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Feeding Strategies and Biological Traits of the Lessepsian Migrant *Pterois miles* (Bennett, 1828) in the Messenian Gulf, SW Greece

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Abstract: The common lionfish, *Pterois miles* (Bennett, 1828), is one of the most recent Lessepsian migrants into Mediterranean Sea. In this study, a first attempt is made to explore some life history parameters of the species in the Messenian Gulf (SW Greece). Its growth, morphometry, and feeding behavior were studied in samples collected with a speargun during the summer and autumn of 2021 at depths from 0 m to 20 m. Lionfish were found to have established a thriving population, growing faster and reaching larger sizes than in their native range. Analysis of their diet showed that this species is a generalized feeder with a preference towards piscivory, targeting key species for local food webs, such as the damselfish (*C. chromis*), possibly provoking competition with other native predators. Overall, the dietary habits of the species, rapid growth rate, and lack of predation pressure make the lionfish an additional risk for the integrity of the Messenian marine ecosystem, an ecosystem which is already disturbed by intense human intervention.

Keywords: *Pterois miles*; growth; marine invasive species; morphometry; feeding behavior; lionfish; Lessepsian migrant

Key Contribution: This research provides a first insight into the dietary preferences, growth and morphometry of lionfish in Greek waters, providing evidence supporting the acclimatization of this species in SW Greece, a bioregion with a very low volume of research on Lessepsian species.

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Citation: Koilakos, S.M.; Georgatis, I.; Leonardos, I. Feeding Strategies and Biological Traits of the Lessepsian Migrant *Pterois miles* (Bennett, 1828) in the Messenian Gulf, SW Greece. *Fishes* **2024**, *9*, 380. https://doi.org/10.3390/fishes9100380

Academic Editor: Audrey M. Darnaude

Received: 13 August 2024
Revised: 19 September 2024
Accepted: 23 September 2024
Published: 26 September 2024

1. Introduction

The Mediterranean Sea, although comprising only a small part of the global ocean, is considered a major marine biodiversity hotspot, accommodating almost 17,000 species, comprising 4–18% of the global marine species richness [1]. The biologically plentiful marine ecosystems of the Mediterranean, among other anthropogenic threats, are now facing peril in the form of marine bioinvasions [2].

The increased influx of tropical waters through the Suez Canal and the Strait of Gibraltar has resulted in the "tropicalization" of the Mediterranean [3]. The rising water temperatures encourage the spread of exotic biota, disturbing the native Mediterranean marine biocommunities [4]. To this date, more than 1000 exotic species are found in the Mediterranean, the majority of which are tropical thermophilic species that have entered the Mediterranean through the Suez Canal [5]. More than 130 Lessepsian fish are found in the Mediterranean, 40% of which have been documented after 2001, with most of them having increased their invasive distribution since [6]. Bioinvasions can disturb marine ecosystems greatly and are considered the second biggest threat to biodiversity after habitat loss [7]. Apart from environmental threats, several exotic species are poisonous, venomous or aggressive, posing a potential danger to human health [8].

An important Lessepsian invader is the common lionfish *Pterois miles* (Bennett, 1828), also known as the "devil firefish" [9]. *Pterois miles* is a species originating from the Indian

Ocean, with a native range from the Red Sea to eastern South Africa, the Arabian Sea, Persian Gulf, the Gulf of Oman, Laccadive Sea, the Gulf of Bengal, Andaman Sea and Indonesia [10]. The invasion of the western Atlantic by the tropical lionfish, *Pterois miles* and *P. volitans*, is considered as one of the fastest and most ecologically harmful marine bioinvasions to date [11], in which they now have established a numerous and expanding population, acting as mesopredators, with destructive consequences to the local ecosystems and biota [9]. The invasive success of the common lionfish can be attributed to a variety of biological traits [12] such as their broad opportunistic diet [13–15], lack of predator pressure due to their natural defenses, wide ecophysiological tolerance, high growth rates and increased fecundity [12].

The first historical record of a lionfish in the Mediterranean was reported in 1991 off the coast of Israel [16], with no further records until 2012, two decades later, when two specimens were captured off the coast of Lebanon, indicating a new invasion event [17]. Soon after, specimens were found in Cyprus, Turkey and Rhodes [18]. Since then, *Pterois miles* has increased in population and expanded its range, reaching as far as Sicily and Tunisia [19]. The lionfish *Pterois miles* are considered among the top three most invasive alien species according to total area of occurrence [20]. This rapid westward expansion of the lionfish has become a cause for distress, since it is speculated to have a profound damaging effect on all the affected ecosystems [21]. The impacts of *Pterois miles* on biodiversity, ecosystem services, economy and human health are considered "major" to "massive", although the evidence supporting these assessments is somewhat uncertain [22]. While the effects of lionfish in the western Atlantic are well documented, there is limited information on their impact in the Mediterranean, leading to lower confidence in assessments at the European scale. These impacts are expected to worsen under climate change scenarios [22].

