Regional Comparisons of Lionfish (*Pterois Spp.*) Population Demographics from the East Coast of Florida

Comparaciones Regionales de la Población Demográfica de Peces León (*Pterois Spp.*) de la Costa Este de Florida

Comparaisons Régionales de la Population Démographique des Poissons-Lion (*Pterois Spp.*) de la Côte Est de la Floride

MARYKATE SWENARTON[1]*, ERIC G. JOHNSON[1], and LAD AKINS[2]
[1]*University of North Florida, 1 UNF Drive, Jacksonville, Florida 32224 USA. *ms1710@scarletmail.rutgers.edu.*
[2]*Reef Environmental Education Foundation, 98300 Overseas Highway, Key Largo, Florida 33037 USA.*

EXTENDED ABSTRACT

Lionfish have invaded the Western Atlantic, Caribbean, and Gulf of Mexico at an unprecedented rate, with substantial negative effects on native ecosystems (Albins and Hixon 2008, Green et al. 2012). The primary method for lionfish removal is spearing by divers, which can yield beneficial results (Green et al. 2014). To estimate the effort needed to reduce or negate the deleterious impacts of local lionfish populations, stage- and age-structured removal models rely on accurate life history inputs. However, because life history information for lionfish is sparse in their invaded range, parameters calculated in one region are often applied to models throughout their range. Since life history parameters, especially growth rates, can vary with a suite of environmental (i.e., temperature), biological and ecological (i.e., prey availability) factors, life history parameters of lionfish will likely vary regionally and among ecosystems. The main goal of this study was to quantify differences in size structure and growth in lionfish populations from two biogeographically different regions of Florida and determine if management models need to include life history information at a finer spatial resolution.

Lionfish were collected in 2013 and 2014 from northeast Florida (off the coast of Jacksonville n = 3,949) and in 2014 in southeast Florida (in the coastal waters of Key Largo n = 651) in coordination with multiple derby events throughout the year. All fish were measured for total length to the nearest 1 mm. Population size structure was analyzed using length frequency analysis and statistical length-based modeling (e.g., Fournier et al. 1990). The length-based model estimates proportion of fish in each age class using a maximum likelihood approach by fitting a predicted length frequency distribution to the observed data. The predicted length frequency distribution is generated from either the classical or seasonalized von Bertalanffy growth function (VBGF), as well as variance (σ^2) of lionfish total length-at-age and the proportion of the population in each age class at time t (P_{at}). Sagittal otolith analysis was used to verify ages and validate model outputs. Four different models were compared:

i) No differences in size structure by region and non-seasonal growth,
ii) No differences in size structure by region and seasonal growth,
iii) Spatially explicit size structure and seasonal growth, and
iv) Spatially explicit size structure and non-seasonal growth.

All parameters were allowed to vary without constraint; Akaike's Information Criterion (AIC) was used to select the best model from the candidate set.

Fish total lengths ranged from 41 - 484 mm in northeast Florida and 68 - 452 mm in the Florida Keys over the study period (Figure 1). Overall, the best fit model allowed for regional differences in population size-structure and non-seasonal growth (model 4, Table 1), indicating that a seasonal growth pattern was not evident in either region, but that growth rates were different in the Florida Keys (K = 0.70) and northeast Florida (K = 0.47 in 2014; K = 0.63 in 2013). These differences likely result from a combination of environmental, biological, and ecological factors. Further, the 2013 and 2014 data sets in northeast Florida were better fit independently, indicating annual differences in growth in that region. The Florida Keys population is predicted to be comprised of larger percentage of age-3 fish (10%) than the northeast Florida data sets (> 1%), demonstrating that although lionfish invaded northeast Florida earlier, fish in the Keys are older at present. Some potential hypotheses for this pattern include mortality events due to extreme cold snaps or a more pronounced ontogenetic shift to deeper water in the north. Increased variance in the fish length-at-ages from south Florida are not likely to have a genetic basis and indicate lionfish juveniles in the Keys may be recruiting over a broader time scale relative to their northern conspecifics, potentially suggestive of a prolonged reproductive season or lower larval mortality in south Florida.

