5	Grande Glorieuse
D1	GLO 6	09/12/2012	11°32 973′S	47°17 755′E	13	Grande Glorieuse
D2	GLO 2	09/12/2012	11°34 880′S	47°16 862′E	10	Grande Glorieuse
R34	34	09/12/2012	11°35 482′S	47°17 883′E	0,9	Grande Glorieuse
R35	35	09/12/2012	11°35 521′S	47°17 777′E	0,9	Ile aux crabes
D3	16	10/12/2012	11°35 122′S	47°20 091′E	12	Roches Vertes
D4	17	10/12/2012	11°35 804′S	47°18 524′E	9	Grande Glorieuse
R27	27	10/12/2012	11°34 134′S	47°17 384′E	0,9	Grande Glorieuse
R28	28	11/12/2012	11°34 128′S	47°17 560′E	0,9	Grande Glorieuse
D5	18	11/12/2012	11°32 067′S	47°24 273′E	10	Ile du Lys
D6	GLO 3	11/12/2012	11°33 625′S	47°22 447′E	13	Between Grande Glorieuse and Ile du Lys
D7	19	12/12/2012	11°30 505′S	47°22 560′E	4	Ile du Lys
D8	20	12/12/2012	11°30 785′S	47°21 712′E	11	Ile du Lys
D9	GLO 7	12/12/2012	11°32 227′S	47°22 402′E	4	Ile du Lys
D10	21	13/12/2012	11°30 257′S	47°20 925′E	13	Ile du Lys
R36	36	13/12/2012	11°30 869′S	47°22 759′E	0,9	Ile du Lys
R37	37	13/12/2012	11°30 899′S	47°22 512′E	0,9	Ile du Lys
R38	38	13/12/2012	11°31 075′S	47°22 379′E	0,9	Ile du Lys
D11	GLO 5	14/12/2012	11°32 388′S	47°20 458′E	6	Between Grande Glorieuse and Ile du Lys
D12	GLO 1	14/12/2012	11°33 673′S	47°17 474′E	11	Grande Glorieuse
R39	39	14/12/2012	11°34 957′S	47°18 683′E	0,9	Grande Glorieuse
R22	22	15/12/2012	11°34 214′S	47°19 833′E	0,5	Roches Vertes
R23	23	15/12/2012	11°34 334′S	47°20 003′E	0,9	Roches Vertes
Land		14/12/2012	11°34 822′S	47°17 553′E	0	Grande Glorieuse (coconut forest)

Islands. The rest of the BIOTAS collections, deposited in the University of La Réunion and the Florida Museum of Natural History, Gainesville, were not available for this study. However, the photographs taken during BIOTAS were obtained and carefully examined. Based on these, seven new records can be confidently added to the Glorieuses Islands fauna (indicated by 'BIOTAS photograph[s]' in the list of species in the Appendix).

Updated inventory, with geographical considerations

An updated list of the Crustacea Decapoda from the Glorieuses Islands is presented in the Appendix. The taxonomic classification follows De Grave *et al.* (2009) and the World Register of Marine Species, WoRMS at http://www.marinespecies.org. The list includes 96 records from the taxonomic literature plus 61 new records obtained during this study (in bold). In total, 99 species were recognized during the fieldwork. They can be recognized in the list by being associated with at least one station number (e.g. Station D3, R33) or by the mention of 'LAND', for terrestrial species. Fifty distinct species (58 samples) have been collected and deposited in the Muséum national d'Histoire naturelle, Paris, indicated by an MNHN registration number in the list (e.g. MNHN-IU-2013-7158). Species identified only from photographs taken during the BIOTAS 2009 Expedition are identified by 'BIOTAS photographs'. The WIO indicates the species that are distributed in the western Indian Ocean only. Six terrestrial species are illustrated in colour in Figure 3, and colour photographs of almost all species are available online at http://crustiesfroverseas.free.fr/glorieuses.php.

The number of species by family is summarized in Table 2. For comparison purposes results already obtained for Europa Island in the Mozambique Channel (Poupin *et al.*, 2013b) are also indicated. Overall the two places appear to have a similar fauna. The few discrepancies observed in Table 2 (e.g. Alpheoidea, Dromioidea, etc.) are not considered significant and can be attributed to either chance, or differing sampling efforts. Also, deep water taxa, such as species of Parapaguridae and Pylochelidae, were not targeted around Europa while they were around the Glorieuses Islands. The single difference that seems to make sense in Table 2 is the absence in the Glorieuses Islands of crabs in the families Sesarmidae and Ocypodidae (genus *Uca*). These species depend on the mudflats and mangroves of Europa Island, but such habitats are absent around the Glorieuses Islands.

