Age, growth parameters and food composition of Invasive Red Lionfish (*Pterois volitans* L., 1758) in İskenderun Bay

Selçuk Yılmaz*, Sefa Ayhan Demirhan

İskenderun Technical University, Marine Sciences and Technology Faculty

Abstract

Age, growth parameters and food of *Pterois volitans* (Linnaeus, 1758) Red lionfish were studied. A total of 254 lion fishes (*P. volitans* and *Pterois miles*) were collected from commercial drift net, angling fisheries and diving with hand net southern coast of the İskenderun Bay between March 2018 and March 2019. 29.53% of sample was *P. volitans*. Age was determined by reading whole sagittal otoliths. Fish ranged from 14.2 to 35.3 cm in total length, which corresponded to fish between 1 to 7 years old. The sex ratio (1:1.07) was biased toward males (P<0.05). The length–weight relationships were $W=0,0042\times L_{3.3514}^{3.3514} (R^2=0,92)$ and $W=0,0108\times L_{3.0423}^{3.0423} (R^2=0,94)$ for females and males, respectively. Growth parameters were estimated using the standard von Bertalanffy growth model ($K=0.1507$, $L=47.58$ cm and to $=-2.0506$ for combined sexes. The diet was composed of fishes and crustaceans.

Keywords: *Pterois volitans*, Age, Growth, İskenderun Bay

Article history:
Received 28 June 2019, Accepted 25 March 2020, Available online 23 June 2020

Introduction

Invasive species are a major threat to global biodiversity for ecosystem health (Carlton and Geller 1993; Ruiz et al. 1997). *P. volitans* and *P. miles* *P. volitans* has been reported as the most documented invader among aquatic organisms (Hixon ve ark., 2016; Azzurro ve ark., 2017; Bilge ve ark., 2016. The opening of the Suez Canal in 1869 was the most important factor leading to an increase in the inflow of Indo-Pacific invasive species into the Mediterranean. With the opening of this channel, alien species began to enter the Mediterranean intensively and in time, the entry of these alien species was described as invasion (Öztürk and Turan, 2012). Studies on lion fish have increased steadily over the last 10 years and are generally related to their geographical distribution (Dağhan and Demirhan, 2020 inpress). *P. volitans* in the Gulf of Iskenderun for the first time the

* * Corresponding Author: Selçuk Yılmaz, E-mail: kanarya_31@hotmail.com
presence of Gürlek et al. (2016). Lion fish should be expected to spread throughout the Gulf of Iskenderun in 5-10 years and affect biodiversity (Dağhan and Demirhan, 2020 in press).

The purpose of the study is to determine age, growth of P. volitans in İskenderun Bay.

Material and Methods

A total of 75 lionfish specimens were obtained from commercial drift net, pole spears and hand net while SCUBA diving or snorkeling from Southern coast of shallow waters of İskenderun Bay. Total lengths to the nearest 1 mm and wet weights to the nearest 0.1 g were recorded for all fish. Lionfish were sexed via macroscopic examination of their gonads, and sagittal otoliths were removed from the fish and cleaned with alcohol, stored with glycerin oil in U shape plate. Age determination was performed using a stereoscopic zoom microscope (Olympus SZX16) under reflected light against a black background. Stomachs are dissected from fish in the field and preserved in formalin. The relationships between wet weights and total lengths was determined by fitting a power function to the relevant data. Age and length data were used to model growth by estimating parameters in von Bertalanffy growth equations (von Bertalanffy, L. 1957; Bagenal, 1978; Avsar, 2005).

Results

Fish ranged from 14.2 to 35.3 cm in total length, which corresponded to fish between 1 to 7 years old (Figure 1). The sex ratio (1:1.07) was biased toward males (P<0.05). The length–weight relationships were for combined data from juveniles, males and females were related to total lengths \( W=0.0042 \times L^{3.3514} \) (\( R^2=0.92 \)) and \( W=0.0108 \times L^{3.0423} \) (\( R^2=0.94 \)) for females and males, respectively (Figure 2a and b). Growth parameters were estimated \( K=0.1507, L_{\infty}=47.58 \) cm and \( t_0=-2.0506 \) for combined sexes using the standard von Bertalanffy growth model (Figure 3). The prey taxa found in the greatest proportion of sampled lionfish stomachs (excluding empty stomachs) were unidentified (i.e. digested) teleosts (65% of sampled stomachs), followed by crusteacea (35% of stomachs).

