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RESEARCH PAPER

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Feeding Habits of Striped Piggy Fish, *Pomadasys stridens* (Forsskål, 1775) in the Persian Gulf

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Abstract

The stomach contents of *Pomadasys stridens* were studied monthly in the Persian Gulf (Hormozgan province) from October 2020 to October 2021. The stomach contents analysis of 591 fish included a wide variety of food items such as bony fish, crustaceans, molluscs, echinoderms, plant materials, annelid worms, and miscellaneous materials. Although the food component percentage differed marginally between sexes, it was not statistically significant (P=0.19). The vacuity index revealed that *P. stridens* is a gluttonous species (19.5 %) and the amount of this index was not significantly different in both sexes, length classes, or months. The food preference varied by size: in younger fish, the dominant food item was fish prey, followed by unknown materials, crustaceans, and plant material, and in larger fish (often including sex-determined fish), the food preference shifted to mostly molluscs, crustaceans, and mixed food groups. These preferences also differed significantly across sexes and months (P<0.05). The Penaeid shrimps made up a major portion of *P. stridens'* diet. Therefore, any change in the stocks of each prey and their predators can have a significant effect on their exploitation potential in the region.

Introduction

The family Haemulidae Gill, 1885 now has 137 recognized species (Fricke et al. 2023). They are small to medium-sized fishes that live in shallow coastal waters in tropical and subtropical locations around the world. Most species are demersal which occur in brackish water from the coastline to a depth of over 100 m (Fischer & Bianchi, 1984; Carpenter et al., 1997). In the Persian Gulf, 18 species of this family have been identified (Eagderi et al., 2019). The striped piggy fish, *Pomadasys stridens* (Forsskål, 1775), is found in the western part of the Indian Ocean, the coastal waters of Pakistan, the Red Sea, South Africa, and the Mediterranean Sea (Fischer & Bianchi, 1984; Carpenter et al., 1997; Golani et al., 2010). This species is the most common bycatch in the shrimp fisheries in the Persian Gulf and the Sea of Oman (Hormozgan province), and it is also caught in coastal stake nets (Moshta) and with hooks. Although *P. stridens* is not as large as other commercial species in the Haemulidae family in the region, it is still commonly consumed by beachgoers.

Food and feeding information obtained from the description of fish stomach contents is extremely valuable in understanding evolutionary processes that force fish to adopt specific behaviors, and it is critical in formulating conservation strategies and acting as a major component in the protection of species and ecosystems (Wootton, 2009). Analysis of fish stomach content provides important insight into feeding

patterns, and quantitative assessment of feeding habits is a fundamental element of fisheries management. Fish diet reflects the integration of many essential ecological components, including behavior, conditions, habitat use, energy intake, inter- and intraspecific interactions, etc. (Zacharia & Abdurahiman, 2004; Sagar et al., 2018). Food and feeding habits are particularly important in fish; the type and value of food directly affect fish growth, survival, and reproduction, and indirectly affect fish mortality (Wootton, 2009; Osmany & Zohra, 2016).

Previous research has primarily focused on the diet and other biological characteristics of *Pomadasys kaakan* (Cuvier, 1830) in the region (Kamali et al., 2011; Fakhri et al., 2011; Valinassab et al., 2011). A few studies have been conducted on the diet and reproductive features of *P. stridens* in the coastal waters of the Bushehr province, south of Iranian waters (Vahabnezhad et al., 2015; Vahabnezhad et al., 2018). The current study investigated some feeding aspects of *P. stridens* in the southern waters of the Hormozgan province, Iran, to gain a more complete understanding of the feeding ecology of this species.