The bulk of knowledge about lionfish biology and ecology comes from research in the western Atlantic, as well as in their natural distribution [9]. In the Eastern Mediterranean, where lionfish seem to be expanding at an increasingly rapid rate [18], the research regarding the biology and ecology of this species is limited, with few relevant studies coming from Cyprus [9,23]. There is a significant lack of research on the assessment of populations in Greece, especially in SW Greece, where the lionfish recently made its appearance and is spreading rapidly [24].

Studying the feeding ecology of lionfish is important in understanding their ecological role and potential impacts on the various marine food webs of their invasive range [25]. Considering the generalist nature of the species' diet, its feeding behavior may differ between regions depending on prey availability and local environmental factors [26].

The aim of this study is to explore the feeding strategies as well as fundamental biological aspects of *Pterois miles*, such as its growth rate and morphology, in the Eastern Mediterranean. The study was conducted in an area characterized by no previous research work, the Mani Peninsula in the Messenian gulf region, SW Greece, a hotspot for invasive exotic species [27,28], where the lionfish made its first appearance in 2019 [29].

2. Materials and Methods

2.1. Study Area

The study was conducted in the Messenian Gulf, Southern Peloponnese, SW Greece. Samples were collected between the Gulf of Limenion and the Gulf of Diros, Messenian Gulf, SW Greece (Figure 1). The study area consists of the middle peninsula of the southern Peloponnese, forming a geological and morphological extension of Mount Taygetos to its southernmost end, Cape Tainaron [29]. The area in terms of climatic conditions is characterized as warm and dry [30]. The sea surface temperature is relatively high (28–30 °C in August) [31].

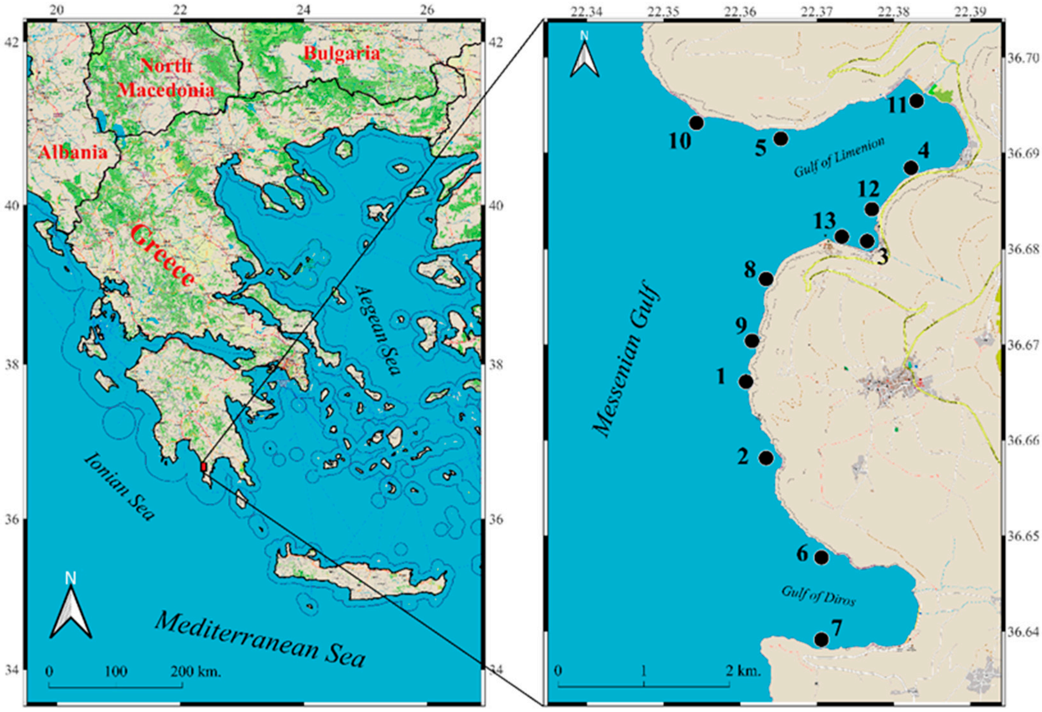

Figure 1. Detailed map of the sampling area. All the sampling sites are represented as dots no 1 to 13 (**right**), between the gulfs of Limenion and Diros. Map obtained via qGIS v.3.24.0.

Local geomorphology is predominantly karstic, with underwater and coastal caves as well as freshwater springs being very common [29,32]. A consequence of the land geology is the morphology of the seafloor, which consists of a patchwork of rocks and reefs, or of an entirely rocky substrate. Between the rocky zones are sand covered areas with scattered *P. oceanica* meadows [29,32,33]. A variety of submerged human-made objects can also be found, as a result of the historical and prolonged human presence in the area [32].

