Simulations indicate that scores of lionfish (*Pterois volitans*) colonized the Atlantic Ocean

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ABSTRACT

The invasion of the western Atlantic Ocean by the Indo-Pacific red lionfish (*Pterois volitans*) has had devastating consequences for marine ecosystems. Estimating the number of colonizing lionfish can be useful in identifying the introduction pathway and can inform policy decisions aimed at preventing similar invasions. It is well-established that at least ten lionfish were initially introduced. However, that estimate has not faced probabilistic scrutiny and is based solely on the number of haplotypes in the maternally-inherited mitochondrial control region. To rigorously estimate the number of lionfish that were introduced, we used a forward-time, Wright-Fisher, population genetic model in concert with a demographic, life-history model to simulate the invasion across a range of source population sizes and colonizing population fecundities. Assuming a balanced sex ratio and no Allee effects, the simulations indicate that the Atlantic population was founded by 118 (54–514, 95% HPD) lionfish from the Indo-Pacific, the Caribbean by 84 (22–328, 95% HPD) lionfish from the Atlantic, and the Gulf of Mexico by at least 114 (no upper bound on 95% HPD) lionfish from the Caribbean. Increasing the size, and therefore diversity, of the Indo-Pacific source population and fecundity of the founding population caused the number of colonists to decrease, but with rapidly diminishing returns. When the simulation was parameterized to minimize the number of colonists (high θ and relative fecundity), 96 (48–216, 95% HPD) colonists were most likely. In a more realistic scenario with Allee effects (e.g., 50% reduction in fecundity) plaguing the colonists, the most likely number of lionfish increased to 272 (106–950, 95% HPD). These results, in combination with other published data, support the hypothesis that lionfish were introduced to the Atlantic via the aquarium trade, rather than shipping. When building the model employed here, we made assumptions that minimize the number of colonists, such as the lionfish being introduced in a single event. While we conservatively modelled the introduction pathway as a single release of lionfish in one location, it is more likely that a combination of smaller and larger releases from a variety of aquarium trade stakeholders occurred near Miami, Florida, which could have led to even larger numbers of colonists than simulated here. Efforts to prevent future invasions via the aquarium trade should focus on the education of stakeholders and the prohibition of release, with adequate rewards for compliance and penalties for violations.

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