Materials and Methods

Sampling and Data Analysis

From October 2020 to October 2021, monthly sampling was conducted in the Persian Gulf's coastal waters (Hormozgan province) with a stake net (Moshta), hook, and bycatch in shrimp trawler (Figure 1). The fish were immediately packed in ice and kept in the freezer until the laboratory procedures began. Fish biometric data, including fork length and body weight, were measured with a biometric ruler with an accuracy of 1 mm, and the fish's weight and stomach contents were measured with a digital scale with an accuracy of 0.01 g. The fish were then dissected from the abdomen area, and the gonads were inspected to determine their sex (Biswas, 1993). First, their stomachs were visually evaluated for fullness, and they were classified into five groups based on fullness: 25%, 50%, 75%, 100%, and absolutely empty (Zacharia & Abdurahiman, 2004). The contents of the stomach were then transferred to Petri dishes and weighed after sorting the different types of contents.

In this study, the food components in *P. stridens*' diet were separated into animal and plant groups, as shown below.

A- Fish remains —entire bony fish or fragments of scales, bones, and vertebrae.

B- Crustacean remains — including entire samples of shrimps, crabs, amphipods, stomatopods, and mysids, as well as parts of carapace, walking legs, and telson.

C- Mollusca remains — including the whole body or pieces of gastropods and bivalves, as well as sepia and squid body parts.

D- Echinoderm remains — including fragile stars

E- Plant material remains —plant material fragments

F- Worm remains — including annelid worms

G- Mixture— Inseparable pieces of food items

H- Unidentified materials — things that could not be identified

I- Debris— sand

In this study, the vacuity index (CV) was calculated as follows by Euzen (1987):

$$CV = \frac{\text{Empty Stomachs(ES)}}{\text{Total Stomachs(TS)}} \times 100$$

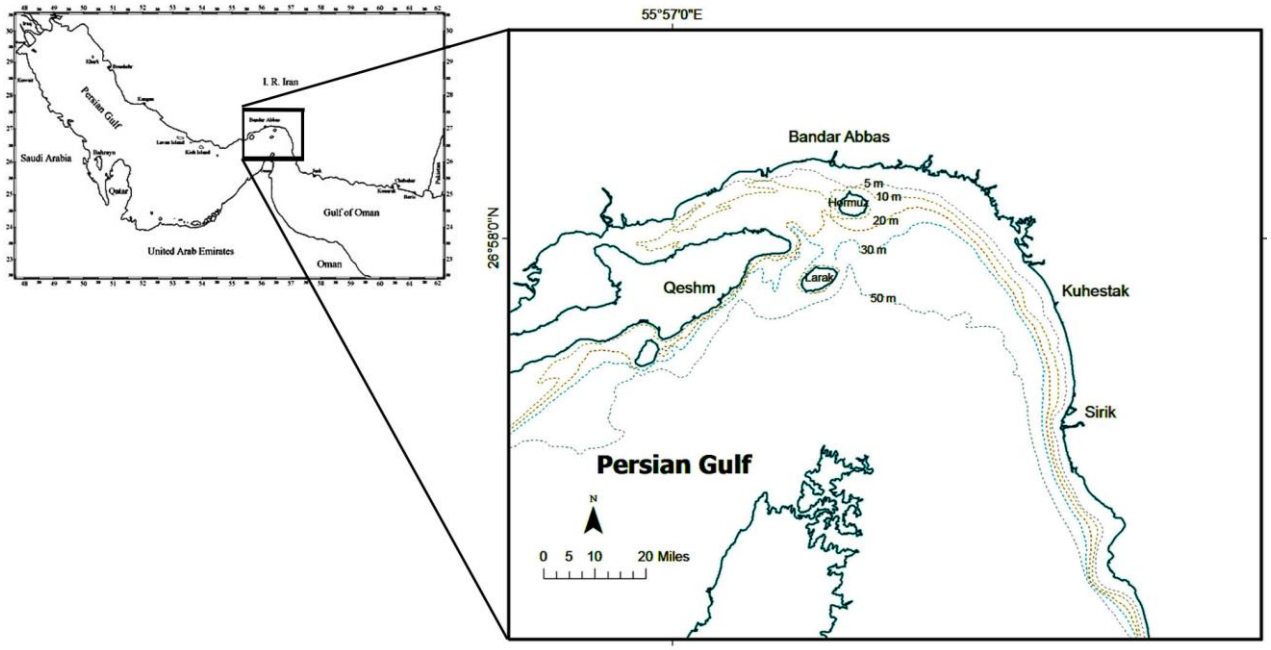

Figure 1. Sampling area for *P. stridens* in the Persian Gulf, Iran.