Most of the species found in the Glorieuses Islands are widespread in the Indo-West Pacific. Among the new records noted in this study, geographical ranges are noticeably extended for two species. *Nursia mimetica* Nobili, 1906 is a small leucosiid crab that was until recently known only from French Polynesia. Poupin (2009) recorded it from La Réunion, and the additional specimen reported herein from the Glorieuses Islands confirms its presence in the WIO. The xanthid crab *Paramedaeus octogesimus* Ng & Clark,

Fig. 3. Terrestrial Decapoda observed at night in the Glorieuses Islands: (A) *Birgus latro* (Linnaeus, 1767); (B) *Coenobita brevimanus* Dana, 1852; (C) *Cardisoma carnifex* (Herbst, 1796); (D) *Discoplax rotunda* (Quoy & Gaimard, 1824); (E) *Geograpsus crinipes* (Dana, 1851); (F) *Geograpsus grayi* (H. Milne Edwards, 1853) (photographs by first author (A–D, F) and Patrick Durville (E)).

2002 was formerly known only from Hawaii and the Cocos (Keeling) Islands, but was recognized in the Marquesas Islands in 2012 (Legall & Poupin, at: http://crustiesfrover-seas.free.fr/). The report in the present work marks a major range extension into the WIO. Seven species of the species listed herein are restricted to the WIO (identified by WIO in the Appendix): anomuran *Areopaguristes abbreviatus* (Dechancé, 1963), *Calcinus rosaceus* Heller, 1861, and *Ciliopagurus tricolor* Forest, 1995; and crabs *Eriphia smithii* MacLeay, 1838, *Euxanthus rugosus* Miers, 1884, *Liocarpilodes armiger* (Nobili, 1905), and *Grapsus fourmanoiri* Crosnier, 1965. A single species is only known from the Glorieuses archipelago, the portunid crab *Thalamita pseudospinifera* Crosnier, 1975, and thus is potentially endemic.

Terrestrial species, with remarks on the coconut crab (*Birgus latro*)

Six terrestrial species (Figure 3) were found during nocturnal searches. Except for the coconut crab (see below), all of them are new records for the islands. Four species were observed in Grande Glorieuse, *Birgus latro* (Linnaeus, 1767), *Coenobita brevimanus* Dana, 1852, *Discoplax rotunda* (Quoy & Gaimard, 1824), and *Geograpsus grayi* (H. Milne Edwards, 1853), while *Cardisoma carnifex* (Herbst, 1796) and *Geograpsus crinipes* (Dana, 1851) were observed only on the Ile du Lys. Although it is probable that the ubiquitous *Geograpsus crinipes* occurs also in Grande Glorieuse, it seems that the land crab *Cardisoma carnifex* has settled only in the small Ile du Lys where it takes advantage of the central marshy depression to dig its burrows. Many individuals were observed there at night, feeding on dead chicken, at the periphery of the seabird colonies.

The coconut crab, *Birgus latro*, has now been recollected from the Glorieuses Islands, for the first time, since the first observation and collection made at the Ile du Lys in 1882 during the voyage of the HMS 'Alert' (Coppinger, 1884; Miers, 1884), with an adult female deposited in the collections of the British Museum. Bouchard *et al.* (2013) reported seeing the species from Glorieuses in 2011, but this record is based on photographs only. They also indicated its presence in Juan de Nova, Mozambique Channel, based on a personal communication by Jean Hivert. Both records are confirmed herein based on the field observations made at Grande Glorieuse during BIORECIE 2 and a new report made at Juan de Nova in March 2013, again shared by Jean Hivert (personal communication).

The coconut crab is not common in Grande Glorieuse. After eight nights of searching (10–12 pm), in five distinct areas (Figure 2), only four coconut crabs were found, including one ovigerous female. These were seen at a single site, near a small swamp, indicated by the black spot inside the A3 area (Figure 2, at 11°34.767′S 47°17.779′E). According to Jean

Table 2. Biodiversity of Decapoda in the Glorieuses Islands expressed as number of species by families and upper classification. For comparative purposes (see text), the right column indicates the results obtained for Europa Island by Poupin *et al.* (2013).

