**Navigating floristic networks: linking oceanic currents and littoral flora across oceanic archipelagos**

**Abstract**

Dispersal through marine currents (thalassochory) is predicted to play an important role in the distribution of plant biodiversity in oceanic archipelagos. Littoral plants, adapted to salt exposure, are often implicitly assumed to disperse particularly well via thalassochory. However, the effectiveness of this mechanism remain largely unknown as it is extremely difficult to observe and contingent on a complex interaction of marine currents. Here, we integrate comprehensive floristic data from the Galapagos, Canaries, and Azores with ocean current data spanning 26 years (1992-2018) to evaluate the effect of currents connectivity on plant distribution. Using Procrustes correlation analysis, we compared distance matrices of flora, ocean currents, and island factors (geographic distance, age, and area) for each archipelago. Network theory was applied to current connectivity data to identify island centrality roles as sinks (In-Degree), sources (Out-Degree), proximals (Closeness), and hubs (Betweenness) within each archipelago. We then assessed whether their centrality predicts its percentage of littoral species. Our results revealed a strong correlation (0.87) between ocean current and floristic connectivity in the Canaries, moderate (0.55) in the Galapagos, and not significant in the Azores. Current connectivity was highly correlated with geographic connectivity on the three archipelagos, and moderately correlated with Age connectivity for Galapagos and Azores. Correlations were consistently higher for littoral plants than for non-littoral plants. In the Canarian archipelago, the percent of littoral flora was predicted by the centrality of islands acting as sinks and hubs in the oceanic currents network. In contrast, no effect was detected in the Galapagos and Azores. These findings underscore the varying influence of currents on littoral flora distributions across different archipelagos and demonstrate the utility of network theory in understanding ocean current connectivity. We suggest that the role of thalassochory in shaping plant biogeographic patterns depends on the spatial configuration of islands and the directionality of currents entering the archipelago.

Introduction

**[P1 - Role of oceanic currents in long-distance dispersal - oceanic archipelagos]**

**[P2 - LDD not reliable - need experimentation and quantify the dispersal vector. In traits such as zoochory is more straightforward. For thalassochory, too complex - infer from both experimentation and a combination of floristic and current patterns - but most analysis on one or few species, and very few at the community level]**

**[P3 - Littoral flora - potentially adapted to thalassochory]**

**[P4 - Hypothesis and objectives]**

We hypothesize that the similarity on the composition of littoral flora (here after floral connectivity) is correlated with the oceanic currents connectivity, and that this correlation is higher than for non-littoral flora. We also predict that, because the spatial distribution of islands within an archipelago influences the ocean current network, archipelagos with similar island configurations, such as the Canaries and Azores, will exhibit similar connectivity patterns and distinct from those of Galapagos (Whittaker and Fernández-Palacios 2007). Secondly, if thalassochory significantly drives littoral flora dispersal, islands with greater in-centrality (i.e., centrality of incoming links) in the ocean currents network should harbor greater diversity of littoral species.

To address these questions, our objectives are to (1) test for a relationship between the connectivity patterns of littoral and non-littoral flora and oceanic currents across archipelagos, and (2) test whether islands with central roles in oceanic current (incoming) connectivity networks contain a higher proportion of littoral plants.

Methods

**Oceanic currents data**

Oceanic current data were obtained from the Hybrid Coordinate Ocean Model (HYCOM) dataset ([www.hycom.org](http://www.hycom.org)), which provides spatially and temporally resolved information on ocean currents (Chassignet et al. 2007). We used data covering 26 years (1992-2018) for the Galapagos (-1.8 to 0.9°N, -92.0 to -88.7°W), Canaries (26.7 to 29.9°N, -18.8 to -12.6°W), and Azores (36.5 to 40.1°N, -32.2 to -23.4°W) archipelagos. Using the "HMMoce" R package, we extracted eastward and northward ocean current velocity vectors at an 8km resolution for every two days along the 26 years. From these, we calculated current mean direction (in degrees) and speed (in m/s). Direction was calculated using the “raster” package and converted from radians.

**Oceanic currents connectivity**

We use the “rWind” package to compute a conductance matrix representing the ease of movement between geographic points based on ocean currents (See Fernández-López & Schliep 2018). This package calculates the movement cost from any starting cell to one of its 8 adjacent cells (Moore neighborhood) accounting for the directional and speed characteristics of ocean currents (Muñoz et al. 2004, Felicísimo et al. 2008).