(If the value of this index is: 0 - 20: gluttonous; 20-40: relatively gluttonous; 40 - 60: moderate, 60 - 80: relatively underfeeding; 80-100: under-feeding).

The percentage frequency of occurrence was estimated as:

$$\frac{\text{No.of stomachs with particular food group}}{\text{Total No.of stomachs with food}} \times 100$$

To estimate the volume of the food by food-group, points were assigned to each group as suggested by Stehlik (1993). Percentage points were estimated as:

$$\frac{\text{Point of particular food group}}{\text{Total points of all food groups}} \times 100$$

The dominance of food groups was evaluated by ranking them by their percentage frequency of occurrence. To calculate food preference (FP), the food categories were given a value ranging from 0–100 according to the percentage of the stomach contents of a given individual represented by that category. The number of points that each category received was weighted according to the actual fullness of the stomach in which it was found. For example, in a stomach that was half full and contained 25% molluscs and 75% crustaceans, the molluscs received a score of 12.5 points, and the crustaceans a score of 37.5 points. The CV and FP indices were evaluated across different sexes, months, and also length classes (5 mm class intervals of fork length).

The normality of data was evaluated with the Kolmogorov–Smirnov test in the spss software ver.24 and the data did not exhibit a normal distribution. The Kruskal-Wallis test was used to compare prey among different length classes and sexes. One-way ANOVA (following data transformation), and the Kruskal Wallis tests were used to analyze the variations in CV and FP indexes, across different sexes, months, and length classes.

Results

During the study period, the stomach contents of 591 *P. stridens* including 390 females, 77 males, and 124 fish with undetermined sex (very young fish with gonads that were not well developed, narrow, and transparent) were examined, and data related to length, weight and sex of examined fish are given in Table 1.

The findings revealed that this species consumes a diverse range of foods, including bony fish; crustaceans (including true crabs (family Matutidae), hermit crabs (Paguridae), lobsters, shrimps (specifically penaeid shrimps from the genera *Metapenaeus* and *Megokris*), Mysidae (opossum shrimp), amphipods, stomatopods as well as fragments of carapace, walking legs, and telson); molluscs (including gastropods (Babylonidae), bivalves (Veneridae and Arcidae), cuttlefish (sepia) and squid); echinoderms (brittle stars); plants (fragments of seaweed); annelid worms (Polychaete) and other materials (including mixed food from inseparable food groups, unidentified materials, and sand) (Figure 2, Table 2).

Although the food group percentages differed somewhat among female, male, and unknown sex *P. stridens*, the differences were not statistically significant (Kruskal Wallis test, P=0.19). Fish (60%), unidentified materials (23%), crustaceans (8%), mixture (4%), plants (3%), and worms (2%) were the most common foods in the diets of fishes with unknown sex (Figure 3a). In males, the highest abundance of food items was related to crustaceans (33%), molluscs (30%), mixed materials (19%), unidentified materials (15%), fish (2%) and worms (1%) (Figure 3b), while molluscs (32%), mixed materials (25%), unidentified materials (20%), crustaceans (16%), worms (4%) and fish (3%), respectively, had the highest abundance in females (Figure 3c).

The amount of CV index revealed that *P. stridens* is a gluttonous animal (CV=19.5%). A more extensive assessment of this index for different sexes revealed that males and females were relatively gluttonous (CV=23.8% and CV=22.1%, respectively), while unknown sex fish were gluttonous (CV=8.9%). The monthly changes in the CV index (Figure 4a) for male, female, and unknown sexes showed a significant difference trend in the study period (F=3.90; df=11; P=0.008). The evaluation of this index in different length classes (Figure 4b) shows similar trends in all three groups and does not have significant differences across length classes (F=1.045; df=32; P=0.455).

