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Short Communication

Intertidal Rock Pool Fishes in the Natural Reserve of Glorieuses Islands (Western Indian Ocean)

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Abstract—The fish diversity of intertidal rock pools in the Glorieuses Islands was investigated using clove-oil anaesthetic. That method, is easy to use and safety is well adapted for this type of census. A total of thirty two species belonging to 14 families were sampled. Of these, 19 were observed as adults in most stations and represented the typical population of these intertidal pools, in particular the Blenniidae that presented the highest species richness and the Gobiidae, which were the most abundant. The 13 remaining species were only observed during their juvenile state and appeared to be only temporary residents. More than half of the species collected (17/32 spp) were not recorded during the previous ichthyofauna study at the Glorieuses islands using UVC, results that show the importance of the anaesthetic method that allows the collection of smaller-sized species that live inside the reef framework and are consequently more difficult to record.

INTRODUCTION

The Glorieuses Islands, along with Tromelin, Juan de Nova, Bassas da India and Europa, make up the "Iles Eparses" of the Indian Ocean (Fig. 1). These are French territories spread out around Madagascar and represent an Exclusive Economic Zone of nearly 650,000 km² (Gabrié, 1998). These islands are classified as natural reserves since 1975 (Le Corre & Safford, 2001). Very few studies have been done on marine invertebrates (Gravier-Bonnet & Bourmaud, 2004; Vergonzanne, 1977), on turtles (Lauret-Stepler *et al.*, 2007) and on the beach dynamics (unpublished data, Troadec, 1996). More recently, a coral fish inventory of this archipelago took place between 0 and 15 m depth using an underwater visual census (Durville *et al.*, 2004). This technique (Fowler, 1987) underestimate fish stocks, specially the cryptic species or the intertidal species that hide inside the reef (Harmelin-Vivien *et al.*, 1985). This study was made to complete the first ichthyofauna inventory and provide information on fish populations of the intertidal zone.

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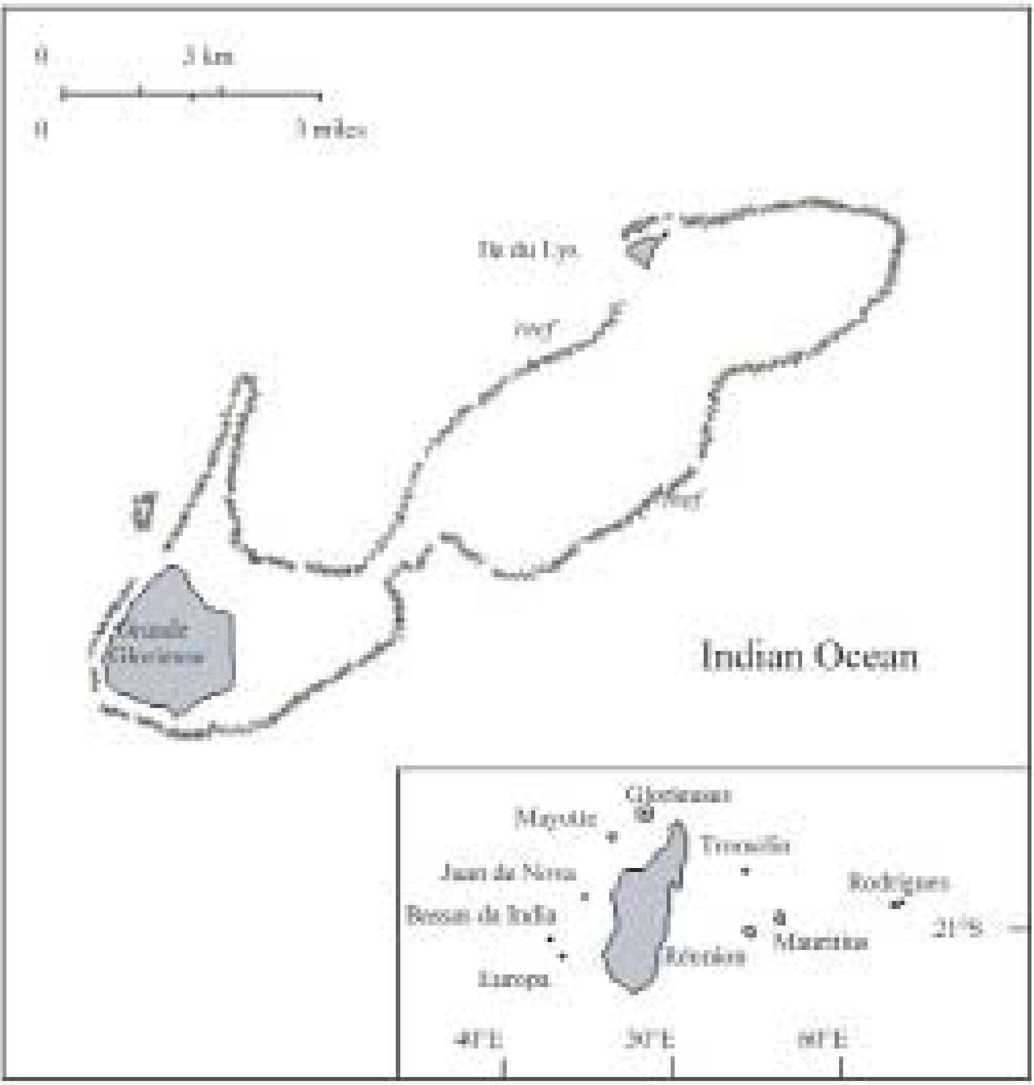