To assess connectivity between islands within each archipelago, cost matrices were derived from the conductance matrices. Using the costDistance function, we computed the minimum cost path (conductance) required to travel between pairs of islands. This process integrated the geographic coordinates (latitude and longitude) of the islands with the conductance values derived from oceanic current data. To cover all orientations (North, South, West, East), we selected a coordinate point on each side of the islands from which we calculated the current connectivity paths to the rest of the islands within the archipelago. For larger islands, we added one connection point every 40 km (5 pixels of 8 km) to increase our sampling of points and, consequently, potential shortest paths connecting with other islands. For example, Isabela Island in the Galápagos archipelago has a total of eight connection points: one in the North and South, and three each on the East and West sides. For small islands with an area occupying less than a pixel of the rasters (<8 km), a single connection point was assigned (Figure S1, S2).

Marine currents can vary over time due to climatological conditions, causing fluctuations in the potential for thalassochory. To account for this variability, we extracted the values corresponding to the highest 5% of maximum connectivity (i.e. lower connection costs) for each pair of islands and calculated their median This procedure results in temporal windows of opportunity for successful thalassochory while excluding the most extreme and rare events.

**Floristic connectivity**

Floristic data for species within lowland habitats (areas under 500m) were obtained from various databases for each archipelago: ref for Galapagos, ref for Canaries, ref for Azores. We then grouped them as those classified as littoral and those that don't, i.e. non-littoral: 25 and 429 in Galapagos, 111 and 1122 in Canaries, and 24 and 121 in Azores (Figure S3).

The relative separation (high dissimilarity) or closeness (low dissimilarity) of floristic composition between islands was quantified with the Bray-Curtis Dissimilarity Index (Bray & Curtis, 1957). This index ranges from zero (maximum similarity) to one (no shared species). We chose this index because it accounts for double-zero attributes, or co-absences, where the absence of a species also informs the floristic composition of an island (Greenacre, 2017; Todeschini et al., 2012), and is widely used in comparing community distances on oceanic islands (e.g. Castro-Urgal & Traveset, 2014; Florencio et al., 2013, Thuesen et al., 2011). We then computed two floristic distance matrices between each pair of islands for each archipelago: one for littoral plant species and another for non-littoral plant species.

**Island factors connectivity**

We then explored how the floristic connectivity of littoral and non-littoral floras relates to geographic distance, island age, and area. Geographic isolation often promotes diversification on isolated islands (ref), and therefore it is expected to be correlated with floristic distances between islands. Additionally, we expect connectivity by currents to correlate with geographic distance, as increased distance typically raises the total travel cost between islands, decreasing colonization probability. Floristic connectivity may also align with island age differences, since many terrestrial groups diversified in tandem with the geological formation of the islands (Parent et al., 2008, refs). Furthermore, younger islands may harbor early colonizing species, whereas older islands may host more competitive species (ref). Lastly, islands with larger areas may support higher diversity by providing wider niche spaces, which enhance coexistence and ecological opportunities (Parent et al., 2020, refs).

To compute geographic distances (km), we downloaded shapefile maps of the archipelagos from NOAA ([www.noaa.gov](http://www.noaa.gov)) and obtained the geographic centroid of each island using QGIS software with the tool ‘geometry by expression’. This function calculates the geometric center of the polygon by averaging the x-coordinates and y-coordinates of all the vertices of the polygon. These maps also provided the measures for island area (km²). For island ages (Myr), we considered the mean between minimum and maximum emergence estimates for the Galapagos from Geist et al. 2014. For the Canaries, we obtained estimated ages from Carracedo et al. 1998 and Anguita & Hernán 2000, and considered the mean for islands with discrepancies between the two sources. For the Azores, we obtained the data from \_\_. For each archipelago, the pairwise geographic distances between island centroids formed a connectivity matrix. We computed Euclidean distances between island ages and areas using the daisy function from the “cluster” package to obtain the connectivity matrices for each.

**Drivers of island floristic connectivity**

To understand how the structure of ocean currents connectivity networks within archipelagos correlates with those of littoral flora and other island factors, we employed Procrustes analysis, which measures the degree of similarity between two matrices by finding an optimal superimposition through transformations such as translation, rotation, and scaling (Legendre & Legendre 2012). Its flexibility and interpretability have made it widely used in ecology to measure biogeographic patterns of floristic connectivity (Munoz et al. 2004, Legendre et al. 2012). After optimal superimposition, the Procrustes distance is calculated as the sum of squared distances between the corresponding points in the transformed configuration and the target configuration, thus quantifying the degree of similarity between the two matrices.