During the study period, the FP index revealed that molluscs (26.9%), unidentified materials (23.8%), mixed (19.4%), crustaceans (18.3%), fish (8 %), worms (3.4%), and food groups consisting of echinoderms and plant materials (with a value of 0.1%) were the food preferences of female *P. stridens* (Figure 5a). Crustaceans (36.9%), molluscs (28.3%), mixed materials

Table 1. Descriptive statistics of length and weight data of *P. stridens*

Sex	Number of fish based on the type of fishing gear used (No.)				Fork length (mm)		Weight (g)	
	Stake net	hook	bottom trawl	Total	Range	Mean±Sd	Range	Mean± Sd
Female	10	158	222	390	82-198	154.1±20.9	12.26-139.27	66.96±25.19
Male	2	37	38	77	98-181	151.3±17.2	12.96-104.97	63.44±18.72
Unknown	95	28	1	124	43-113	72.1±13.9	1.35-26.33	7.49±4.60
Total	107	223	261	591	43-198	136.5±38.4	1.35-139.27	54.03±32.33

(21%), unidentified materials (11.5%), fish (1.5%), worms (0.08%), and minor amounts of echinoderms and plant materials were found in male stomachs (Figure 5b). In fish with unknown gender, recorded food preferences included a considerable percentage of fish (58.9%), followed by unidentified materials (24.7%), crustaceans (8%), plant materials (2.8%), mixed materials (2.7%), worms (2.6%) and molluscs (0.2%) (Figure 5c). A more detailed examination of the FP index revealed that the food preference changed concerning the size of the *P. stridens*, so that in younger fish (mostly unknown gender fish), the fish prey was the most dominant, followed by unidentified materials, crustaceans, and plant material as their food preference, and in larger length classes (often including sex-determined fish), their food preference was mostly molluscs, crustaceans and mixed food groups, which amount the FP index has also increased in them (Figure 5a-c). The results of the Kruskal Wallis test also showed that the amount of FP for the food groups of fish, molluscs, mixed and unidentified substances in different length classes and for different sexes was significantly different ($P<0.05$). Furthermore, the amount of FP in different months of *P. stridens* changed significantly during the study period ($P<0.05$). The preferred food items by females in this study, included molluscs, crustaceans, unidentified materials, and mixed food groups (Figure 6a). Males had the same feeding preference as females, with a little difference in the frequency of crustaceans and molluscs (Figure 6b). The recorded results of unknown sex fish were observed only for a specific period (from March 2021 to July 2021) in the area, and the feeding habits showed the fish and unidentified material were the preferred food by these groups (Figure 6c).

Figure 2. Some of the food groups identified in the diet of *P. stridens*, including crustaceans (a-j), molluscs (k-n), echinoderms (o), annelids (p), fish (q), unidentified digestive materials (r), mix (s) and plant materials (t); Scales: a, b, d-j, n, o, q, r = 10 mm; c, k, l, m, p, s, t=2 mm.

Table 2. The frequency of food groups in the stomach contents of *P. stridens* in the study period (2020-21)