	Upper classification	Family	Glorieuses	Europa
Shrimps and lobsters 22 species (14%)	**Penaeoidea**		2	1
		Penaeidae	1	1
		Sicyoniidae	1	-
	Stenopodidea	Stenopodidae	1	1
	Palaemonoidea		8	12
		Gnathophyllidae	1	1
		Hymenoceridae	–	1
		Palaemonidae	7	10
	Alpheoidea		6	16
		Alpheidae	5	14
		Hippolytidae	1	2
	Crangonoidea	Crangonidae	**1**	–
	Achelata		**4**	**1**
		Palinuridae	3	1
		Scyllaridae	1	–
Anomurans39 species (25%)	**Galatheoidea**		9	11
		Galatheidae	2	3
		Porcellanidae	7	8
	Hippoidea	Hippidae	–	**1**
	Paguroidea		30	28
		Coenobitidae	4	2
		Diogenidae	21	23
		Paguridae	2	3
		Parapaguridae	2	–
		Pylochelidae	1	–
Crabs 96 species (61%)	**Dromioidea**		7	1
		Dromiidae	3	1
		Dynomenidae	4	–
	Calappoidea		3	3
		Calappidae	2	2
		Matutidae	1	1
	Carpilioidea	Carpiliidae	1	1
	Dairoidea		–	3
		Dacryopilumnidae	–	2
		Dairidae	–	1
	Eriphioidea		5	5
		Eriphiidae	3	3
		Oziidae	2	2
	Goneplacoidea	Euryplacidae	1	–
	Leucosioidea	Leucosiidae	1	–
	Majoidea		4	5
		Epialtidae	3	3
		Majidae	1	2
	Parthenopoidea	Parthenopidae	1	–
	Pilumnoidea	Pilumnidae	1	1
	Portunoidea	Portunidae	10	12
	Pseudozioidea	Pseudoziidae	1	–
	Trapezioidea		6	8
		Domeciidae	–	1
		Tetraliidae	1	2
		Trapeziidae	5	5
	Xanthoidea	Xanthidae	38	41
	Cryptochiroidea	Cryptochiridae	–	1
	Grapsoidea		15	16
		Gecarcinidae	2	1
		Grapsidae	9	10
		Percnidae	3	2
		Plagusiidae	1	–
		Sesarmidae	–	1
		Varunidae	–	2
	Ocypodoidea		2	8
		Macrophthalmidae	–	2
		Ocypodidae	2	6
		Total	157	176

Table 3. Distribution status of the coconut crab (*Birgus latro*) in the western Indian Ocean based on literature, data obtained during the BIORECIE program, and ICS investigation in the Seychelles between 2006 and 2013. 'protected', indicates islands that are inhabited by a permanent team that can prevent human predation. The islands are listed from west to east.

Place	Status	Reserve	Occasional and protected	Occasional	Potential but no data	Searched not found	Extinct
Chumbe		x					
Europa						x	
Juan de Nova			x				
Mayotte						x	
Aldabra		x					
Assumption				x			
Grande Glorieuse			x				
Ile du Lys						x	
Cosmoledo				x			
Astove				x			
Providence					x		
Farquhar				x			
Alphonse			x				
Bijoutier				x			
St François					x		
Desneuf						x	
Marie Louise						x	
Poivre				x			
D'Arros			x				
Remire						x	
Desroche			x				
Platte				x			
Mahé						x	
Cousine			x				
Aride			x				
Coetivy				x			
Agalega							x?
Mauritius							x

Hivert (personal communication) the coconut crab is also rare in Juan de Nova where, despite several investigations undertaken during both night and day, it was observed at a single site in April 2011 (near 'Maison Patureau', about 9.00 pm, 17°03.119′S 42°43.380′E, 2 specimens) and at two different sites in 2013 (14 March, 'Camp Séga to Faré', 9.00 pm, 17°03.015′S 42°43.583′E, 1 specimen; 23 March, south of airstrip, 7.00 am, 17°03.390′S 42°43.043′E, 1 specimen). In comparison, near Zanzibar in Tanzania, Nordlund & Walther (2010) mentioned 'without any doubt' more than 280 adult coconut crabs in Chumbe Island, a private nature reserve. Nocturnal searches of the small Ile du Lys failed to find any coconut crab although the specimen collected in 1882 was from this island (Coppinger, 1884; Miers, 1884). As camps belonging to illegal fishermen were observed on the Ile du Lys during BIORECIE 2, it is probable that human predation on this small island is responsible for its disappearance there. On the contrary, the presence of a military detachment that prevents illegal fishing in the waters off Grande Glorieuse also provides good protection for the coconut crab on that island.