To explore how the structural pattern of ocean currents connectivity networks matches that of the littoral flora, we analyzed the correlation between the oceanic current cost matrices and the floristic distance. Additionally, we examined the correlation between the structure of the ocean current connectivity network and the networks formed by geographic, age, and area distances. Procrustes analysis was implemented through package “vegan” (Oksanen et al., 2007). Significance was estimated by comparing observed Procrustes distances with those of 999 random permutated matrices (Peres-Neto & Jackson, 2001).

**Island centrality**

The inverse of the current cost matrix represents the matrix of ocean current connectivity within an archipelago. Within networked systems, graph theory offers centrality measures that assess the importance or influence of nodes within a network (Scardoni & Laurdanna 2012, Chen et al. 2012). In landscape connectivity studies, centrality analysis helps identify critical ecological patches in terms of connectivity, information flow, or network influence (e.g. Estrada & Bodin 2008, Bodin & Saura 2010, Treml & Kool 2018, Cecino et al. 2021, Pereira et al. 2017). In our system, nodes correspond to specific islands (nodes) in the current network of the archipelago, with edge or link weights derived from ocean current velocity and direction. To approximate the islands’ roles as critical connectors of the current network, we computed In-degree, Out-degree, Closeness, and Betweenness centrality measures (Freeman 2002, Opsahl et al. 2010). Starting with a cost matrix representing distances for ocean currents, we inverted the weights to obtain connectivity values (). In- and Out-degree centrality were calculated using these inverted weights to identify islands that act as major sinks and sources in the network, respectively. For Closeness and Betweenness centrality, we used the original distance-based weights. Higher Closeness reflect shorter mean distances to all other islands within the archipelago. Higher Betweenness reflects islands that are more often included in the shortest paths connecting all islands.

Degree centrality () is a straightforward measure that counts the total number of connections linked to a vertex. In ecological networks, the weighted In-Degree of a node sums the weights (or strengths) of all edges connected to that node, reflecting its overall importance or influence based on these weighted interactions. Conversely, the weighted Out-degree measures the sum of weights of all outgoing edges from a node, indicating the total contribution or output of resources or influence from the node to others in the network. We note them as and :

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We interpret islands with higher as “sinks” for oceanic currents in the archipelago, and those with higher as “sources”.

*Island Closeness -*

A path is a series of steps that go from one node to another. Closeness centrality () of a node is the inverse of the sum of distances to all the other vertices in a graph. For a node in a network with nodes:

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where is the shortest path distance between nodes and . quantifies how central and accessible an island is within the current connectivity network of an archipelago. Islands with higher values are positioned closer to all other nodes in terms of oceanic current flow costs, enhancing their potential influence in facilitating efficient information dissemination or resource transfer.

Betweenness centrality () is defined as the number of shortest paths that pass through the node divided by the total number of shortest paths between all pairs of nodes. Within a network of ocean currents in an archipelago, islands with high may serve as stepping stones for species dispersal.

Centrality metrics describe similar aspects and are usually correlated somehow (Oldham et al. 2019). We study the correlation of these central measures by computing their Pearson correlation between the islands of each archipelago.

**Does island centrality in the ocean connectivity network affect its percentage of littoral flora?**

To explore the relationship between the proportion of littoral plants and centrality measures across the Azores, Canaries, and Galapagos archipelagos, we employed the 'glmmTMB' package to fit a generalized linear model. The proportion of littoral plants was modeled using a beta distribution with a logit link function, chosen for its suitability in analyzing proportional data:

for which

Where is a given island, and “” refers to one of the predictor centrality variables: either , , or . was log-transformed and centered to address its large variance across archipelagos. In the three models, represents the baseline logit proportion of littoral plants for Azores. ​ and represent how the logit proportion of littoral plants changes for Canaries and Galapagos compared to Azores, respectively. ​ and ​ represent how the effect of on the logit proportion of littoral plants varies with Canaries and Galapagos, respectively. All models underwent diagnostic assessments for uniformity, dispersion, homoscedasticity, and identification of outliers, employing the “DHARMa” package (Hartig 2022).