All samples were collected during the summer and autumn of 2021 (from 28 July 2021 to 21 November 2021) by means of freediving and speargun. Samples were collected, during daytime, from the surface to depths of about 20 m. The use of a speargun was selected due to this method's ability to instantaneously kill the fish, thus avoiding the digestion of the stomach contents until further analysis, compared to fish nets or traps, where the fish is allowed to digest for a longer period before its collection. A total of 79 individuals were collected, 69 during the summer and 10 during the autumn. The vast majority of sampled individuals were captured in areas with hard substrata such as natural or artificial reefs (shipwrecks, concrete structures, anchors, etc.). Captured lionfish were frozen at −20 °C until the subsequent analyses. Subsets of the total sample were used for the different analyses. Each specimen was numbered, photographed, measured (to an accuracy of 0.1 mm) and weighed (Mw, wet mass to the nearest 0.1 g). During dissection, an abdominal incision was performed on each specimen and the stomach was removed. Lionfish were sexed by macroscopic examination of the gonads. The stomachs were removed and preserved in small containers with formalin solution (8% v/v) for further examination. A total of 79 stomachs were examined.

2.2. Length–Weight Relationship

Total length (TL) and standard length (SL) of each specimen were measured using a digital caliper to the nearest 0.1 mm. Individual total weight (TW) was recorded to the nearest 0.1 g using a digital balance. All specimens were mature and were studied prior to their reproductive period. Length–weight relationship ($TW = aSL^b$), was calculated with TW as the weight (g) and SL as the standard length (cm), in the linear (after logarithmic transformation) form of the equation, where a is the intercept to the *y*-axis of the best-fit line and b is the slope of the line [34]. The length–weight equation was performed for each sex separately and for both sexes combined.

2.3. Morphometric Analysis

Morphometric analysis was performed using distances between several landmarks defined on the digital photos of each specimen (Figure S1). The fish were digitized along their right lateral profile and analyzed using an image analyzing software (ImageJ Version 1.54). Homologous landmarks were used to explore fish morphology, selected to include all measurements that adequately represent the shape of the fish [35]. Twenty-six landmarks were selected, among which a truss network of 53 distances was extracted to explore the shape through statistical means (Table S1). To nullify the effect of individual size in multivariate morphometric data group diversity [36], all individual morphometric measurements were transformed [36–38] according to the formula:

$$\text{Madj} = \text{logM-b(logSL-logSLmean)}. \tag{1}$$

where Madj is a fixed measurement, M is the length of the measured character, SL is the standard length of the fish and SLmean is the mean standard length of the studied group. The b coefficient was calculated as the slope of the regression of log10 Mi with log10 SLi using individuals of all groups but allowing the intercept to differ between groups [36]. According to Reist [39], this transformation better reflects the variation in shape between groups regardless of the effect of individual size. For this reason, the total length and SL of each specimen were excluded from the final analysis.

Principal component analysis (PCA) of the variance–covariance matrix of log-transformed measurements was used to reveal the morphological characters responsible for the phenotypic differentiation between males and females [37]. Forward stepwise discriminant function analysis (DFA) was performed to investigate the morphological differentiation between the three length classes specified in the stomach content analysis (see Section 2.5). Population centroids, along with 95% confidence limits obtained through the DFA, were utilized for visualizing the group relationships. Discriminant functions derived were then applied to allocate individuals to respective samples. A cross-validation procedure was employed to assess the misclassification rate. Statistical analyses were performed using the SPSS package version 28.

2.4. Age and Growth Rate Analyses

Age was determined from scales, which were taken from the area under the pectoral fin and in front of the dorsal fin. After extraction, the scales were cleaned and were placed between two glass slides. The total radius of the scale and the radius of each annual ring were measured as the smallest distance from the center of the scale to the distal edge. A stereoscope with transmitted and reflected light was used for the observations. The growth parameters were estimated iteratively by fitting the von Bertalanffy growth function [40,41] on the mean observed standard lengths (SL) at age using the non-linear (VBGE):

$$\text{Lt} = \text{L} \times (1 - \text{e}^{-\text{k(t} - \text{t0)}}) \tag{2}$$

where Lt is the SL (cm) at age t (year), L∞ is the asymptotic SL (cm), i.e., the mean length an individual would reach if it were to grow indefinitely, k is a constant expressing the rate at which L∞ is approached (year^{-1}), and t_0 the theoretical age (year) at which predicted mean length is zero. The analysis was carried out for the entire study group and for both sexes separately. Statistical analyses were performed using the SPSS package version 28.

2.5. Stomach Content Analysis

To estimate variation in feeding habits as a function of size, the total sample was divided into three size classes to accommodate a similar number of specimens: 1. Small sized (Mw < 150 g), 2. Medium sized (150 g < Mw < 250 g), 3. Large sized (Mw > 250 gr).

For the identification of the food items, stomachs were placed in water for two days to remove the formalin then, after being placed on absorbent paper to remove excess dampness, they were weighed to the nearest 0.01 g. Contents of each stomach were washed in a petri dish, and the prey items were identified to the lowest possible taxonomic level, separated and counted using a stereoscope (Olympus SZ61, Olympus Corporation Tokyo, Japan, Basler camera Basler AG, Ahrensburg, Germany). When possible, food items were weighted to the nearest 0.01 g. Fragments of organisms (e.g., skeletal elements, fragmentary remains) were considered to be individuals.