The coconut crab is an endangered species with populations declining throughout its geographical range, and as it is esteemed as food it is particularly vulnerable to human predation. *Birgus latro* was listed as globally vulnerable in 1981 under the International Union for Conservation of Nature (IUCN) *Red List*, and although this was downgraded in 1996 to the 'data deficient' category, this was not because populations were known to have recovered, but simply because it was recognized there was insufficient good data for decision making. Its geographical distribution in the Indo-West Pacific is shown in Drew *et al.* (2010, figure 1a, table A1). The results of the BIORECIE programme, complemented by investigations in the Seychelles by the Island Conservation Society (ICS), between 2006 and 2013, allow the distribution of this species in the WIO to be more precisely defined (Table 3; Figure 4). The western limit of distribution is Chumbe Island, a private nature reserve off Zanzibar, Tanzania, where the crab is abundant. *Birgus latro* has sometimes been reported from the African mainland (Reyne, 1939); however, it now appears to be extinct there (see Reay & Haig, 1990; Nordlund & Walther, 2010). Drew *et al.* (2010, table A1) presumed that despite no published records that the species still exists on the Mayotte and Comoros Islands; however, Bouchard *et al.* (2013) did not find it on Mayotte in 2009, despite several inquiries and field investigations. It is therefore probable that *Birgus latro* is not present in Mayotte nor in the nearby Comoros (Grande Comore, Anjouan and Mohéli) and if they were ever present, then they have long-since been taken as food by the impoverished local human population. In the Scattered Islands visited during the BIORECIE programme the coconut crab was not found in Europa or in the Ile du Lys, but it is present in Juan de Nova and Grande Glorieuse. In the Seychelles, the coconut crab has been over-hunted for food on the granitic islands and inhabited outer islands. Inquiries made by the ICS (see also Bowler, 1999) indicate that the presence of *Birgus latro* has now been restricted to

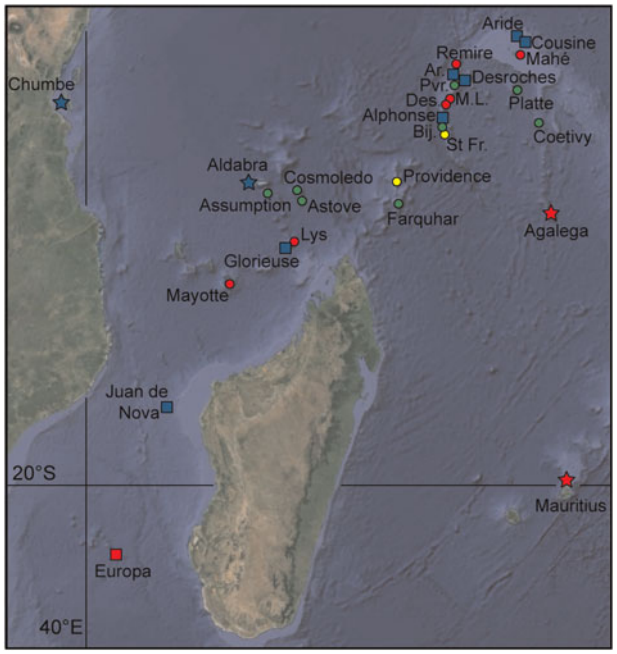

Fig. 4. Distribution of the coconut crab (*Birgus latro*) in the western Indian Ocean: data from BIORECIE program and ICS investigation, between 2006 and 2013. Blue stars, reserves; squares, effectively protected islands (blue, present; red, searched but not found); spots, non-protected islands (green, occasional; yellow, potential but no data; red, searched but not found); red stars, extinct; Ar., D'Arros; Bij., Bijoutier; Des., Desneuf; M.L., Marie Louise; Pvr, Poivre; St Fr., Saint François. Adapted from ® Google Earth map, available at http://crustiesfroverseas.free.fr/pdf/coconut-crab.kmz.

only the two inner islands, Cousine and Aride (2 specimens seen in 2006 and 1 specimen in 2007). In the Amirantes, it is occasionally observed on D'Arros, Desroches (Jupiter *et al.*, 2013), Alphonse (Duhec, 2011), Bijoutier (1 specimen seen in 2012), and is regularly observed on Coetivy (3 specimens seen in 2010), Assumption, Cosmoledo, Astove, and Farquhar (confirmed in 2012). There is a high probability that they occur in small numbers on Providence and St François but this has not been confirmed. Only Aldabra Atoll, a UNESCO world heritage site, still supports an abundant population of coconut crabs estimated at more than one thousand individuals. In the Agalega Islands (Mauritius Republic) the coconut crab was reported by Haig (1984) but its presence can no longer be confirmed (M.K. Rossan, personal communication). As these are populated islands it may have now become extinct there because of human predation. The crab was reported from Mauritius in 1836 by Darwin (1909) in his narration of the voyage of the 'Beagle' but even then he noted that the species was declining. It is now considered extinct there. It is perhaps important to note that the very low incidence of *Birgus latro* on the islands of the WIO does not necessarily mean that there are still viable populations across most of this area. These animals are slow growing and known to live for at least 40–50 years. Such long-lived species, that most likely have only low and sporadic recruitment, are potentially at great survival risk, and need careful management. Islands such as Aldabra Atoll, where there are still significant populations, are thus crucial reservoirs for repopulating other suitable islands in the WIO.