Results

**Correlation between littoral flora and oceanic currents connectivity**

The correlation between the network structures of oceanic currents and littoral flora connectivity varied across the studied archipelagos. In the Galapagos, the correlation approached significance (ProcCor = 0.55, p = 0.057), while it was strong and significant in the Canaries (ProcCor = 0.87, p = 0.002). Conversely, in the Azores, this correlation was not significant (ProcCor = 0.15, p = 0.919). For non-littoral flora, a significant correlation was observed in the Canaries (ProcCor = 0.82, p = 0.008), while correlations in the Galapagos (ProcCor = 0.49, p = 0.122) and Azores (ProcCor = 0.38, p = 0.452) were not significant (Fig. 2A).

The network structure of littoral flora connectivity also showed a significant correlation with the connectivity by geographic distance in the Galapagos (ProcCor = 0.62, p = 0.015) and Canaries (ProcCor = 0.88, p = 0.002), but not in the Azores (ProcCor = 0.16, p = 0.918). For non-littoral flora, the correlation was significant only in the Canaries (ProcCor = 0.79, p = 0.015), with weaker correlations observed in the Galapagos (ProcCor = 0.54, p = 0.070) and Azores (ProcCor = 0.43, p = 0.337) (Fig. 2*A*).

Island age distances were only positively correlated with the littoral flora similarity in Galapagos (ProcCor = 0.58, p = 0.018), but not in the Canaries (ProcCor = 0.28, p = 0.690) or Azores (ProcCor = 0.20, p = 0.733). Correlations between island age distances and non-littoral flora similarity was not detected on any archipelago (Galapagos: ProcCor = 0.33, p = 0.301; Canaries: ProcCor = 0.23, p = 0.786; Azores: ProcCor = 0.20, p = 0.686) (Fig. 2*A*).

Similarly, island area distances were also not significantly correlated with either littoral or non-littoral floras in the three archipelagos (Galapagos: …ProcCor = 0.38 and 0.44, p = 0.174 and 115 in Galapagos; ProcCor = 0.17 and 0.13, p = 0.876 and 0.907 in Canaries; ProcCor = 0.11 and 0.26, p = 0.924 and 0.566 in Azores) (Fig. 2*A*).

**Correlation between oceanic currents and island factors connectivity**

ocean currents networks and geographic connectivity were strongly and positively correlated in all three archipelagos (ProcCor = 0.92, p = 0.001 in Galapagos; ProcCor = 0.98, p = 0.001 in Canaries; ProcCor = 0.98, p =0.001 in Azores). Significant correlations with island age connectivity were found in Galapagos (ProcCor = 0.62, p = 0.003) and Azores (ProcCor = 0.69, p = 0.039), but not in Canaries (ProcCor = 0.19, p = 0.671). No significant correlations were detected with connectivity patterns by island area (ProcCor = 0.18, p = 0.697 in Galapagos; ProcCor = 0.12, p = 0.847 in Canaries; ProcCor = 0.09, p =0.860 in Azores) (Fig. 2*B*).

**Island centrality and percentage of littoral species**

The proportion of littoral species was highest in the Azores (Mean=16.5%± 1.49), followed by the Canaries at 14.74% (SD = 6.59) and the Galapagos at 9.75% (SD = 2.51) (Table 1). The islands with the highest and lowest percentages were Graciosa (19 %) and Flores (15 %) in Azores, Fuerteventura (24 %) and La Palma (8 %) in Canaries, and Genovesa (16 %) and Isabela (8 %) in Galapagos (Table S1).

The Canaries exhibited a mean In-Degree () of 0.56 (SD = 1.48), while values were markedly lower in Galapagos ( **=** 0.03, SD = 0.02) and Azores ( **=** 0.01, SD = 0.02). Similar results were observed for  in the three archipelagos. Mean Closeness was much greater in the Galapagos = 0.17 ±0.04), than in the Canaries (= 0.09, SD = 0.03) and Azores (= 0.06, SD = 0.02). Lastly, Betweenness was highest in Azores (= 13.56, SD = 11.20), followed by the Galapagos (= 10.17, SD = 10.18) and the Canaries (= 7.43, SD = 7.72).

Islands with the highest centrality measures included Santa Cruz ( and ) and Santa Fe ( and ) in Galapagos; Fuerteventura (), Lanzarote (), and Tenerife ( and ) in Canaries; and Pico ( and ), Faial ( and ), and Sao Jorge ( and ) in Azores (Table S1).

