Clonality, Genetic Diversity, and Connectivity of *Acropora* Coral Populations in the Lesser Antilles

Clonalidad, Diversidad Genética y Conectividad de las Poblaciones de los Corales *Acropora* en las Antillas Menores

Clonalité, Diversité Génétique et Connectivité des Populations de Coraux du Genre *Acropora* dans les Petites Antilles

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EXTENDED ABSTRACT

Species of the genus *Acropora* with a wide range of relatively complex morphologies, mainly described as branchy or tabular, are largely responsible for the structure of current coral reefs. In the Caribbean region, the Acroporidae family is represented by only two emblematic species, the elkhorn coral *Acropora palmata* (Lamarck, 1816) and the staghorn coral *Acropora cervicornis* (Lamarck, 1816). These two Caribbean *Acropora* species and particularly *A. palmata* used to be highly responsible for the structural complexity of Caribbean reefs (Bruckner 2002). Since the late 1970s, Caribbean tropical marine ecosystems show signs of alteration (Wilkinson 2008). At the same time, Caribbean *Acropora* populations have dramatically declined and now *A. palmata* and *A. cervicornis* are considered as "critically endangered" by the International Union for Conservation of Nature (IUCN). Estimate resilience induced by high genetic diversity and connectivity induced by gene flows among populations is crucial to better know the health status of populations in order to conservation objectives. On the Caribbean scale, most of the previous works investigating *Acropora* population genetics and connectivity involved the reefs of Florida, the Bahamas, the Mesoamerican Reef System and the Greater Antilles (Japaud et al. 2019). Little is known regarding the eastern Caribbean populations, especially in the Lesser Antilles. Thus, the main objectives of this study were:

i) To estimate the levels of clonality and genetic diversity of *Acropora* populations of the Lesser Antilles,
ii) To investigate *Acropora* spatial scales of larval dispersal in the Lesser Antilles and
iii) To explore the possible contributing factors explaining the genetic structure of *Acropora* populations in this region.

A total of 1,042 colonies of *Acropora palmata* and 186 colonies of *A. cervicornis* were sampled among 42 sampled sites from 11 islands of the Lesser Antilles, from the northern islands of St. Martin and St. Barthélemy to the southernmost islands of St. Vincent and the Grenadines (Figure 1) between May 2011 and May 2015. Additional 31 *Acropora* colonies from Guadeloupe and Saint Barthélemy presenting an intermediate morphology between those of *A. palmata* and *A. cervicornis* were also sampled. For all samples, fourteen microsatellite loci specific to *A. palmata* (Baums et al. 2005, 2009) were amplified by PCR according to the protocol described in (Japaud et al. 2015). Total genomic DNA extractions, molecular analyses and data analyses were performed as described in (Japaud et al. 2019). The 31 colonies presenting a different morphology were identified as *Acropora prolifera*, a hybrid taxon of *A. palmata* and *A. cervicornis* (van Oppen et al. 2000).

Less than 200 colonies of the species *A. cervicornis* were observed on three islands surveyed in this study: Guadeloupe, St. Martin and St. Barthélemy. In addition, populations of this species have had a very small number of distinct genetic individuals, reflecting a predominance of asexual reproductive mode and clonal colonies in populations and a lower genetic diversity than for *A. palmata* species. Thus, these results seem to reveal relict populations of the *A. cervicornis* species in the Lesser Antilles. However, *A. cervicornis* is historically described as being able to evolve to a depth of 20 m on the outer reef slopes (Goreau 1959) and the majority of the sampled colonies of this species were observed in this study on shallow sandy bottoms such as in lagoons. Thus, it would probably have been necessary to further explore the outer reef slopes and lagoons of the Lesser Antilles islands in order to potentially find more colonies of *A. cervicornis* and to make a more accurate assessment of its status in the Lesser Antilles. In this context, illustrating a probable "Allee effect" for the species *A. cervicornis*, the probability of intraspecific fertilization is therefore strongly limited (Fogarty et al. 2012). The presence of the hybrid taxon *A. prolifera* associated with the hypothesis that the decline of Caribbean *Acropora* species could lead to an increase in the probability of hybridization phenomena would be in agreement with the fact that since the early 2000s, publications have regularly reported the appearance of this hybrid on Caribbean reefs even though it was recognized as relatively rare until now (Fogarty et al. 2012).

