ECOLOGICAL CORRELATES OF ESTABLISHMENT SUCCESS IN LESSEPSIAN FISHES

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Abstract

A database on Lessepsian fish species occurrences from 1869 until 2006 was built and the colonization rate of each species was estimated. Data about geographic distribution and ecological traits were gathered from the literature. Classical test of hypothesis were used to investigate the relationships between fish ecological attributes and establishment success. Among the ecological variables studied, the climate match and the propagule characteristics are significantly related to the establishment success of Lessepsian species: the subtropical species and the species with pelagic propagules may have an advantage in the colonization process of the Mediterranean Sea.

Keywords : Species Introduction, Red Sea, Suez Canal.

Introduction

The completion of the Suez Canal in 1869 has led to spectacular biotic exchanges between the Mediterranean and Red seas which are both hotspots of endemism. Despite the importance of the phenomenon, determinants of establishment success for Lessepsian fishes in the Mediterranean Sea have been poorly investigated. In this study we reconstructed the spatio-temporal dynamic of all the Lessepsian fish species and we analysed the relationship between ecological variables and invasion rate.

Methods

By compiling the existing bibliography, we reconstructed the chronological history of fish species invasions since their first Mediterranean record in 1896 until 2006. Each record was plotted on a map using a Geographical Information System (GIS) software (Arcview). Through this GIS application, we measured the distance covered by each fish species during a period of time and then we estimated the invasion rate.

All the species were classified into three categories according to their ability to spread over the Mediterranean Sea: (1) absence of colonization; (2) limitation to the Levantine basin; (3) widespread colonization. A database containing some predictor variables for each species was elaborated from the literature and from FishBase [1]. Then, we formulated some hypotheses:

- Climate matching: the establishment success of some exotic species was positively related to the match between their native and their colonized environment [2,3]. Based on this prediction, the subtropical species are more likely to colonize the Mediterranean Sea than the tropical species because they are more tolerant to cooler waters.
- Location in the water column: our prediction suggests that pelagic species have higher colonization ability than benthic species owing to their swimming performance and their hydrodynamic body shape.
- Maximum length: fishes with rapid growth, high reproduction rate and early sexual maturity would be better colonizers because invaders have to breed quickly to avoid extinction [4]. We may expect that small species, with earlier sexual maturity, are more likely to colonize the Mediterranean Sea than larger species.
- Propagules: species whose propagules have wider dispersal ability are expected to reach larger geographic range sizes [5,6]. Our hypothesis posits that fishes with pelagic egg would expand more widely their geographic range size than fishes with benthic egg.
- Confamilial resistances: it has been demonstrated that exotic taxa less related to native species are more invasive [7]. In our case confamilial resistance predicts that invading species with no or few confamilial counterparts in the Mediterranean Sea would be more likely to successfully colonize than species that encounter close relatives.

The non parametrical test of Kruskal-Wallis was used to test the hypothesis including quantitative variables and the Khi2 was used to test hypothesis involving qualitative variables.

Results

When species are split between the benthic and pelagic categories no significant relation with the invasion success was observed, the null hypothesis is not rejected. Neither species size nor confamilial resistance have an effect on the establishment success in the Mediterranean Sea or influence species colonization.

The Khi2 test revealed a significant dependence (P=0.024) between the latitudes of species and their invasion success in the Mediterranean Sea. Tropical species spread less than expected by chance while the spread of subtropical species was greater than expected, colonising areas outside the Levantine basin. This result confirms that establishment success depends on the suitability of the abiotic environment for the exotic species at the introduction site: the Mediterranean Sea water temperature seems more appropriate for the subtropical species than for the tropical ones.

When we test the effect of propagule on the colonization, it appears that species with pelagic propagules tend to colonize more the northern side of the Mediterranean Sea than the benthic propagules species can do. Pelagic propagules are more exposed to the general circulation of sea waters than benthic propagules. It may explain why fishes with pelagic propagules are more likely to colonize the north side while fishes with benthic propagules colonize more proportionally both south and north sides of the Mediterranean Sea. Thus, the counterclockwise circulation in the Levantine basin appears to be one the main forcing factors in the Lessepsian species propagation.

Conclusion

Overall 28% of the Lessepsian species succeeded in colonizing the Mediterranean Sea. The northern side is more rapidly invaded than the southern one because of the counterclockwise oceanic circulation in the Levantine basin. In conclusion, crossing the Suez Canal does not guarantee the establishment and the widespread colonization for fish populations. Instead, it appears that some life-history and functional traits are key determinants for invasion (climate matching, propagules). Some Lessepsian fishes, favoured by warmer temperatures and selected according to their ecological attributes, may establish to the detriment of the Mediterranean species. This phenomenon may accelerate with the global warming occurring nowadays.

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