Europa Island (22°21′S) lying to the south of the Mozambique Channel would appear at first to be a suitable refuge for *Birgus latro*, especially as it is permanently protected from human predation by a French military detachment. However, it has never been reported from there and searches over several nights during the BIORECIE 1 Expedition proved to be in vain (Poupin *et al.*, 2013b). The pelagic larval development at sea of the coconut crab takes 3–4 weeks (Reese & Kinzie, 1968). As it is present in Juan de Nova, 640 km to the north of Europa, crabs on Juan de Nova would be a potential source of recruitment for Europa. In the Mozambique Channel the currents consist of mesoscale anticyclonic and cyclonic eddies (Heileman *et al.*, 2009; Ridderinkhof *et al.*, 2010). These eddies can be equally responsible for retaining larvae close to their source over extended periods of time, or conversely, promoting rapid southward drift along corridors formed by the succession of cyclonic and anticyclonic eddies (Hancke *et al.*, 2011; J.F. Ternon, personal communication). The most likely explanation for the absence of *Birgus latro* on Europa Island is that the time taken for oceanic dispersal of larvae between Juan de Nova and Europa is probably far longer than the 4 week larval development phase, and thus recruitment so far south is not successful.

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Correspondence should be addressed to:
J. Poupin
IRENAV, Institut de Recherche de l'École navale
Groupe des Écoles du Poulmic, CC 600
29240 Brest, France
email: joseph.poupin@ecole-navale.fr

APPENDIX: LIST OF THE DECAPODA FROM THE GLORIEUSES ISLANDS

See main text for abbreviations used in this list. Species names in bold typeface are new records for the Glorieuses Islands.

Order DECAPODA Latreille, 1803
Suborder DENDROBRANCHIATA Spence Bate, 1888
Superfamily PENAEOIDEA Rafinesque, 1815
Family PENAEIDAE Rafinesque, 1815
Metapenaeopsis incisa Crosnier, 1991
Family SICYONIIDAE Ortmann, 1898
Sicyonia fallax De Man, 1907
Suborder PLEOCYEMATA Burkenroad, 1963
Infraorder STENOPODIDEA Bate, 1888
Family STENOPODIDAE Claus, 1872