In the Lesser Antilles, estimates of genotypic indices for *A. palmata* have thus varied considerably between sampling sites, even for relatively close sites or sites located on the same island. Differences in estimates of genotypic richness between populations from different reefs appear more likely to be associated with site-specific environmental conditions, rather than with other factors such as a difference in the sampling strategy used (Mège et al. 2014). Thus, it would appear that dense populations of relatively large coral colonies on a site characterized by a shallow, flat bottom and regularly swept by swells and/or strong currents correspond to general characteristics that appear to favor the expansion of branchy *Acropora* corals by fragmentation (Baums et al. 2006). Conversely, reefs where *A. palmata* has shown little or no clones could represent areas of less suitable habitat and low population densities (Mège et al. 2014). Alternatively, populations of *A. palmata* with low colony density, with few or no clones, could be relics of old and dense populations that have faced significant disruptive events (such as episodes of white band disease, coral bleaching, hurricanes, significant growth of macroalgae, high predation...), resulting in massive colony losses without effective and consecutive resilience of these populations (Bruckner 2002). Globally, genetic diversity levels in *Acropora* populations from the Lesser Antilles were lower compared to what was previously reported within the wider Caribbean and may indicate a lower evolutionary potential, and therefore a lower resilience capacity for these eastern Caribbean *Acropora* populations (Japaud et al. 2019). Due to the small number of *A. cervicornis* samples, all subsequent analysis of the genetic structure of *Acropora* populations of the Lesser Antilles were carried out for the *A. palmata* species alone. Because of a similar reproduction mode of the two Caribbean *Acropora* species, the discussion of the results of the genetic structure of *A. palmata* populations can illustrated the situation of *A. cervicornis* populations. For *A. palmata*, the analysis of the genetic structure, crossed with spatial autocorrelation analysis, revealed an isolation-by-distance pattern at both reef and Lesser Antilles (Figure 1; Figure 2). Altogether, these results suggest a restricted population connectivity and short distance dispersal of *Acropora* larvae within the Lesser Antilles, further limited by geographic distances among suitable habitat patches.