Feeding activity was evaluated using the vacuity index (IV):

$$IV = E/N \times 100 \quad (3)$$

where E is the number of empty stomachs and N is the number of stomachs examined [40]. To determine the importance of each food category to the diet of *P. miles*, percent number (%N), percent weight (%W) and frequency of occurrence (%F) were calculated. Percent number (%N) is the number of individuals of a food category divided by the total number of individuals and expressed as a percentage, after pooling the gut contents of all fish. Percent weight (%W) is the equivalent index applied to weight data. Frequency of occurrence (%F) is the percentage of guts in which a food category was present, as discussed and revised by [42–44]. To provide a balanced, general picture of the importance of food categories that combines the effects of these indices and allows comparison between dietary items of the whole sample and between different age groups and sexes [43], the index of relative importance (IRI) [45], expressed as a percentage, was used [44].

To determine the species feeding strategy, the modified Costello graphical method [46] was used. According to this method, the prey-specific abundance (Pi%), defined as the percentage a prey taxon comprises in only those predators in which the specific prey occurs, is plotted against the frequency of occurrence (FO%) on a two-dimensional graph. Information on prey importance and feeding strategy of the predator can be obtained by examining the distribution of points along the diagonals and the axes of the diagram [46,47]. Information on the variety in food categories, both in the diet of each individual and of the population, can be extracted through this method.

3. Results

3.1. Length–Weight Relationship

Standard length (SL, cm)–total weight (TW, gr) equations were calculated for males, females (Figure S2) and both sexes combined. The slope of the TW–SL equation was found to be $b = 3.06$, with a 95% confidence interval from 2.86 to 3.26. Since the confidence interval for b includes the value 3, the growth pattern of lionfish in this study is assumed as isometric. The slope of the TW–SL relationship for males was $b < 3$ ($a = 0.0407$, $b = 2.89$), while for females was $b > 3$ ($a = 0.0104$, $b = 3.35$), although there was no statistically significant difference between the two sexes $F = 0.062$; $P = 0.806$).

3.2. Morphometric Analysis

All 79 sampled specimens were studied for the morphometric analyses. Principal component analysis (PCA) did not morphologically distinguish lionfish males from females. For this reason, both sexes were pooled together for the discriminant function analysis (DFA). To emphasize the differentiation among size groups, DFA was employed. The Wilks' lambda test indicated significant results. The coefficients of canonical correlation (0.83, 0.71) underscored the substantial significance of the two discriminant functions (DFs), explaining 69.1% and 39.1% of the total variance, respectively. The misclassification rate of specimens was 11.4%. The separation of the subgroups is clearly visible in the scatterplot of the discriminant functions (Figure 2).

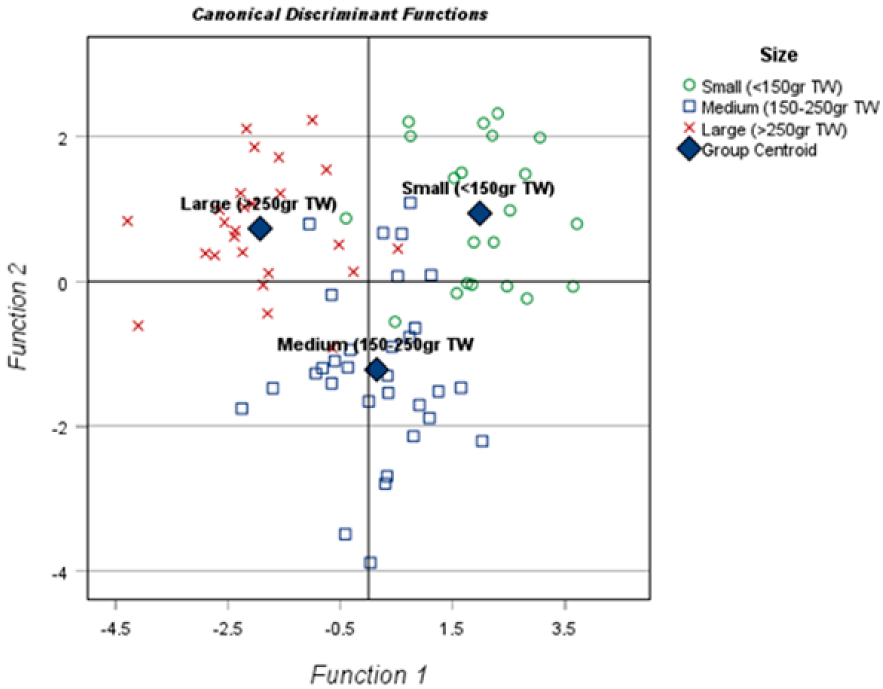

Figure 2. Calculated scatterplot of canonical discriminant functions for the three size groups found in the study area [Small (<150 gr TW): green; Medium (150–250 gr TW): blue; Large (>250 gr TW): red.