Fig. 1. Geographical location of The Glorieuses Islands

MATERIALS AND METHODS

The Glorieuses archipelago (11°29' S, 47°23' E) have a total surface area of 7 km² including the islands of Grande Glorieuse and Ile du Lys (Fig. 1). The fish were sampled by using a clove-oil based anaesthetic. This product is commonly used in fish farming (Durville & Collet, 2001) and for field sampling of small individuals (Griffiths, 2000). A total of 15 pools were studied at low tide, nine on the Ile du Lys and six at the south of the Grande Glorieuse. The intertidal pools were located on the high part of the infralittoral (zone between high and low tides), an environment not investigated during previous studies. The pools selected had a surface area of approximately 2 m^2 and an average volume of $1m^3$. They were lined mainly by rubble, sand, and vegetatation debris (algae and seagrasses). The clove-oil used ($0.05\ ml.1^{-1}$) were vigorously mixed with seawater to create an emulsion and added to the pools (as described by Durville *et al.*, 2003). After a few minutes, fish were collected counted, listed, photographed and, for those not identified at species level, fixed using a 5% formalin solution. The study was conducted at the end of the austral summer (April - May 2008). For data analysis, fish were categorised into three trophic categories: herbivores, omnivores, and carnivores *sensu lato* after (Hobson, 1974; Harmelin-Vivien, 1979; Myers, 1999).

RESULTS

In total, 32 species belonging to 14 families were sampled (Table 1). In term of species richness, the Blenniidae was the best represented family (seven species), followed by the Pomacentridae and the Gobiidae (six species respectively). Among the 11 families, nine of them were represented by a single species, e.g. the Moringidae, the Muraenidae or the Pseudochromidae. The mean species richness per station was 10.4 ± 3.2 species per pool with a minimum of five species and a maximum of 17 species.

The majority of the 155 fish sampled (more than 88%) belonged to three main families: the Gobiidae with 37% of individuals the Blenniidae (26%) and the Tripterygiidae (25%). The mean abundance per station was 50.3 + 30.7 individuals per pool with a minimum of 19 individuals and a maximum of 133 individuals.

The best-represented trophic category in terms of species richness was the carnivores *sensu lato* (53% of individuals captured) that feed on zooplankton and/or small invertebrates, such as the Gobiidae and the Tripterygiidae. Next in abundance were the herbivores (37%) namely the Blennidae and lastly the omnivores (10%) such as the Mugilidae. In terms of abundance, carnivores are also the best represented with 70% of individuals captured, then the herbivores (29%) and then the omnivores (1%).

DISCUSSION

The study recorded 32 species using clove oil, of which 17 coral reef species were not reported in the previous reef fish inventory conducted using underwater visual census methods (UVC) (Durville *et al.*, 2004). The limitations of UVC are thus revealed, since the UVC recorder does not record the absolute number of individuals (or species) present in the field but only those seen. Furthermore, some families, genera or species have limited distribution, such as the Blennidae genus *Istiblennius* found only in the infralittoral zone. For a complete fish inventory it is necessary to sample the rock pools of the Glorieuses Islands. This work brings the number of reef fish species recorded on this archipelago to 349 species, which is the highest species richness observed in this area (Quod *et al.*, 2007). Sampling methods using anaesthetic are complimentary to those more classically used such as UVC or fishing methods. They allow the difficult collection of smaller-sized species that live inside the reef framework. The clove-oil is also an anaesthetic that is safely used with a minimum toxicity for the environment and one that does not systematically kill all the fish. Experimentation on hard corals *Pocillopora* showed that this genus could resist to a concentration 20 times higher (1 ml. 1-1) that the one used in the present study (0.05 ml.1-1) (Mulochau & Durville, 2004).

In this study, some families such as Blenniidae, Gobiidae and Tripterygiidae were observed as adults in most stations and represent the typical population of these intertidal pools. These fish are remarkably well-adapted to their environment, each of them occupying a specific type of habitat (see Horn & Gibson, 1988). Other families such as the Lutjanidae, Chaetodontidae, Pomacentridae, Labridae, Mugilidae, Acanthuridae and Bothidae were only represented in some stations and as juveniles. These fish could be simply trapped accidentally in the intertidal pools during low tide or may use this strategy to escape the numerous predators of the reef.