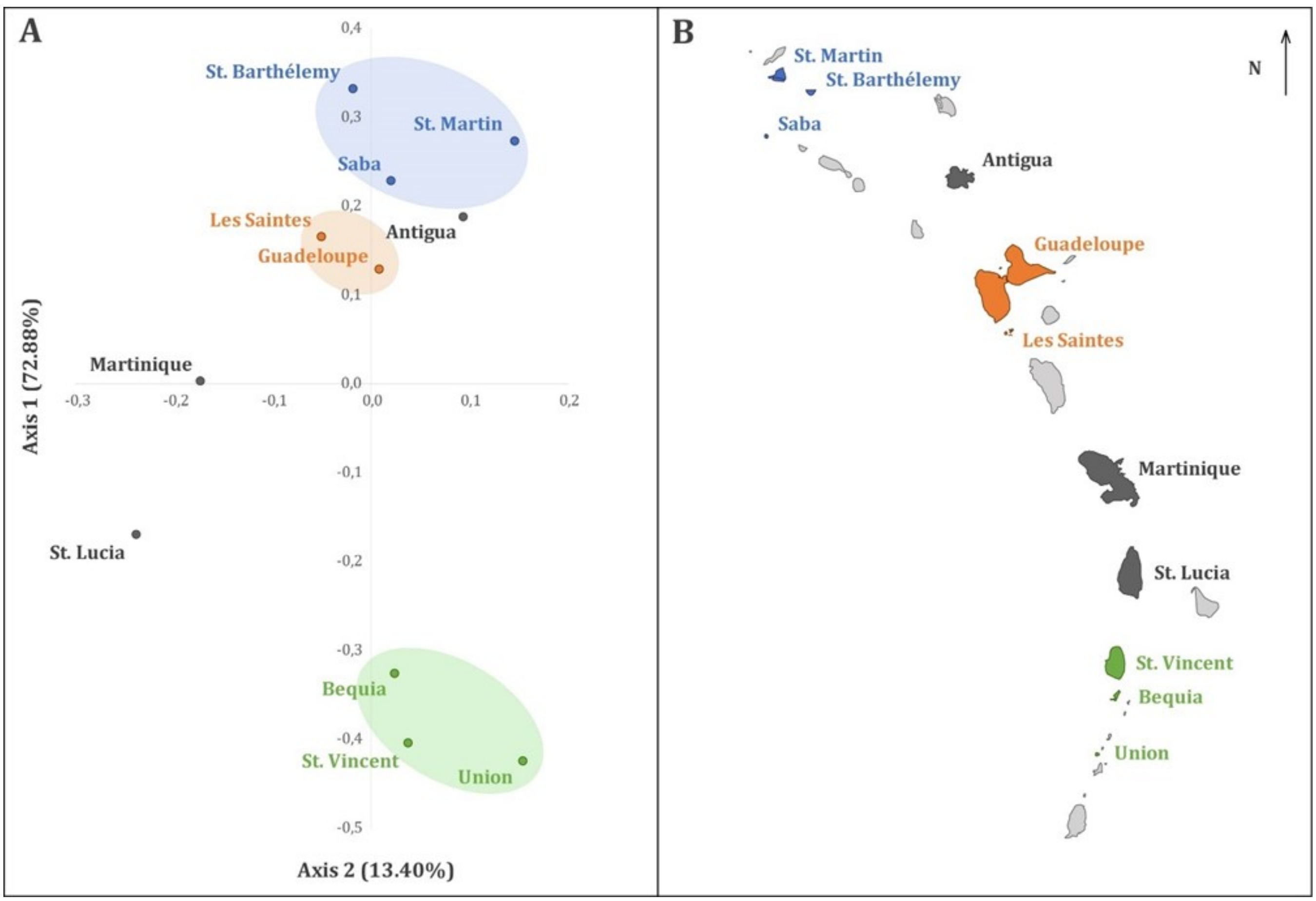

Figure 1. Illustration of the genetic structure of *Acropora palmata* populations of the Lesser Antilles as isolation-by-distance pattern. **A.** Principal Coordinates Analysis (PCoA) based on genetic similarities among the sampled island populations of *Acropora palmata*, estimated through the analysis of microsatellite loci. **B.** Map of the 11 islands prospected in the Lesser Antilles.

Based on these results, conservation efforts for the *Acropora* populations of the Lesser Antilles would be realized on a local scale. Guadeloupe Port Authority, as manager of natural areas, has initiated a project to conserve and restore *Acropora* populations in Guadeloupe.

KEYWORDS: *Acropora*, Lesser Antilles, larval dispersal, genetic diversity, isolation-by-distance

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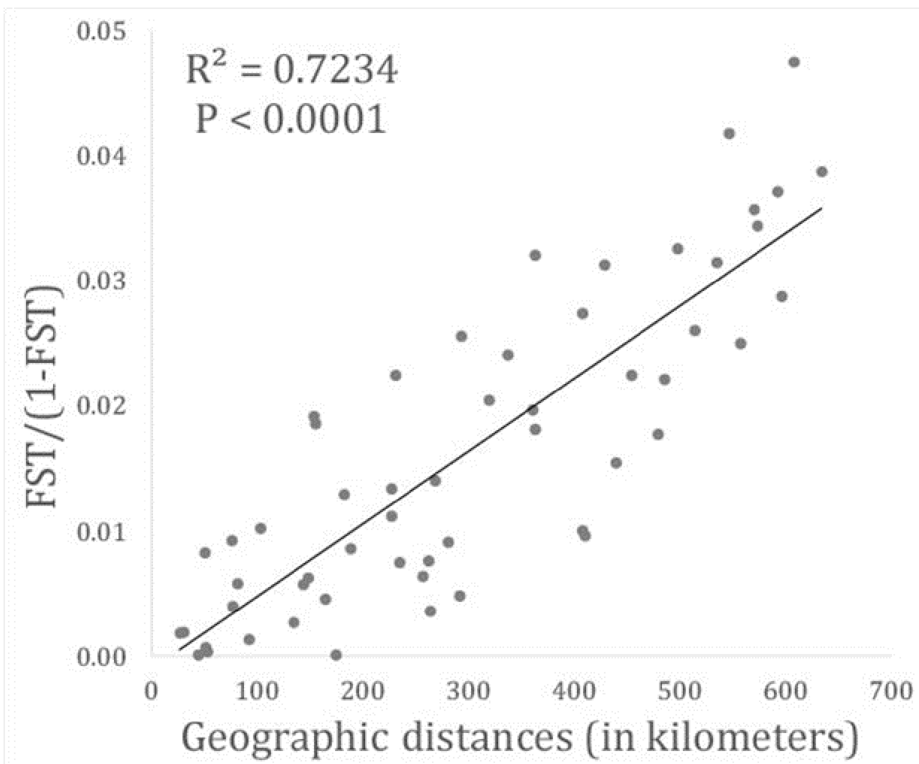

Figure 2. Relationship between genetic (FST/1-FST) and geographic (in km) distances estimated among *Acropora palmata* sampling sites in the Lesser Antilles among islands (i.e. pooling sampled sites per island).