Figure 1. Length frequency of P. volitans

![Length Frequency of Pterois volitans (L., 1758)](image)
Figure 2. Length-Weight relationship of *P. volitans* females

\[ W = 0.0042L^{2.354} \]
\[ R^2 = 0.9158 \]

Figure 3. Length-Weight relationship of *P. volitans* males

\[ W = 0.0108L^{2.203} \]
\[ R^2 = 0.9448 \]

Figure 4. Growth curve of *Pteroïs volitans* (L., 1758)
Discussion

First of all, the situation that attracts attention in the studies with lion fish is the handling of the species. In most studies, two species were evaluated together as P. volitans/miles complex, while in some studies two species were identified as Pterois spp. Additionally, in species discriminated studies, P. miles has been studied in few studies and P. volitans has been studied mostly (Dağhan and Demirhan, 2020 inpress). The primary reason that the studies are mostly related to P. volitans is that the species was carried out in the West Atlantic where proportionally it is very abundant (Morris ve ark., 2008). In addition, researchers may have overlooked a small number of P. miles because of the complexity and difficulty of species discrimination (Kochzius et al., 2003; Hamner, 2005), and may have evaluated two species together in this region (Dağhan and Demirhan, 2020 inpress). Turan et al. (2020 inpress) reported the presence of P. miles and P. volitans in the Mediterranean, and the DNA Barcodes of the species for the definitive differentiation of these two species.

Allometric growth obtained in the present study is similar to the values reported by other researchers (Tablo 1). “b” value of males is very close to 3 called isometric growth. Actually, the difference between males and females may be due to the fact that the species has mature gonads that are constantly mature due to its reproductive strategy throughout the year and the nutritional habit that it can starve for a long time. The fact that the female individuals obtained in the study were above the height of reaching sexual maturity reported in the literature and that the stomach content was generally empty support this situation.

In the present study, larger asymptotic length value and lower growth coefficient value were found other researchers reported (Tablo 2). Differences between populations of the same species in different ecosystems are expected (Pusack et al., 2016). The reason for the low growth coefficient may be that the Mediterranean is less nutritionally inefficient than the other regions reported in the literature. It is expected that the species with lower growth coefficient will reach a larger asymptomatic length value (Gubiani et al., 2011). However, sampling methods have an impact on the results obtained. Selective methods are used in the sampling of lion fish, and therefore the sample may not adequately reflect the population.

Table 1. Length-weight relationships of P. volitans (re-edited from Dağhan and Demirhan, 2020)