3.3. Age and Growth Rate Analyses

The age was determined in 69 out of 79 specimens. The scale reading revealed four age classes ranging from 1 to 4 years. The 3-year-old specimens were dominant (48%), followed by the 2-year-old (42%) and 1-year-old (7%). The standard length (SL) ranged from 11.2 to 25.4 cm, with an average value of 18.93 cm.

The von Bertalanffy growth equation was applied to the longitudinal composition data of males, females, and the whole sample. The growth parameters $L\infty$ and k, calculated for each sex separately as well as for sexes combined, are presented in Table 1. Growth parameters yielded by the non-linear regression model were similar for all categories. Females exhibit a slightly slower growth rate (k = 0.69 $year^{-1}$) and they reach a smaller asymptotic standard length ($L\infty$ = 22.95 cm) than males (k = 0.79 $year^{-1}$; $L\infty$ = 23.37 cm). Observed maximum SL for males was 25.4 cm, while for females it was 24.5 cm; in both cases the values are greater than the corresponding $L\infty$ yielded by the model. This suggests that the model underestimates the maximum size of individuals in the population.

Table 1. Calculated von Bertalanffy growth parameters ($L\infty$ = calculated maximum standard length (cm); k = growth constant ($year^{-1}$); t_0 = theoretical age at length zero (year)), for the whole 79 individuals, for males and females. Confidence bounds are included.

Parameter Estimates					
Subset	**Parameter**	**Estimate**	**Std. Error**	**95% Confidence Interval**	
				Lower Bound	**Upper Bound**
All	L∞	24.234	2.472	19.298	29.170
	k	0.626	0.275	0.078	1.175
	t0	−0.215	0.455	−1.123	0.693

Table 1. *Cont.*

		Parameter Estimates			
Subset	Parameter	Estimate	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Males	L∞	23.371	2.090	19.143	27.598
	k	0.790	0.380	0.022	1.558
	t0	0.028	0.473	−0.928	0.984
Females	L∞	22.959	4.280	14.126	31.792
	k	0.694	0.552	−0.446	1.834
	t0	−0.217	0.756	−1.779	1.344

3.4. Diet and Stomach Analyses

Of the total stomachs (n = 79) examined, 54 (68.4%) contained food while 25 (31.6%) were empty. Females showed a much higher vacuity index (43.33%) than males (22.44%). The vacuity index seems to decrease in proportion to the increase in body weight, as specimens in the first size category (<150 gr) showed the highest index and individuals in the third category (>250 gr) the lowest.

A total of 113 items were identified from the 79 examined stomachs. Analysis of stomach contents identified 20 prey categories. Eighty-seven were fish, where 44 individuals from 8 taxa were identified (*C. chromis*, *S. porcus*, *A. imberbis*, *Atherina* sp., *T. pavo*, family Blennidae, Gobiidae, Labridae), while 43 individuals were categorized as "unidentified teleost". A total of 19 crustaceans from 5 taxa were also found (*S. spinosus*, *G. strigosa*, *Pagurus* sp., family Paleamonidae, Gammaridae); the unidentifiable individuals from the Brachyura infraorder, were categorized as "unidentified crabs", while the rest of the unidentified crustaceans, as "unidentified crustaceans". Other stomach contents were also found: a marine angiosperm *C. nodosa*, two fragments of marine algae, a marine snail of the genus *Jujubinus* and three individuals of Nematodes. For a detailed table of the stomach contents see Table S2, Supplementary Data.

C. chromis had the highest W% (42.83) and the unknown fish category had the highest FO% (34.17) and N% (38.05); IRI% revealed the unknown fish category (47.89) and *C. chromis* (44.32) as the most important prey items. The next most important prey item was *A. imberbis* (2.66). Similarly, for both sexes the most important food categories by IRI% were *C. chromis* (males: 33.14; females: 41.63) and the unknown fish category (males: 48.48; females: 51.94). More food categories were found in the stomachs of males overall. A similar trend was found for all three size classes with the most important food categories by IRI% being *C. chromis* (Small: 17.09; Medium: 58.83; Large: 29.21) and the unknown fish category (Small: 51.94; Medium: 37.53; Large: 37.98). For large individuals, *A. imberbis* (15.56) also appeared to be an important food item. The highest abundance of food categories was found in the category of large individuals (>250 gr body weight), while in the category of small individuals (<150 gr body weight) the abundance was lowest. In cases where weight could not be calculated, the barometric method (W%) was assumed to have a value of zero (0).