**Effect of island centrality on the percent of littoral species**

The proportion of littoral plants significantly varied across archipelagos in all models (In degree: χ²(2) = 40.96, p < 0.001;Closeness: χ²(2) = 26.17, p < 0.001;Betweeness: χ²(2) = 21.76, p < 0.001) (Table 2 and S2).

*Island In-degree*

Island In-degree and archipelago significantly affected the proportion of littoral plant (χ² = 11.67, p = 0.001), (Table S2). Analyzing the individual coefficients, the interaction with archipelago showed a trend towards significance for the Canaries (β = 0.144, p = 0.103), indicating a potential effect where a one-unit increase in centered log-transformed in-degree centrality could correspond to a 14.4% increase in the odds of having littoral plants. This was non-significant for the Galapagos (β = -0.21, p = 0.257) and Azores (β = -0.01, p = 0.864) (Table 2).

*Island Closeness*

The ANOVA table indicated that the interaction between island and archipelago was significant (χ²(2) = 16.41, p < 0.001) (Table S2), indicating that the effect of varies among archipelagos. For the Canaries, a one standard deviation increase in results in a logit change of 1.075, corresponding to a substantial increase in the proportion of littoral plants, with an odds ratio of approximately 2.929. This means there is a 192.9% increase in the odds of having littoral plants for each standard deviation increase in . For the Galapagos and Azores, the interaction term was not significant (β = -0.046, p = 0.862; β = 0.084, p = 0.729) (Table 2).

*Island Betweenness*

The ANOVA table indicated that neither the main effect of (χ² = 0.117, p = 0.733) nor its interaction with archipelago (χ² = 0.675, p = 0.714) were statistically significant (Table S2). Consistent with the ANOVA results, the model summary indicated that neither the effect of itself (β = -0.002, p = 0.842) nor the interaction with Galapagos (β = -0.01, p = 0.693) or Canaries (β = 0.01, p = 0.585) was significant (Table 2).

Discussion

**[Correlation patterns]**

The correlation between littoral flora and ocean currents connectivity varied significantly among the three archipelagos studied. The Canaries exhibited an exceptionally high correlation, followed by a moderate correlation in the Galapagos, and a lack of significant correlation in the Azores. This pattern may be partly explained by the geographic arrangement of the islands and the converging dynamics of oceanic currents. Islands aligned in a chain-like formation, coupled with oceanic current convergence in a consistent direction, likely enhances the transport of plant propagules towards specific islands at either end of the chain promoting a stronger congruence between floristic and ocean current connectivity. This could be the case of the Canaries, which presents a linear spatial arrangement of the islands and are influenced by the Canary Current. This current moves parallel to the African coastline and begins to flow west under the influence of the Equatorial Countercurrent when reaches the area of 15°N (Batten et al. 2000). During winter, peak trade winds further intensify this flow, with core velocities exceeding 75 cm s-1 as the current traverses through the Canary archipelago (Fedoseev 1970).

Conversely, archipelagos with circular or complex spatial configurations and diverse incoming currents may obscure this pattern, as propagules are subjected to intricate and non-directional flow patterns. This complexity might partially elucidate why the Galapagos Islands exhibit a lower correlation between floristic and ocean current connectivity. The islands in the archipelago are arranged in a circular shape and three large and strong sea currents - namely, the Humboldt Current, Panama Flow, and South Equatorial Countercurrent (ref) - constantly enter the archipelago, creating a dynamic and probably less predictable environment for plant dispersal.

In the Azores, the lack of pattern could be due to the convergence of oceanographic processes that manifest in the archipelago in combination with the presence of a highly energetic eddy field, which is characterized by circular and constantly in motion currents (Caldeira & Reis 2017, Le Traon & De Mey 1994). This may also influence the marked homogeneous pattern of distribution of littoral flora across the islands, which differs from the more heterogeneous patterns in the Canaries. Finaly, the greater mean distances between Azorean islands can also contribute to the apparent reduced importance of ocean currents.

The connectivity between littoral flora and island age was only significant in the Galapagos [...]. This means that islands of more similar age also tend to have more similar floras, pointing to the importance of island ontogeny dynamics.

and Azores [...].