***Stenopus hispidus* (Olivier, 1811)**—Station R33
Infraorder CARIDEA Dana, 1852
Superfamily PALAEMONOIDEA Rafinesque, 1815
Family GNATHOPHYLLIDAE Dana, 1852
***Gnathophyllum americanum* Guérin-Méneville, 1855**—Station R35, 1 spec. MNHN-IU-2013-7158
Family PALAEMONIDAE Rafinesque, 1815
Cuapetes grandis (Stimpson, 1860)—Station R37, 1 spec. MNHN-IU-2013-7148
***Cuapetes tenuipes* (Borradaile, 1898)**—Station D3, 1 spec. MNHN-IU-2013-7146
***Exoclimenella maldivensis* Duriš & Bruce, 1995**—BIOTAS photographs
Harpiliopsis depressa (Stimpson, 1860)
Palaemonella crosnieri Bruce, 1978
Palaemonella tenuipes Dana, 1852
***Periclimenes imperator* Bruce, 1967**—BIOTAS photographs
Superfamily ALPHEOIDEA Rafinesque, 1815
Family ALPHEIDAE Rafinesque, 1815
***Alpheus pacificus* Dana**, 1852—Stations R22 & R30, 2 F ov. MNHN-IU-2013-7147, 1 F ov. R31, MNHN-IU-2013-7159
***Alpheus roseodigitalis* Nomura & Anker, 2005**—Station R39, 3 specs MNHN-IU-2013-7160
Salmoneus brevirostris (Edmondson, 1930)
***Synalpheus ?tumidomanus* (Paul'son, 1875)**—Station D3, 2 specs MNHN-IU-2013-7151
Synalpheus neptunus Dana, 1852
Family HIPPOLYTIDAE Bate, 1888
***Thor amboinensis* (De Man, 1888)**—Station D3, 1 spec. MNHN-IU-2013-7157
Superfamily CRANGONOIDEA Haworth, 1825
Family CRANGONIDEA Haworth, 1825
Parapontophilus abyssi (Smith, 1884)
Infraorder ACHELATA Scholtz & Richter, 1995
Family PALINURIDAE Latreille, 1802
Palinustus unicornutus Berry, 1979
***Panulirus longipes* (A. Milne-Edwards, 1868)**—Station D11
***Panulirus versicolor* (Latreille, 1804)**—Station R23
Family SCYLLARIDAE Latreille, 1825
Chelarctus cultrifer (Ortmann, 1897)
Infraorder ANOMURA MacLeay, 1838
Superfamily GALATHEOIDEA Samouelle, 1819
Family GALATHEIDAE Samouelle, 1819
Galathea spinosorostris Dana, 1852
Galathea tanegashimae Baba, 1969—Stations D3, 1 spec. MNHN-IU-2013-7316, R22, 1 spec., MNHN-IU-2013-7317, R39, 1 spec. MNHN-IU-2013-7318
Family PORCELLANIDAE Haworth, 1825
***Petrolisthes borradailei* Kropp, 1983**—Stations R30, 7 specs MNHN-IU-2013-7343, R34, 7 specs MNHN-IU-2013-7342
Petrolisthes decacanthus Ortmann, 1897
Petrolisthes lamarckii (Leach, 1820)—Stations R30, 2 specs MNHN-IU-2013-7344, R34
Petrolisthes tomentosus (Dana, 1852)
Pisidia delagoae (Barnard, 1955)
Polyonyx biunguiculatus (Dana, 1852)
Polyonyx triunguiculatus Zehntner, 1894
Superfamily PAGUROIDEA Latreille, 1802
Family COENOBITIDAE Dana, 1851
Birgus latro (Linnaeus, 1767)—Station 'LAND'
***Coenobita brevimanus* Dana**, 1852—Station 'LAND'
Coenobita perlatus H. Milne Edwards, 1837—Stations R29, 1 F juv. MNHN-IU-2013-7345, R37
Coenobita rugosus H. Milne Edwards, 1837—Stations R29, 1 F MNHN-IU-2013-7346, R32
Family DIOGENIDAE Ortmann, 1892
Aniculus retipes Lewinsohn, 1982
Areopaguristes abbreviatus (Dechancé, 1963)—WIO
***Calcinus elegans* (H. Milne Edwards, 1836)**—Stations R22 & R37
Calcinus laevimanus (Randall, 1840)—Stations R22, R32 & R34
Calcinus latens (Randall, 1840)—Stations D11, R22, R27, R28, R29, R33, R35 & R39
Calcinus morgani Rahayu & Forest, 1999
Calcinus pulcher Forest, 1958
Calcinus rosaceus Heller, 1861—Stations D3, D12 & R39—WIO
***Calcinus seurati* Forest, 1951**—Station R37
Calcinus vachoni Forest, 1958
Ciliopagurus tricolor Forest, 1995—Station R33—WIO
Clibanarius englaucus Ball & Haig, 1972—Station R34, 5 specs MNHN-IU-2013-7347
Clibanarius eurysternus (Hilgendorf, 1879)—Station R22
Clibanarius virescens (Krauss, 1843)—Stations R30, 7 specs MNHN-IU-2013-7348, R34
Dardanus deformis (H. Milne Edwards, 1836)—Station R37
***Dardanus gemmatus* (H. Milne Edwards, 1836)**—Station R31
Dardanus guttatus (Olivier, 1812)—Stations R30 & R39
Dardanus lagopodes (Forskål, 1775)—Stations D3, 1 F ov. MNHN-IU-2013-7349, D11, D12, R29, R31, R33 & R39
***Dardanus megistos* (Herbst, 1804)**—Station R22
***Dardanus scutellatus* (H. Milne Edwards, 1848)**—Stations D3 & D11
Pseudopaguristes laurentae (Morgan & Forest, 1991)
Family PAGURIDAE Latreille, 1802
Pagurixus carinimanus Komai & Osawa, 2006—Station D2, 3 specs MNHN-IU-2013-7352
***Pagurixus haigae* Komai & Osawa, 2007**—Stations R22, 4 specs MNHN-IU-2013-7351, R39, 1 F ov., 1 spec. MNHN-IU-2013-7350
Family PARAPAGURIDAE Smith, 1882
Strobopagurus sibogae (de Saint Laurent, 1972)
Sympagurus dofleini (Balss, 1912)
Family PYLOCHELIDAE Bate, 1888
Trizocheles hoensonae McLaughlin & Lemaitre, 2009
Infraorder BRACHYURA Linnaeus, 1758
Superfamily DROMIOIDEA De Haan, 1833
Family DROMIIDAE De Haan, 1833
Cryptodromia fallax (Latreille, in Milbert, 1812)
Cryptodromiopsis tridens Borradaile, 1903
Dromidiopsis tridentata Borradaile, 1903
Family DYNOMENIDAE Ortmann, 1892
***Dynomene hispida* (Latreille, in Milbert, 1812)**—Station R39, 1 spec. MNHN-IU-2013-7326
Dynomene praedator A. Milne-Edwards, 1879
Hirsutodynomene spinosa (Rathbun, 1911)
Metadynomene crosnieri McLay, 1999
Superfamily CALAPPOIDEA De Haan, 1833
Family CALAPPIDAE De Haan, 1833
Calappa gallus (Herbst, 1803)