| Reference            | Species                  | Region             | a       | b       | R²    |
|----------------------|--------------------------|---------------------|---------|---------|-------|
| Recent study         | P. volitans (males)      | NE Mediterranean    | 0,0108  | 3,0423  | 0,94  |
| Recent study         | P. volitans (females)    | NE Mediterranean    | 0,0042  | 3,3514  | 0,92  |
| Recent study         | P. volitans (all)        | NE Mediterranean    | 0,0089  | 3,1116  | 0,92  |
| Edwards et al., (2014)| Pterois spp.             | Western Atlantik    | 0,000003| 3,2400  | 0,97  |
| Barbour et al., (2011)| P. volitans ve P. miles | Western Atlantik    | 0,000003| 2,8900  | -     |
| Sandel et al. (2015)  | P. volitans ve P. miles  | Western Atlantik    | 0,0235  | 2,8100  | -     |
| Chin et al., (2016)   | P. volitans ve P. miles  | Western Atlantik    | 2,8000  | 2,8500  | 0,87  |
| Reference | Species | Region | Ages | $L_{\infty}$ | $K$ | $t_0$ |
|-----------|---------|--------|------|-------------|----|------|
| V-Derbez and Fitzgerald (2016) | $P. volitans$ $P. miles$ | Western Atlantik | 0,3200 | 3,2300 | 0,98 |
| Fogg et al., (2013) | $P. volitans$ | Western Atlantik | 0,1400 | 3,4300 | 0,99 |
| Dahl and Patterson (2014) | $P. volitans$ | Western Atlantik | 0,2100 | 3,3400 | 0,98 |
| P-Chan and A-Perera (2014) | $P. volitans$ | Western Atlantik | 0,104 | 3,30 | 0,98 |
| Toledo-Hernández (2014) | $P. volitans$ | Western Atlantik | 0,0800 | 3,1100 | 0,96 |
| Rodriguez et al., (2015) | $P. volitans$ | Western Atlantik | 0,0110 | 3,3300 | 0,97 |
| Itza et al., (2016)-2012 | $P. volitans$ | Western Atlantik | 0,0041 | 3,25 | 0,97 |
| Itza et al., (2016)-2013 | $P. volitans$ | Western Atlantik | 0,0049 | 3,19 | 0,98 |
| Cobián-Rojas et al., (2016) | $P. volitans$ | Western Atlantik | 0,012 | 3,01 | - |
| Sabido-Itza et al., (2016) | $P. volitans$ | Western Atlantik | 0,5200 | 3,1800 | 0,99 |
| A-Perera and Q-Puerto (2016) | $P. volitans$ | Western Atlantik | 0,2900 | 3,3000 | 0,95 |

Table 2. Von Bertalanffy growth parameters of $P. volitans$ (re-edited from Dağhan and Demirhan, 2020)
The lion fish floating egg masses can be transported by currents to long distances (Hare and Whitfield, 2003; Morris and Whitfield, 2009; Ahrenholz and Morris, 2010; Morris et al., 2011). The larvae, which are planktonic in 25-40 days, can be carried by currents (Hare and Whitfield, 2003; Morris and Whitfield, 2009; Ahrenholz and Morris, 2010). This breeding strategy is the reason that the species passes through the Suez Canal to the Mediterranean Sea (Morris et al., 2011). Probably, the larvae passing through the Mediterranean Sea and reaching the shallow waters could not increase their populations due to the predation pressure and the larvae reaching the deeper regions could increase their populations due to the lower predation pressure. The lion fish, which increased its population in deeper water, started to spread in shallow water in time. This may be the reason for the rapid spread of *P. miles*, other species of *Pterois* in the region, 20 years after 1991 (Golani and Sonin, 1992), when it was first observed in the Mediterranean, as it was first observed in the Atlantic in 1985 (Semmens et al., 2004) and was not observed for a period of 15 years and then increased and expanded in intensity (Schofield, 2009). The species discussed in this study is probably to have a similar story. The 7 age values obtained in the present study indicate that *P. volitans*, which was first detected in 2016 (Gürlek et al., 2016; Turan and ark., 2017) has been in the Gulf of İskenderun since 2012. As it is known, lion fish spread to mesopotic depth (Nuttall et al., 2014; Goodbody-Gringley et al., 2019).

There are two species of lion fish in the Mediterranean: *P. volitans* and *P. miles* (Golani and Sonin, 1992; Turan and ark., 2014; Gürlek and ark., 2016). *P. miles*, one of the lion species, is more invasive than *P. volitans* (Australian Bureau of Rural Sciences, 2008; Azzurro and ark., 2017; Bilge and ark., 2016), while *P. volitans* is more common than *P. miles* (Morris and ark., 2008). As in the Mid-West Atlantic, the spread from lagoons (Jud et al., 2011) to mesopthic depth (Nuttall et al., 2014; Goodbody-Gringley et al., 2019) or even very shallow longos (Barbour et al., 2010; Biggs and Olden 2011; Claydon et al., 2012; Pimiento et al., 2015) should be expected to become widespread throughout the Iskenderun Gulf in 5-10 years and affect biodiversity if it does not encounter ecological resistance. Additionally, it is possible that other species (*P. antennata* Bloch, 1787; *P. brevipectoralis* Mandritsa, 2002; *P. mombasea* Smith, 1957; *P. andover* Allen and Erdman 2008; *P. paucispinula* Matsunuma and Motomura 2014; *P. sphex* Jordan and Evermann 1903) will enter the Mediterranean with first priority two species (*P. cincta* Rüppel 1838 and *P. radiate* Cuvier 1829) still present in the Red Sea and one species (*P. russelii* Bennett 1831) in Persian Gulf.