The relationship between prey-specific abundance and frequency of occurrence suggested some feeding variation. The graphical modified Costello method for the description of the feeding strategy of *Pterois miles* (Figure 3) revealed three groups. The first group is mainly represented by the damselfish *Chromis chromis*, followed by an unidentified fish category, indicating a degree of specialization toward one prey in the lionfish's diet. Damselfish have a relatively high prey-specific abundance (more than 95%) and frequency of occurrence compared to the rest of the food items, being consumed by more than 25% of the fishes, so they can be considered a dominant prey item. The second group consists of all the remaining found fish taxa (e.g., *A. imberbis*, *S. porcus*), with high prey-specific abundance (higher than 40%) but low frequency of occurrence, and indicates the existence of rare or less frequent teleost prey in the stomach contents of lionfish and that they are consumed sporadically. The third group, which includes the prey categories exhibiting the lowest prey-specific abundance (lower than 40%), and occurrence frequency, consists of the sum of the crustacean food items and taxa (e.g., *G. strigosa*, *S. spinosus*), indicating a secondary role for crustaceans in the fishes' diet. Food items that could not be weighed were excluded from the analysis. The trophic levels of identified prey items based on Fishbase (https://fishbase.se/search.php (accessed on 2 August 2024)) ranged from 2.3 to 4.1. For identified fish prey items, the trophic level range was 2.8–4.1, ranging from omnivores–detritivores such as members of Blennidae to high level predators such as *Scorpeana porcus*. Similarly, for the crustaceans, the trophic level ranged from 2.3–3.6, ranging from herbivorous paleamonid shrimps to carnivorous taxa such as *Stenopous spinosus*. These findings indicate that *Pterois miles* feeds on a wide range of the local food web.

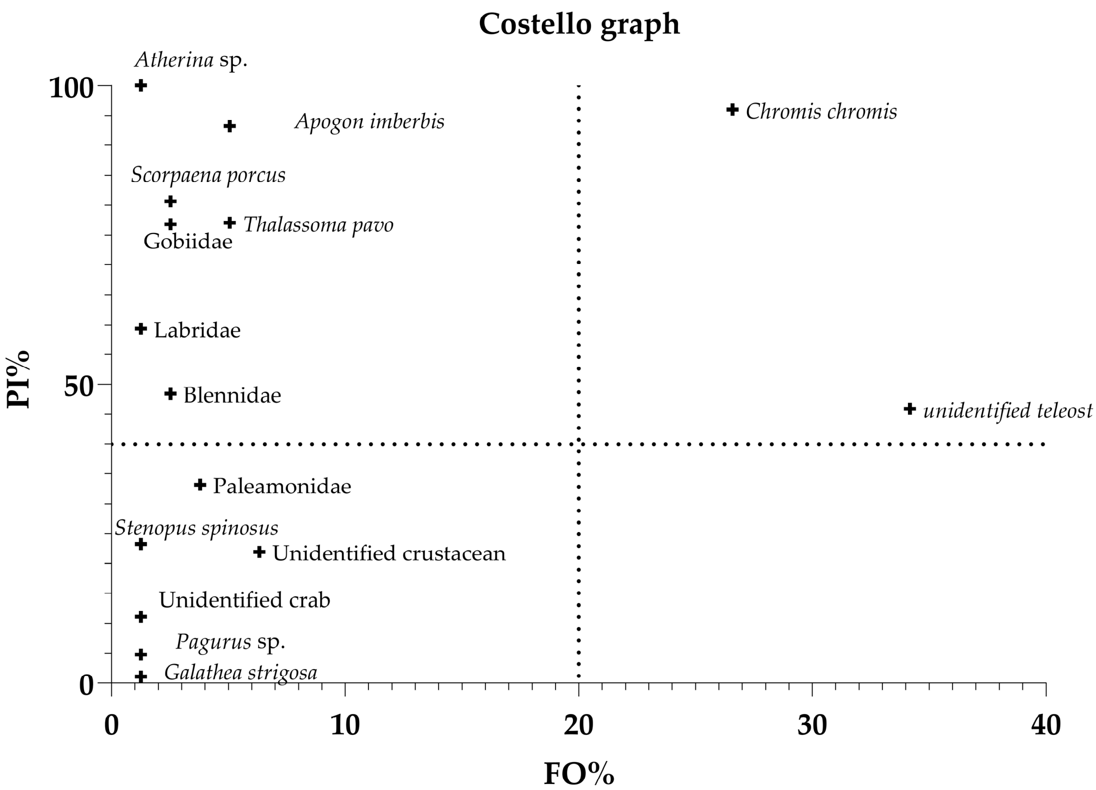

Figure 3. Relationship among prey-specific abundance (%Pi) and frequency of occurrence (%FO) of food categories in *P. miles* diet. Plots based on modified Costello graphical method [46]. (*Chromis chromis*, *Apogon imberbis*, *Thalassoma pavo*. Unidentified crustacean, Paleamonidae, *Scorpaena porcus*, Gobiidae, Blennidae, Labridae, *Stenopus spinosus*, Unidentified crab, *Atherina* sp., *Pagurus* sp., *Galathea strigosa*).