Food groups	Food Item				Months												Total weight (g)
	Food items	Family	Genus	Species	Oct-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	
					Weight (g)												
Fishes	Fish				2.42	0.97	0	0.01	0.33	9.92	0	0	1.48	0	0.01	2.41	17.54
Crustacean	Crab	Matutidae	*Matuta*	*M.victor*	0	0	0	0	0.01	0	0	0	0.67	0.42	0	0	1.1
					0.06	0.08	0	0	0.68	0	0.71	0	0.94	0	0.18	0.32	2.97
	Lobster				0	0	0	0.43	0	0	0	0	0	0.40	0.13	0	0.95
	Hermit crab	Paguridae			0	0	0	0	0	0	0	0	0.15	0	0	0	0.15
	Shrimp		*Megokris*		0	0	0	0	0	0	0.08	0	0	0	0	0	0.08
		Penaeidae	*Metapenaeus*		0.11	0	0	0	0	0	0	0	11.11	0	0.09	0	11.31
					0.29	0.42	0	0.01	8.19	0	0	0	2.60	0	0	0.10	11.60
	Opossum shrimp	Mysidae			1.90	0	0	0	0	0	0	0	0	0	0	0	1.90
	Amphipoda				0	0	0	0.01	0.01	0	0	0	0	0	0	0	0.01
	Stomatopoda				0	0.60	0	0	0	0	0	0	0	0	0	0	0.60
	Parts of Malacostraca body				0.03	0.94	0	0	0.30	0	0	0	0	0.66	0.19	0.03	2.14
Mollusca	Gastropoda	Babyloniidae			0	0	0	0	0.01	0	0	0	0	0	0	0	0.01
	Bivalve	Veneridae			0	0.04	0.01	0.06	0.07	0	0	0	0	0	0	0	0.18
		Arcidae			0	0	0	0.01	0.02	0	0	0	0	0	0	0	0.03
					0	1.69	3.32	0.91	0.44	0.04	0.01	0	0.03	0.02	0.02	0.10	6.58
	Cuttlefish				0	4.39	16.61	3.19	4.83	0	0	0	0	0	0	1.86	30.88
	Squid				0	0	0	0	0	0	0	0	0	0	0	15.79	15.78
Echinodermata	Brittle star	Ophionereididae			0	0	0.08	0.06	0.04	0	0	0	0	0	0	0	0.18
					0	0	0.01	0	0	0	0	0	0.11	0	0	0	0.12
Plants	Plant material				0	0	0	0	0.42	0	0	0	0.01	0	0	0	0.43
Worms	Polychaete				0	3.89	1.92	0.23	0.20	0.26	0.23	0	0.53	0	0	0	7.25
Other	Stone				0	0.01	0	0	0	0	0	0	0.01	0	0	0	0.01
	Mix				0	5.94	18.43	2.15	10.14	1.03	0.61	0	2.27	0	0.13	0.77	41.48
	Digested				9.54	5.08	12.75	1.19	4.62	1.95	2.92	0.08	3.95	0.75	1.13	1.79	45.74
Total number of stomachs examined					80	57	31	27	67	71	33	2	60	16	58	89	591

Discussion

P. stridens is a gluttonous species, according to the CV index data during the research period. Also, the stomach contents of *P. stridens* revealed that this species feeds on a diverse range of food items such as bony fish, crustaceans, molluscs, echinoderms, plants, annelids, mixed and unidentified substances, which in the unknown sex groups the highest percentage of food composition were fish items (60%) and unidentified substances (23%), while in females included molluscs (32%), mixed substances (25%), unidentified substances (20%) and crustaceans (16%), and in males, included crustaceans (33%), molluscs (30%), mixed materials (19%) and unidentified materials (15%). According to Vahabnezhad et al. (2015), this species is a relatively underfeeding species, so crustaceans (39.60%), molluscs (34.33%), and miscellaneous materials (16.58%) have the highest percentage, while foraminifera, nematodes, annelids, and echinoderms have a lower percentage in the coastal waters of the Persian Gulf (Bushehr province). Safi et al. (2013) reported a diet similar to the current study on the same species in the coastal waters of Karachi, Pakistan. Tüzün & Gücü (2023) investigated the stomach content of *P. stridens* in Mersin, Turkey. According to the findings, this species mainly feeds on crustaceans (primarily copepods), followed by annelids (polychaetes and oligochaetes). Kamali et al. (2011) reported the diet of javelin grunter, *Pomadasys kaakan* (Cuvier, 1830) is relatively low in the coastal waters of Hormozgan province. Also, Valinassab et al. (2011) stated that the main stomach contents of *P. kakkan* were recorded crustaceans (true crab and shrimp), fish, molluscs (bivalves, gastropods, and cuttlefish), stomatopods, brittle stars, *Lingula* sp., and seaweeds in the Persian Gulf and Oman Sea (Iranian waters). In research conducted by Rodríguez-Preciado et al. (2014) on the feeding habits of *Pomadasys panamensis* (Steindachner, 1876) in the Gulf of California, crustaceans made up the majority (more than 95%) of the food diet. They also highlighted that the CV index changed seasonally. The CV index's fluctuation during the research period can be linked to its reproductive cycle. When the gonads grow well and occupy the major part of the abdominal cavity, the intensity of feeding and the amount of food entering the stomach may be decreased during this period. Additionally, the feeding intensity increased during gonad maturation to offset the energy demands of reproduction (Ghanbarzadeh et al., 2020).