It is known that lion fish are not dominant in the Indian Ocean and Pacific because of the balance in the natural ecosystem. Green and Co’té (2009) and Pusack et al. (2016) suggest that volitans grow faster in the Atlantic than in the Pacific, where they may reach a larger population level and larger average asymptotic length than natural populations in the invading region. Albins and Hixon (2008) that lion fish infested in the region of natural species in the inventory reduces the participation by 80%, Green et al. (2012) reported that they reduce natural biomass by 65%. Over the last 2 year, *P. volitans* and *P. miles* has rapidly become established in the Southern coastal waters of İskenderun Bay. Management strategies have to be developed to control of this invasive...
species for protecting of biodiversity ecosystems, and to society and health, which translate directly into threats to the economy. Management and control strategies are implemented with lion fish in various regions in the Atlantic (Morris et al., 2009; Morris ve Withfield, 2009; Sealey et al., 2009; Ritterman, 2016). It is seen that the fishing pressures applied in these regions (Morris ve ark., 2011; Barbour ve ark., (2011) do not provide the expected benefit. Barbour et al. (2011) reported that the population of lion fish can only be controlled when kept under constant high fishing pressure, but this requires high cost and is not likely to eliminate the species with this effort. The researcher stated that this application may yield small scale results.

Consequently, region-specific control and management strategy with lion fish should be developed; (1) selective and over fishing pressure should be established on lion fish (by supporting spearfishing in shallow waters, pot fishing methods (Demirhan et al., 1998) or other methods like underwater robots should be developed in deeper waters by special licensed fishermen), (2) fishing pressure over the other species should be reduced, (3) public awareness should be raised, (4) consumption should be encouraged, (5) regular monitoring studies of the species should be established and supported.

Conflict of Interest: No potential conflict of interest was reported by the authors.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

References

Ahrenholz, D. W., and Morris, J. A. (2010). Larval duration of the lionfish, *Pterois volitans* along the Bahamian Archipelago. *Environmental biology of fishes*, 88(4), 305-309.

Australian Bureau of Rural Sciences. 2008. *CLIMATCH*. Available: http://data.daff.gov.au:8080/Climatch/climatch.jsp. May 2014.

Avşar, D. (2005). *Balıkçılık biyolojisi ve popülasyon dinamiği*, 332 s.

Azzurro, E., Stancanelli, B., Di Martino, V., and Bariche, M. (2017). Range expansion of the common lionfish *Pterois miles* (Bennett, 1828) in the Mediterranean Sea: an unwanted new guest for Italian waters. *BioInvasions Records*, 6(2), 95-98.

Bagenal, T. B. (1978). Age and growth. *Methods for assessment of fish production in fresh waters*, 101-136.

Barbour, A. B., Allen, M. S., Frazer, T. K., and Sherman, K. D. (2011). Evaluating the potential efficacy of invasive lionfish (*Pterois volitans*) removals. *PloS one*, 6(5), e19666.

Biggs, C. R., and Olden, J. D. (2011). Multi-scale habitat occupancy of invasive lionfish (*Pterois volitans*) in coral reef environments of Roatan, Honduras. *Aquatic Invasions*, 6(3), 447-453.