Regarding the feeding strategy, there appeared to be a relative specialization in the predation of fish and especially *Chromis chromis*, since all fish food items were situated high on the feeding strategy axis, and secondarily a generalized feeding strategy for the capture of individual food categories, such as the various species of crustaceans and invertebrates (e.g., *S. spinosus*, *G. strigosa*, *Paleamon* sp.).

4. Discussion

The Messenian Gulf has turned into a "hotspot" for invasive tropical species [27], with lionfish having established their presence in recent years (since 2019) and becoming more and more numerous [28]. Using a speargun at shallow depths (0–20 m), a total of 79 *Pterois miles* specimens were collected. The analysis of these samples yielded important information on the biology and diet of the species, in an area where no previous research has been carried out, the Messenian Gulf, providing evidence of acclimatization and adaptation of *Pterois miles* in this newer part of its distribution.

The presence of both adults and juveniles during the sampling period, as well as the higher abundances and encounter frequencies of the species compared to previous years, is indicative that the local *Pterois miles* population is well established and thriving [9]. Unlike the western Atlantic region, where the sex ratio is 1:1 [48,49], and Cyprus, where the population is dominated by females [9] the study area seems to have a male-dominated population. This finding may have come about because of the relatively small sample size, as well as a possible bias created by the fishing gear. All female *P. miles*, aged 2 years and older, captured during the summer months, were found to have mature and enlarged ovaries. This is indicative of an increased reproductive potential during the summer period. Similar results have been seen in other studies about fish of tropical origin, which reproduced more intensively during the warm months [9,10,50].

The length–weight relationship showed a rapid increase in body weight in relation to length. This is indicative that, as the lionfish grows, it becomes increasingly heavier, relatively stockier, or deeper bodied. Females follow this trend to a greater degree, while males show a slight tendency for greater body elongation. This may be due to the enlargement of the gonads of the females during the sampling period (summer–autumn), where lionfish appeared to have increased reproductive potential [9,10,50]. These results are similar to studies of the species in the Atlantic [51] and Cyprus [9] and the small discrepancy observed between studies is usually attributed to sample size, time of year, feeding habits, maturity stage, environmental factors and rapid growth in early life stages [52,53]. Concerns arise in the case of lionfish, as the sexually dimorphic growth pattern could lead to the removal of more males, as current methods have been shown to remove the largest males first [54], which the present research confirms. If removal efforts do not eliminate enough females, then their success may be compromised due to the continued reproductive output of the species.

No differentiation was found between male and female morphology via PCA, indicating that even if the growth rates of the two sexes show dimorphism, the external morphology does not follow the same rule. However, an ontogenetic shift of external morphology is observed, with the discriminant analysis morphologically highlighting the three categories based on size ((1.) <150 gr body weight, (2.) 150–250 gr body weight, (3.) >250 gr body weight). This finding suggests that lionfish modify their structural features as they grow, to increase their hunting success [9,55,56], supporting the dietary study findings.

The most numerous age groups during the sampling period were those of 2 and 3 years of age. The lack of juveniles may be attributed to the timing of the sampling period, due to mortality of younger age groups during the preceding colder months [57], or due to fishing gear limitations and the lack of thorough investigation of marine angiosperm meadows, that juveniles are speculated to use as shelter [58]. The lack of larger individuals is probably due to an ontogenetic migration of larger individuals into deeper waters, a phenomenon observed in the Lebanon Sea [59] and the Atlantic [14,58]. This hypothesis is supported by numerous sightings of large individuals at greater depths by local fishermen and recreational divers. Most of the previous studies in the Atlantic invasion region yielded recorded ages averaging about 3 years [60–62], with a maximum age of 9 years [63]. Considering that lionfish have a life expectancy of at least 30 years [62] the 4-year-old population of the study area can be considered "young" and roughly coincides with the year of their first appearance in the wider Messenian area, in 2019 [28].

The calculated von Bertalanffy growth curves appear to underestimate the maximum length of individuals in this population, since individuals longer than the theoretical maximum were found. This underestimation may be due to the lack of large individuals, which probably find refuge in deeper waters (>20 m) [14,58,59]. Therefore, the resulting growth curves should only be considered as estimates of growth for the specific depths and habitats where sampling took place, i.e., rocky bottoms at depths of 0 to 20 m, and not as representative of the entire local population. Nevertheless, lionfish in the Messenian Gulf area show significantly greater growth parameters, i.e., they grow faster [64] and reach greater lengths [65], than lionfish in the natural distribution of the species. Although the reasons behind this difference are unclear (e.g., predator pressure, foraging frequency, prey size selectivity, and reduced parasite loads), lionfish in the Mediterranean and Atlantic regions potentially have a greater advantage for successful propagation and population growth, because larger body sizes reflect higher reproductive output, increased probability of survival and better larval quality [66]. Males were observed to have a slightly faster growth rate and higher maximum length than females, which grow more slowly and reach smaller body lengths. Sexually dimorphic growth is relatively common in fish, and it has been reported for a variety of related taxa, such as *P. volitans* [48]. A similar study [67] has shown that the relatively fast growth rate exhibited by this species may promote the fastest possible reproductive maturation of females, which need to reach slightly larger body sizes than males to enter sexual maturity.