Calappa hepatica (Linnaeus, 1758)
Family MATUTIDAE De Haan, 1835
***Ashtoret lunaris* (Forskål, 1775)**—Stations R28 & R33, 1 F MHHN-IU-2013-7339
Superfamily CARPILIOIDEA Ortmann, 1893
Family CARPILIIDAE Ortmann, 1893
Carpilius convexus (Forskål, 1775)—Stations D3 & R22
Superfamily ERIPHIOIDEA MacLeay, 1838
Family ERIPHIIDAE MacLeay, 1838
Eriphia scabricula Dana, 1852—Stations R22, 1 M MNHN-IU-2013-7338, R37
Eriphia sebana (Shaw & Nodder, 1803)—Stations R22, R34 & R37
Eriphia smithii MacLeay, 1838—Station R37—WIO
Family OZIIDAE Dana, 1851
***Eupilumnus calmani* (Balss, 1933)**—Stations D3 & R39, 1 F MNHN-IU-2013-7340
Lydia annulipes (H. Milne Edwards, 1834)—Stations R22, R32 & R37
Superfamily GONEPLACOIDEA MacLeay, 1838
Family EURYPLACIDAE Stimpson, 1871
***Platyozius laevis* (Borradaile, 1902)**—BIOTAS photographs
Superfamily LEUCOSIOIDEA Samouelle, 1819
Family LEUCOSIIDAE Samouelle, 1819
***Nursia mimetica* Nobili, 1906**—Station R22, 1 spec. MNHN-IU-2013-7315
Superfamily MAJOIDEA Samouelle, 1819
Family EPIALTIDAE MacLeay, 1838
***Menaethius orientalis* (Sakai, 1969)**—BIOTAS photographs
***Perinia tumida* Dana**, 1851—Station D3, 1 spec. MNHN-IU-2013-7330
***Tylocarcinus styx* (Herbst, 1803)**—Station D2
Family MAJIDAE Samouelle, 1819
***Pseudomicippe* aff. *varians* Miers, 1879**—Station R37, 1 F MNHN-IU-2013-7327
Superfamily PARTHENOPOIDEA MacLeay, 1838
Family PARTHENOPIDAE MacLeay, 1838
Daldorfia horrida (Linnaeus, 1758)—Station R37, 1 M MNHN-IU-2013-7341
Superfamily PILUMNOIDEA Samouelle, 1819
Family PILUMNIDAE Samouelle, 1819
***Pilumnus ?longicornis* Hilgendorf, 1878**—Station R39, 1 spec. MNHN-IU-2013-7356
Superfamily PORTUNOIDEA Rafinesque, 1815
Family PORTUNIDAE Rafinesque, 1815
***Charybdis annulata* (Fabricius, 1798)**—Station R30, 1 F ov. MNHN-IU-2013-7313
***Charybdis obtusifrons* Leene, 1937**—Station D11
***Cycloachelous granulatus* (H. Milne Edwards, 1834)**—BIOTAS photographs
Thalamita cooperi Borradaile, 1902
***Thalamita foresti* Crosnier, 1962**—Station R30, 1 spec. MNHN-IU-2013-7312
Thalamita gloriensis Crosnier, 1962
Thalamita picta Stimpson, 1858—Station R22, 1 spec. MNHN-IU-2013-7311, R33
Thalamita pseudospinifera Crosnier, 1975
Thalamita sima H. Milne Edwards, 1834
***Thalamitoides quadridens* A. Milne-Edwards, 1869**—BIOTAS photographs
Superfamily PSEUDOZIOIDEA Alcock, 1898
Family PSEUDOZIIDAE Alcock, 1898
Pseudozius caystrus (Adams & White, 1849)—Stations R30, 5 specs MNHN-IU-2013-7333, R34, 3 juv. MNHN-IU-2013-7334
Superfamily TRAPEZIOIDEA Miers, 1886
Family TETRALIIDAE Castro, Ng & Ahyong, 2004
Tetraloides nigrifrons (Dana, 1852)
Family TRAPEZIIDAE Miers, 1886
Trapezia bidentata (Forskål, 1775)—Station D3
Trapezia cymodoce (Herbst, 1801)
Trapezia digitalis Latreille, 1828
Trapezia lutea Castro, 1997—Station R39, 1 M MNHN-IU-2013-7328
Trapezia rufopunctata (Herbst, 1799)—Station D3
Superfamily XANTHOIDEA MacLeay, 1838
Family XANTHIDAE MacLeay, 1838
Actaea polyacantha (Heller, 1861)
***Actaeodes hirsutissimus* (Rüppell, 1830)**—Station R39, 1 juv. MNHN-IU-2013-7359
Actaeodes tomentosus (H. Milne Edwards, 1834)
***Atergatis floridus* (Linnaeus, 1767)**—Station R34, 1 juv. MNHN-IU-2013-7337
Atergatopsis signata (Adams & White, 1849)
Chlorodiella barbata (Borradaile, 1900)
***Chlorodiella cytherea* (Dana, 1852)**—Station R39, 1 juv. MNHN-IU-2013-7360
Chlorodiella laevissima (Dana, 1852)—Stations D2 & R28
***Cyclodius granulosus* De Man, 1888**—Station R33
Cyclodius nitidus (Dana, 1852)
Cyclodius ungulatus (H. Milne Edwards, 1834)—Station R39, 1 F MNHN-IU-2013-7353
***Etisus dentatus* (Herbst, 1785)**—Station R37
***Euxanthus exsculptus* (Herbst, 1790)**—Station R33
Euxanthus rugosus Miers, 1884—WIO
Forestia depressa (White, 1848)
***Kraussia rugulosa* (Krauss, 1843)**—Station R34, 7 specs MNHN-IU-2013-7331
Lachnopodus subacutus (Stimpson, 1858)
Leptodius nudipes (Dana, 1852)
***Leptodius sanguineus* (H. Milne Edwards, 1834)**—Station R34, 1 F, 1 juv. MNHN-IU-2013-7332
Liocarpilodes armiger (Nobili, 1905)—WIO
***Liocarpilodes integerrimus* (Dana, 1852)**—Station R39, 1 spec. MHNH-IU-2013-7314
Liomera bella (Dana, 1852)
Liomera cinctimana (White, 1847)
Liomera rubra (A. Milne-Edwards, 1865)
Liomera rugata (H. Milne Edwards, 1834)
Lybia tessellata (Latreille, in Milbert, 1812)
Macromedaeus nudipes (A. Milne-Edwards, 1867)—Station R34
***Neoxanthias impressus* (Latreille, in Milbert, 1812)**—BIOTAS photographs
Paractaea retusa (Nobili, 1905)
***Paramedaeus octogesimus* Ng & Clark, 2002**—Station D3, 1 F ov. MNHN-IU-2013-7354
***Paramedaeus simplex* (A. Milne-Edwards, 1873)**—Station R39, 1 juv. MNHN-IU-2013-7355
Pilodius areolatus (H. Milne Edwards, 1834)—Stations D11 & R27
***Pilodius pugil* Dana, 1852**—Station R39, 2 juv. MNHN-IU-2013-7358
Pilodius scabriculus Dana, 1852