As anticipated, current connectivity shows a strong correlation with geographic distances across all archipelagos, although there is a slight discrepancy observed in the Galapagos, potentially due to the islands being more evenly spaced compared to the Canaries and Azores. Consequently, it is challenging to distinguish the specific contributions of current connectivity versus geographic distance, which could also affect dispersal through mechanisms such as wind or bird transport. However, we found a significant correlation for littoral flora but not for non-littoral flora in the Galapagos, with a stronger correlation observed for littoral flora compared to non-littoral in the Canaries. This suggests that alongside other potential dispersal modes influenced by geographic distance, current connectivity likely plays a more prominent role in shaping the distribution of littoral flora.

**[Correlations between centrality metrics]**

There was substantial variation in correlations of centrality metrics between archipelagos, indicating distinct network configurations and roles of islands. The Canaries exhibit marked differences compared to the Galapagos and Azores, which show greater similarity.

The correlation between and , reflecting islands that act as sinks and sources of current flow, provides insights into the overall directionality of currents within an archipelago. In the Azores, this correlation was notably high, indicating a significant exchange of currents among the islands. This pattern is likely influenced by the presence of a highly energetic eddy field and complex current interactions. Conversely, the Canaries displayed a remarkably low correlation, aligning with its more directional current patterns. The Galapagos exhibited a moderate correlation, falling between the Azores and Canaries, possibly reflecting a balance between complex currents and directional influences. Probably for the same reason, correlations were high between and in Azores and Galapagos, and not present in the Canaries.

**[Efect of centrality on percentage of littoral species]**

* No effect of centrality on the % of littoral flora.
* May be due to the even distribution of islands in the space coupled with the confluence of three major currents, which may create internal complex current dynamics within the archipelago.
* Still, some islands show centrality measures and percentages of littoral species that may suggest a role of thalassochory. An example is Fernandina, which shows the second lowest percentage of littoral plants, the lowest , and low centrality for the rest of measures. This is probably because of a shield effect of Isabela that may isolate the island from the rest of the archipelago by blocking the currents and preventing propagules to disperse from and towards the island. Another possibility is that this is due to being the youngest of the islands, although littoral plants may be first colonizers and a large biodiversity of littoral plants would have had time enough to establish.
* However, other islands show the opposite expected relationship between centrality by currents and percentage of littoral species. This is the case for Genovesa, which shows the highest percentage of littoral plants, and still, it has the lowest and is among the islands with the lowest [...].
* Canaries: Effect of on the % littoral flora, and while not statistically significant at the conventional threshold of 0.05, results for suggests a meaningful relationship.
* This may be explained by the directionality and island distribution of the archipelago, and the distance respect to the continent.
* Fuerteventura the highest % littoral plants, followed by Lanzarote. Lanzarote the highest together with Tenerife, and the highest by a lot. Both are in the east, closer to the continent. A potential explanation is that continental littoral flora reaches first these islands through The Canarian Current that flows west from the continental coast, and therefore have higher diversity. These are also the oldest islands and the accumulation of biodiversity may be due to time for diversification.
* Azores had the highest proportion of littoral flora, but no effect of centrality by currents on the % littoral flora on each island.
* Azores is considered a confluence zone between the west and the east North Atlantic (Caldeira & Reis 2017). This suggests that western currents flow east and eastern currents flow west, showing a pattern of convergence towards the middle islands. This may explain why Sao Jorge and Faial show the highest values of all three archipelagos, and together with Pico, also in the center, makes Azores the archipelago with the highest .
* The fact that none of the measured centrality metrics, including , don't show significant correlation with % littoral may suggest that other dispersal modes are probably strongly affecting their dispersal in this archipelago.

**[Limitations]**

* Temporal depth - colonization dynamics may occur over longer timescales, and currents regimes may change.
* Other archipelago-specific factors may influence these patterns: submerged islands, geographic history, proximity to continents. For instance, the Galapagos had approximately half the mean % littoral plants than Canaries and Azores, and this may be explained by contingent conditions.
* Strong homogenizing effect of archipelago floras by human movements (Castro et al. 2010). Although we don't see this in examples like Santa Cruz or San Cristobal, which are the most populated islands in Galapagos and have some of the lowest percentages of littoral plants in the archipelago.