Bilge, G., Filiz, H., Yapıcı, S., and Gülşahin, A. (2016). On the occurrence of the devil firefish *Pterois miles* (Scorpaenidae), from the southern Aegean Sea with an elaborate occurrences
in the Mediterranean coast of Turkey. HydroMediT 2016. In 2nd International Congress on Applied Ichthyology and Aquatic Environment, Messolonghi, Greece.

Carlton, J. T., and J. B. Geller. 1993. Ecological roulette: the global transport of nonindigenous marine organisms. Science 78–82.261

Claydon, J. A. B., Calosso, M. C., and Traiger, S. B. (2012). Progression of invasive lionfish in seagrass, mangrove and reef habitats. Marine Ecology Progress Series, 448, 119-129.

Dağhan H. and Demirhan, S.A., 2020. İskenderun Körfezinde Yakalanılan Aslan Balığı Pterois miles (Bennet, 1828)’in Biyo-Ekolojik Özellikleri. Marine and Life Sciences, 2(1):xx-xx (inpress)

Golani, D., and Sonin, O. (1992). New records of the Red Sea fishes, Pterois miles (Scorpaenidae) and Pteragogus pelycus (Labridae) from the eastern Mediterranean Sea. Japanese Journal of Ichthyology, 39(2), 167-169.

Goodbody-Gringley, G., Eddy, C., Pitt, J. M., Chequer, A. D., and Smith, S. R. (2019). Ecological Drivers of Invasive Lionfish (Pterois volitans and Pterois miles) Distribution Across Mesophotic Reefs in Bermuda. Frontiers in Marine Science, 6, 258.

Green, S. J., and Côté, I. M. (2009). Record densities of Indo-Pacific lionfish on Bahamian coral reefs. Coral Reefs, 28(1), 107-107.

Gubiani E. A., Gomes L. C., Agostinho, A.A., 2012. Estimates of population parameters and consumption/biomass ratio for fishes in reservoirs, Paraná State, Brazil. Neotropical Ichthyology, 10(1): 177-188, 2012

Gürlek, M., Ergüden, D., Uyan, A., Doğdu, S. A., Yağlıoğlu, D., Öztürk, B., and Turan, C. (2016). First record red lionfish Pterois volitans (Linnaeus, 1785) in the Mediterranean Sea. Natural and Engineering Sciences, 1(3), 27-32.

Hamner, R. (2005). Genetic analyses of lionfish: venomous marine predators invasive to the western Atlantic (Doctoral dissertation, Honors thesis]. Wilmington (NC): University of North Carolina).

Hare, J. A., and Whitfield, P. E. (2003). An integrated assessment of the introduction of lionfish (Pterois volitans/miles complex) to the western Atlantic Ocean. NOAA Tech Memo NOS NCCOS 2:1–21

Hixon, M. A., Green, S. J., Albins, M. A., Akins, J. L., and Morris Jr, J. A. (2016). Lionfish: a major marine invasion. Marine Ecology Progress Series, 558, 161-165.

Jud ZJ, Layman CA, Shenker JM (2011) Diet of age-0 tarpon (Megalops atlanticus) in anthropogenically-modified and natural nursery habitats along the Indian River Lagoon, Florida. Environ Biol Fishes 90:223–233
Kochzius, M., Söller, R., Khalaf, M. A., and Blohm, D. (2003). Molecular phylogeny of the lionfish genera Dendrochirus and Pterois (Scorpaenidae, Pteroinae) based on mitochondrial DNA sequences. *Molecular Phylogenetics and Evolution*, 28(3), 396-403.

Morris, J., Alkins, J., Barse, A., Cerino, D., Freshwater, D., Green, S., Muñoz, R., Paris, C. and Whitfield P. 2008. Biology and Ecology of the Invasive Lionfishes, *P. volitans* and *P. miles*. *Proceedings of the 61st Gulf and Caribbean Fisheries Institute, Fort Pierce: Gulf and Caribbean Fisheries Institute* 1-5.