Table 1. Inventory of the intertidal rock pool fishes of the Glorieuses Islands (family, species and authors); life stage (A: adult, J: juvenile); Location (GGlo: Grande Glorieuse; Lys: Ile du Lys); diet (Ca: Carnivores; Her: Herbivores; Om: Omnivores) and number of individuals of each species

FAMILY Species - Authors of individuals	Life stage	Location	Diet	Number
MORINGIDAE				
Moringa sp.*	J	GGlo	Ca	1
MURAENIDAE				
Siderea picta (Ahl, 1789)	J+A	GGlo+Lys	Ca	5
PSEUDOCHROMIDAE				
*Haliophis guttatu*s (Forsskål, 1775)*	A	Lys	Ca	14
KUHLIIDAE				
Kuhlia mugil (Forster in Bloch & Schneider, 1801)	J	GGlo+Lys	Ca	13
LUTJANIDAE				
Lutjanus sp.	J	GGlo	Ca	2
CHAETODONTIDAE				
Chaetodon lunula (Lacepède, 1802)	J	GGlo+Lys	Ca	2
POMACENTRIDAE				
Abudefduf notatus (Day, 1870)	J	Lys	Her	1
Abudefduf septemfasciatus (Cuvier, 1830)*	J	GGlo+Lys	Her	3
Abudefduf sordidus Forsskål, 1775*	J	GGlo+Lys	Her	9
Abudefduf vaigiensis (Quoy & Gaimard, 1825)	J	GGlo+Lys	Her	6
Chrysiptera biocellata (Quoy & Gaimard, 1825)	J	GGlo+Lys	Om	4
Chrysiptera glauca (Cuvier & Valenciennes, 1830)	J	Lys	Om	5
LABRIDAE				
Stethojulis albovittata (Bonnaterre, 1788)	J	Lys	Ca	2
Thalassoma purpureum (Forsskål, 1775)*	J	GGlo+Lys	Ca	18
MUGILIDAE				
Mugilidae sp.	J	Lys	Om	2
BLENNIIDAE				
Blenniella cyanostigma (Bleeker, 1849)*	A	GGlo+Lys	Her	26
Entomacrodus sp.*	A	GGlo+Lys	Her	44
Istiblennius dussumieri (Valenciennes, 1836)*	A+J	GGlo+Lys	Her	28
Istiblennius edentulus (Schneider, 1801)*	A+J	GGlo+Lys	Her	54
Istiblennius cf. meleagris (Valenciennes, 1836)*	A	Lys	Her	10
Istiblennius spilotus Springer & Williams, 1994 *	A+J	GGlo	Her	22
Istiblennius sp.	A+J	GGlo+Lys	Her	12
GOBIIDAE				
Callogobius sp.*	A+J	GGlo+Lys	Ca	19
Eviota bimaculata Lachner & Karnella, 1980*	A	GGlo+Lys	Ca	25
Gnatholepis sp.	J	GGlo	Ca	1
*Istigobius ornatus**	A+J	GGlo+Lys	Ca	81
Istigobius sp.*	?	GGlo	Ca	149
Gobiidae sp.*	?	Lys	Ca	6
TRIPTERYGIIDAE				
Enneapterygius sp.1*	A	Lys	Ca	98
Enneapterygius sp.2*	A	Lys	Ca	90
ACANTHURIDAE				
Acanthurus triostegus triostegus (Linnaeus, 1758)	J	GGlo+Lys	Her	2
BOTHIDAE				
Bothus mancus (Broussonet, 1782)	J	GGlo	Ca	1

* Species not observed during the recent inventory of the Glorieuses Islands reef fish (Durville *et al.*,2004)

The abundance recorded by station (max. 133 individuals) is difficult to interpret because of the phenomenon of fish concentration in the rock pools at low tide. Yet in many studies on reef ichthyofauna, these species are not taken into account and are often considered as "negligible" not only because of their small size, but also because of the difficulty of recording them using UVC methods (Chabanet, 1994; Letourneur, 1996). This study shows that such fish abundance can be high, particularly for the Gobiidae or the Tripterygiidae. As these families could play an important role in determining the number and composition of algae and invertebrate communities of intertidal rock pools (Grossman, 1986), they could have an important impact on this biotope due to their high density.

It was also noticed that some species, such as members of the Tripterygiidae and the Pseudochromidae, were found in high densities in rock pools at Ile du Lys but were lacking at Grande Glorieuse. Conversely, Globiidae species (*Istigobius* sp.) was abundant in the rock pools at Grande Glorieuse but was not observed at Ile du Lys. The presence of thousands of seabirds, such as sooty stern (*Sterna fuscata*) at Ile du Lys at this time of the year (Le Corre & Jaquemet, 2005; Probst, 2000) could explain the abundance of the Tripterygiidae in the littoral rock pools. The guano of these birds enriching the coastal zones in phosphates could favour the development of the phytoplankton and then of the zooplankton, the main diet of the small carnivorous fish. The warm water recorded at the end of the austral summer (between 28 to 29°C, ARVAM, unpublished data) could also favour the increase of plankton. Lastly the recruitment of coral reef fish which is higher in February and March in the Indian Ocean (Durville *et al.*, 2002) could increase fish abundance adding new recruits to the littoral rock pool community.

In conclusion, this study provides new information about the lesser known fish species of the littoral rock pools of Glorieuses Islands, which are found sometimes in high density in this particular biotope and should be systematically included in the overall inventories on the coral reefs ichthyofauna.

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