The diet of *Pterois miles* in the area studied was found to be similar to that in areas of the natural and invasive range of the species, consisting mainly of teleost fish and crustaceans [9,13,52,68]. The parts of plant matter or algae found in the stomachs of the species were considered to have been accidentally consumed, along with another food item, while the nematodes found were considered as parasites, as in a similar study in Cyprus [9].

The studied lionfish seemed to exhibit a strong tendency towards piscivory. Relative importance indices and Costello's graphical method highlight fish as the most important food source of *Pterois miles* in the study area, with crustaceans and other food categories occurring sporadically and in smaller quantities. The lionfish's main recognized prey appears to be the damselfish *C. chromis*, a planktivorous benthopelagic fish very common on Mediterranean rocky bottoms [69,70].

This observed trend for increased fish consumption occurs regardless of size class or sex and appears to characterize the entire study sample. The increased preference for fish as a food source for lionfish is not unheard of, as similar dietary trends have been observed in the populations of Cyprus [9] the Bahamas [71], the Mexican Caribbean and the Southeast coast of the United States [72].

In proportion to the increase in body size there is an observed decrease in the vacuity index, indicating increased hunting success. This is consistent with the optimal foraging theory [73], suggesting that lionfish modify their structural features and hunting strategy as they grow, e.g., with increased mouth opening per length [9], to reduce unsuccessful feeding attempts [55] and to possibly target larger prey [55,56], thus ensuring that increased energy demands are met with less energy expenditure. The increased vacuity index shown by female subjects is probably due to the increased size of the gonads which reduces the stomach capacity.

The identified prey categories found in lionfish stomachs mainly consist of species native to the Mediterranean (see Table S2). Among the main prey categories in the lionfish diet, only a few socioeconomically important species were found sporadically (e.g., *Atherina* sp., *S. porcus*). However, species of high ecological value were predominant. For example, the damselfish *C. chromis*, which is seemingly the main food item of *Pterois miles* in the studied area, is also an important prey item for native predators, such as the dusky grouper *E. marginatus* [74], *E. costae* [75] and *S. porcus* [76]. Depending on local fishing pressures and local predator communities, lionfish predation could increase competition in already stressed populations [9]. Understanding the diet preferences of *Pterois miles* is critical for developing effective management strategies. Knowledge of preferred foods, such as its piscivorous diet and specific preference for *Chromis chromis*, suggests targeted control measures, such as baited traps, possibly enhancing the success of eradication efforts. Diet analysis also helps assess ecosystem impacts, particularly on native or endangered species such as *E. marginatus* (listed as "Vulnerable" by IUCN), guiding protection priorities.

Continuous monitoring of dietary shifts ensures adaptive management strategies that remain effective over time.

5. Conclusions

In conclusion, this study enhances the available knowledge on the presence and biology of the lionfish *Pterois miles* in the Eastern Mediterranean and especially on its distribution in SW Greek waters. The information obtained is useful for researchers, conservation managers and policy makers, creating a preliminary assessment of the dynamics of the lionfish invasion in an area where no previous research had been conducted. Morphology and growth studies confirm that lionfish can flourish in just 4 years and establish their presence in the Messenian area. Their increasing population densities observed over the years, combined with their generalist diet and consumption of ecologically and socioeconomically important fish, can lead to competition with native predators of the same trophic level and thus further disruption of local marine communities, further shaking a marine ecosystem that is already under intense anthropogenic pressure and simultaneously in the "crosshairs" of invasion by multiple alien species. Although lionfish cannot be completely eradicated, diet analysis is an essential tool for implementing precise, sustainable management approaches for invasive species. As a final note, the development of a policy targeting lionfish fisheries could provide a management tool to improve impacts on Mediterranean coastal ecosystems.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/fishes9100380/s1, Figure S1: Landmarks used for the morphometric study; Figure S2: Length–Weight charts for male and female lionfish; Table S1: Measurements taken for the study of fish body shape using the landmarks method; Table S2: Stomach contents of the studied lionfish, with their respective importance indices.

Author Contributions: Conceptualization: S.M.K. and I.L.; Methodology: I.L.; Validation: I.L.; Supervision: I.L.; Writing–Original and Review Draft: S.M.K.; Format analysis: I.G. and S.M.K.; Investigation: I.G. and S.M.K.; Resources: S.M.K. and I.L.; Visualization: S.M.K. and I.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was approved by the undergraduate thesis committee of the Department of Biological Applications and Technology Department of the University of Ioannina, Greece. (Protocol number: 1988, Approval date: 1 October 2021).

Informed Consent Statement: Not applicable.

Data Availability Statement: Any data concerning from the current project can be requested from the corresponding author: Ioannis Leonardos, ileonard@uoi.gr.

Conflicts of Interest: The authors declare no conflicts of interest.

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