Pilodius spinipes (Heller, 1861)—Station R39, 1 M MNHN-IU-2013-7357
***Tweedieia laysani* (Rathbun, 1906)**—BIOTAS photographs
Zosimus aeneus (Linnaeus, 1758)
Zozymodes cavipes (Dana, 1852)—Stations R30, 3 F MNHN-IU-2013-7335, R34, 2 M, 1 F MNHN-IU-2013-7336
Superfamily GRAPSOIDEA MacLeay, 1838
Family GECARCINIDAE MacLeay, 1838
***Cardisoma carnifex* (Herbst, 1796)**—Station 'LAND'
***Discoplax rotunda* (Quoy & Gaimard, 1824)**—Station 'LAND'
Family GRAPSIDAE MacLeay, 1838
***Geograpsus crinipes* (Dana, 1851)**—Station 'LAND'
***Geograpsus grayi* (H. Milne Edwards, 1853)**—Station 'LAND', 1 F MNHN-IU-2013-7321
***Grapsus fourmanoiri* Crosnier, 1965**—Stations R22 & R34, 1 spec. MNHN-IU-2013-7319, 2 specs MHNH-IU-2013-7322, R37—WIO
***Grapsus longitarsis* Dana, 1851**—Station R37
***Grapsus tenuicrustatus* (Herbst, 1783)**—Stations R22, R30, R32, R34 & R37
***Pachygrapsus minutus* A. Milne-Edwards, 1873**—Stations R22, R30 & R34, 7 specs MNHN-IU-2013-7323
***Pachygrapsus planifrons* De Man, 1888**—Stations R22 & R34, 1 spec. MNHN-IU-2013-7324
Pachygrapsus plicatus (H. Milne Edwards, 1837)—Station R34, 2 specs MNHN-IU-2013-7325
***Planes major* (MacLeay, 1838)**—Station D3 (drifting with a buoy)
Family PERCNIDAE Števcic, 2005
Percnon abbreviatum (Dana, 1851)
Percnon guinotae Crosnier, 1965
Percnon planissimum (Herbst, 1804)—Stations R22 & R31
Family PLAGUSIIDAE Dana, 1851
***Plagusia immaculata* Lamarck, 1818**—Station R22 (drifting on a buoy), 1 M, 1 F MNHN-IU-2013-7320
Superfamily OCYPODOIDEA Rafinesque, 1815
Family OCYPODIDAE Rafinesque, 1815
***Ocypode ceratophthalmus* (Pallas, 1772)**—Station R31, 1 juv. MNHN-IU-2013-7329, Stations R32 & R37
***Ocypode cordimanus* Latreille, 1818**—Station R27