**[Future perspectives]**

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**Figures**

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| **Figure 1.** **Network representation of ocean current connectivity in each archipelago and the percent of littoral species in each island.** (A) Galapagos, (B) Canaries, and (C) Azores. Edge width and transparency corresponds to the connectivity weights ( between island pairs. These are log transformed for Canaries and square root transformed for Azores to facilitate readability. |

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| **Figure 2. Procrustes correlations between structures of connectivity networks within archipelagos.** (A) Procrustes correlations between island connectivity by floristic composition (Bray-Curtis DI) and by ocean currents and island factors. (B) Procrustes correlations between island connectivity by ocean currents and island factors. Black asterisks indicate the level of statistical significance. The solid point indicates marginally significant (p = 0.055 in this case). |

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| **Figure 3.** **Pearson correlation between island centrality measures for the ocean current connectivity network in each archipelago.** In and Out-degree are calculated from connectivity weights ( and approximate the role of islands as sinks or sources of currents. Closeness and Betweenness are calculated on the direct weights (distances) and approximate the role of islands as being more accessible and acting as hubs or bridges in the currents network, respectively. |
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| **Figure 4. Network representation and island centrality of the ocean current connectivity in each archipelago.** (A-B) Galapagos, (C-D) Canaries, and (E-F) Azores. In the network plots (A, C, E), the edge width and transparency corresponds to the connectivity weights ( between island pairs. These are log transformed for Canaries and square root transformed for Azores to facilitate readability. Panels B, D, and F show the results of a Generalized linear model (GLM) with a beta distribution fitted with the data for all archipelagos together, with the interaction between archipelago and centrality as predictor of the percent of littoral flora. Black and red trend lines indicate absence or presence of significance. In-degree was marginally significant. |

**Tables**

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| **Table 1.** Summary statistics for the percentage of littoral plants and centrality within the ocean currents network in each archipelago. | | | | | |
| Variable | Statistic | Galapagos |  | Canaries | Azores |
| % littoral plants | Mean | 9.75 |  | 14.74 | 16.51 |
|  | SD | 2.51 |  | 6.59 | 1.49 |
|  | Mean | 0.03 |  | 0.56 | 0.01 |
|  | SD | 0.02 |  | 1.48 | 0.02 |
|  | Mean | 0.03 |  | 0.56 | 0.01 |
|  | SD | 0.02 |  | 1.48 | 0.02 |
|  | Mean | 0.17 |  | 0.09 | 0.06 |
|  | SD | 0.04 |  | 0.03 | 0.02 |
|  | Mean | 10.17 |  | 7.43 | 13.56 |
|  | SD | 10.18 |  | 7.72 | 11.20 |

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| **Table 2.** Coefficients summary for the Generalized Linear Mixed Models with the interaction of the archipelago and the centrality measure in the ocean current network as predictor of the percent of littoral plants in islands. | | | | |
| Predictor | Estimate | SE | z value | p value |
| **In-Degree ()** | | | | |
| (Intercept) | -1.62 | 0.08 | -19.11 | **<0.001** |
| archipelago[Canaries] | -0.19 | 0.12 | -1.56 | 0.120 |
| archipelago[Galapagos] | -0.51 | 0.13 | -3.83 | **<0.001** |
|  | -0.01 | 0.08 | -0.17 | 0.864 |
| archipelago[Canaries]\* | 0.14 | 0.09 | 1.63 | 0.103 |
| archipelago[Galapagos]\* | -0.21 | 0.18 | -1.13 | 0.257 |
| **Closeness ()** | | | | |
| (Intercept) | -1.53 | 0.25 | -6.13 | **<0.001** |
| archipelago[Canaries] | 0.11 | 0.27 | 0.41 | **0.678** |
| archipelago[Galapagos] | -0.73 | 0.28 | -2.63 | **0.009** |
|  | 0.08 | 0.24 | 0.35 | 0.729 |
| archipelago[Canaries]\* | 1.07 | 0.35 | 3.05 | **0.002** |
| archipelago[Galapagos]\* | -0.05 | 0.27 | -0.17 | 0.862 |
| **Betweenness ()** |  |  |  |  |
| (Intercept) | -1.58 | 0.14 | -10.90 | **<0.001** |
| archipelago[Canaries] | -0.29 | 0.21 | -1.37 | 0.171 |
| archipelago[Galapagos] | -0.56 | 0.20 | -2.83 | **0.005** |
|  | -0.002 | 0.01 | -0.20 | 0.842 |
| archipelago[Canaries]\* | 0.01 | 0.02 | 0.55 | 0.585 |
| archipelago[Galapagos]\* | -0.01 | 0.01 | -0.40 | 0.693 |
| was transformed to logit scale.  was centered by subtracting the mean of the variable from each value, and scaled by dividing the centered values by the SD. | | | | |