Morris, J. A., and Whitfield, P. E. (2009). Biology, ecology, control and management of the invasive Indo-Pacific lionfish: an updated integrated assessment. *NOAA Technical Memorandum NOS NCCOS 99*

Morris Jr, J. A., Sullivan, C. V., and Govoni, J. J. (2011). Oogenesis and spawn formation in the invasive lionfish, *Pterois miles* and *Pterois volitans*. *Scientia Marina*, 75(1), 147-154.

Nuttall, M. F., Johnston, M. A., Eckert, R. J., Embesi, J. A., Hickerson, E. L., and Schmahl, G. P. (2014). Lionfish (*Pterois volitans* [Linnaeus, 1758] and *P. miles* [Bennett, 1828]) records within mesophotic depth ranges on natural banks in the Northwestern Gulf of Mexico. *BioInvasions Records*, 3(2), 111-115.

Özturk, B., Turan, C. (2012) Alien species in Turkish Seas. In: The State of the Turkish Fisheries (eds., A. Tokaç, A.C. Gücü, B. Öztürk), *Publication no. 34, Turkish Marine Research Foundation (TUDAV), Istanbul, Turkey*, pp. 92-130.

Pimiento, C., Nifong, J.C., Hunter, M.E., Monaco, E., Silliman, B.R., 2015. Habitat use patterns of the invasive red lionfish *Pterois volitans*: a comparison between mangrove and reef systems in San Salvador, Bahamas. *Mar. Ecol.* 36, 28–37. http://dx.doi.org/10.1111/maec.12114.

Pusack, T. J., Benkwitt, C. E., Cure, K., and Kindinger, T. L. (2016). Invasive Red Lionfish (*Pterois volitans*) grow faster in the Atlantic Ocean than in their native Pacific range. *Environmental Biology of Fishes*, 99(6-7), 571-579.

Rittermann, A. 2016. A Review of Present and Alternative Lionfish Controls in the Western Atlantic. Capstone. Nova Southeastern University. Retrieved from NSUWorks, . (327)

Ruiz, G. M., J. T. Carlton, E. D. Grosholz, and A. H. Hines. 1997. Global invasions of marine and estuarine habitats by non-indigenous species: mechanisms, extent, and consequences. *American Zoologist* 621–632

Sealey S.K., Anderson L., Stewart D. and Smith N., 2009. The Invasion of Indo-Pacific Lionfish in the Bahamas: Challenges for a National Response Plan. *Proceedings of the 61st Gulf and Caribbean Fisheries Institute November 10 - 14, 2008 Gosier, Guadeloupe, French West Indies GFC61 P: 404-408*
Semmens, B. X., Buhle, E. R., Salomon, A. K., and Pattengill-Semmens, C. V. (2004). A hotspot of non-native marine fishes: evidence for the aquarium trade as an invasion pathway. Marine Ecology Progress Series, 266, 239-244.

Schofield, P. J. (2009). Geographic extent and chronology of the invasion of non-native lionfish (Pterois volitans [Linnaeus 1758] and P. miles [Bennett 1828]) in the Western North Atlantic and Caribbean Sea. Aquatic Invasions, 4(3), 473-479.

Turan, C., Ergüden, D., Gürlek, M., Yağlıoğlu, D., Uyan, A., and Uygur, N. (2014). First record of the Indo-Pacific lionfish Pterois miles (Bennett, 1828)(Osteichthyes: Scorpaenidae) for the Turkish marine waters. Journal of the Black Sea/Mediterranean Environment, 20(2), 158-163.

Turan, C., Uygur, N., and İğde, M. (2017). Lionfishes Pterois miles and Pterois volitans in the North-eastern Mediterranean Sea: Distribution, Habitation, Predation and Predators. Natural and Engineering Sciences, 2(1), 35-43.

Turan, C., Uyan A., Gürlek, M., Doğdu S, A. 2020. DNA Barcodes of Pterois miles (Bennett, 1828 and P. volitans (Linnaeus, 1758 (Scorpaenidae) in the MediterraneanSea. Fishtaxa, inpress

Von Bertalanffy, L. (1957). Quantitative laws in metabolism and growth. The quarterly review of biology, 32(3), 217-231.