This study was the first to use length-based modeling to predict size-at-age in lionfish, a method that may be more practical than ageing by otoliths, which has been found to be troublesome and imprecise in other studies (Edwards et al. 2014). This study was also the first to show significantly different growth rates by region and by year, suggesting that life history parameters should be collected at a high spatial and temporal scale for accurate modeling of population growth and removal strategy impacts, and that life history estimates from one part of the lionfish range may not be applicable to other regions. Finally, these data can be used directly to lessen uncertainty in estimating growth in the varying ecosystems of Florida.

KEY WORDS: Lionfish, growth, population structure, Florida

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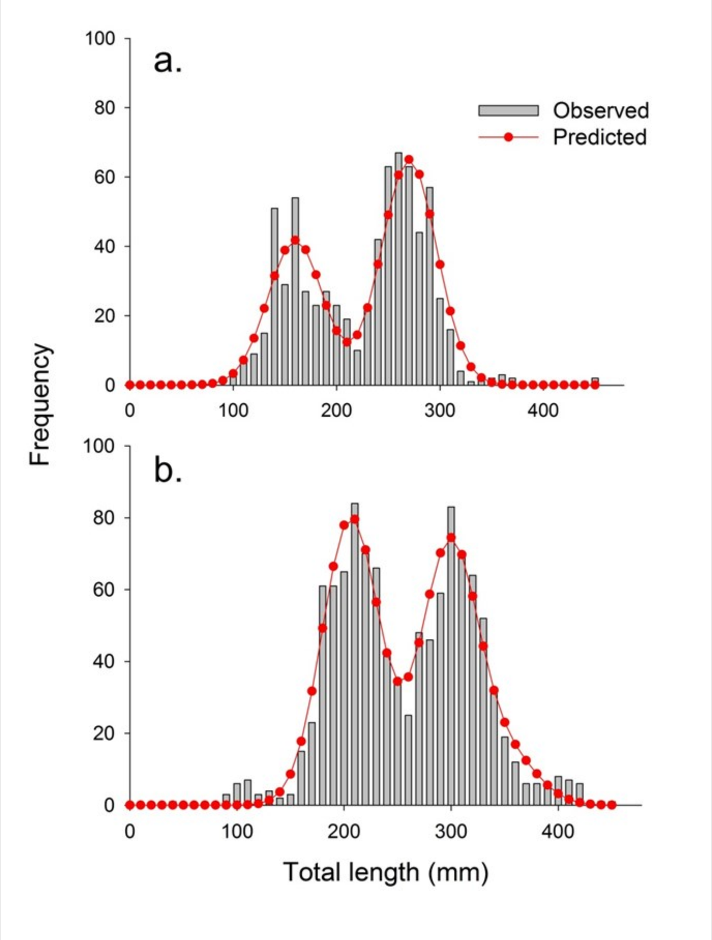

Figure 1. Length frequency histograms of lionfish collected from northeast Florida by derby events in (a) April 2014 (n=714) and (b) August 2014 (n=1102). The red line depicts the predicted size distribution of cohorts from a statistical length-based model. The predicted size distribution is generated from three von Bertalanffy growth parameters (L_∞, K, t_0), as well as variance (σ^2) of lionfish total length-at-age and the proportion of the population in each age class at time t (P_{at}).

Table 1. Akaike Information Criterion (AIC) for the candidate model comparisons. Four model sturtcures were tested: (1) populations were assumed to be either spatially-explicit (all varying) or region-wide (comnied) and (2) growth was modeled assuming either traditional and seasonalized von Bertalanffy growth dyanmics. K = number of model parameters, -ln(L) = log likelihood of the model, AIC_c= corrected AIC, ΔAIC = change in Akaike Information Criterion, ω_i= Akaike weights for each model. Model 4 (ΔAIC = 0) had the strongest support of the data and was selected as the best model.

Spatial	Growth	-ln(L)	*K*	AIC	AIC_c	ΔAIC	ω_i
No	Non-seasonal	-525.01	17	1084.02	1086.51	41.94	0.00
No	Seasonal	-505.21	19	1048.42	1051.54	6.34	0.01
Yes	Seasonal	-489.84	33	1045.68	1055.44	3.60	0.02
Yes	Non-seasonal	-494.04	27	1042.02	1048.49	0	0.97