The results of the FP index in different length classes revealed that in younger *P. stridens*, fish prey was the most dominant food preference, followed by unidentified materials and, to a lesser extent, crustaceans, and plant materials, whereas in larger length classes, the food preference was mostly crustaceans, molluscs, and mixed food groups, with significant changes in the value of this index in different months and sexes. According to Vahabnezhad et al. (2015), *P.stridens* prefer crustaceans, molluscs, and miscellaneous materials (more than 50%), nematodes, foraminifera (more than 10%), echinoderms, and annelids worms (less than 10%) in the coastal waters of southern Iran (Bushehr province). They also stated that, while all food groups were present at different seasons of the year, there was a considerable variance in terms

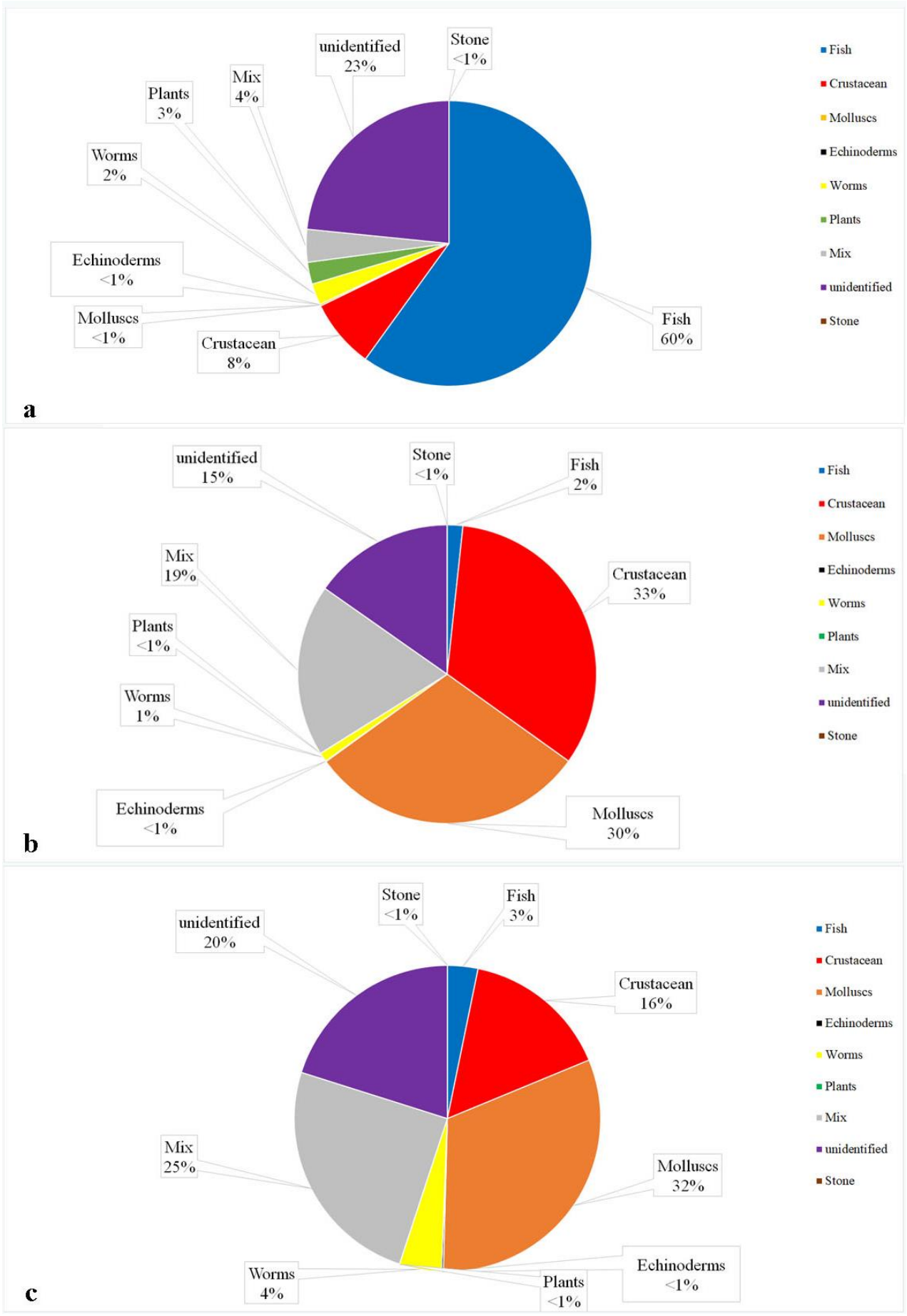

Figure 3. The percentage composition of food items in the stomach contents of unknown sexes (a), males (b), and females (c) of *P. stridens* in the study period.

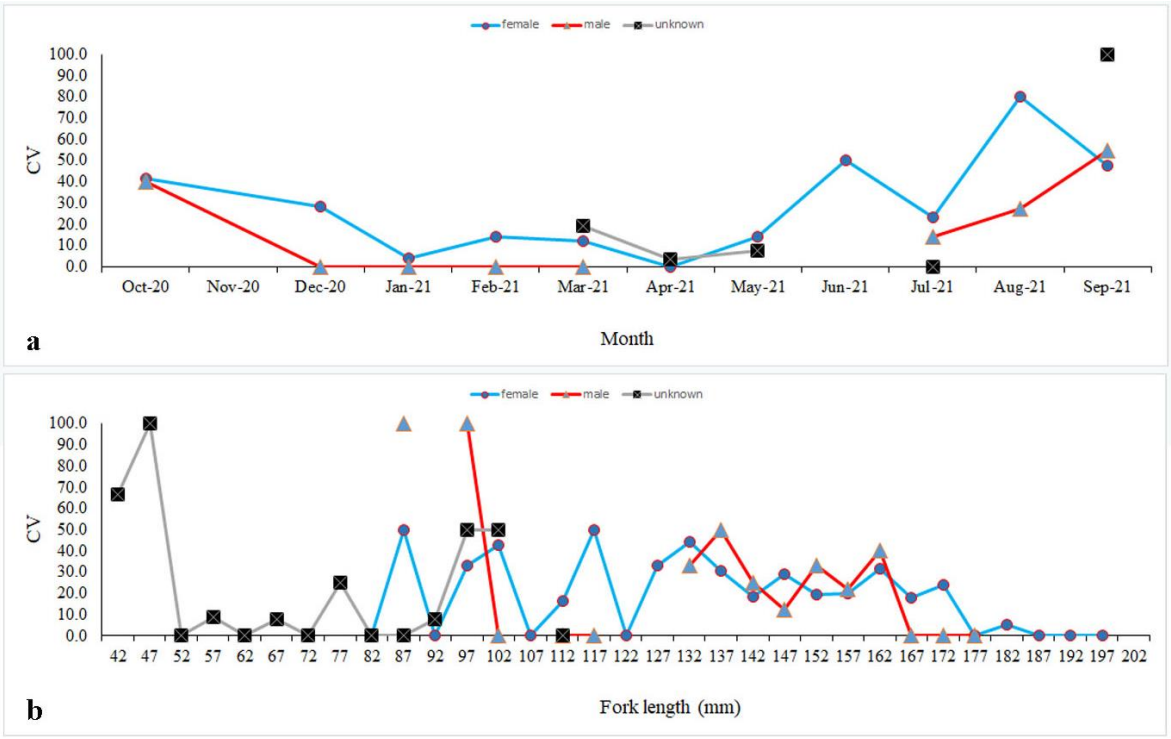

Figure 4. The changes of CV index in different sexes of *P. stidens* in different months (a) and size classes (b) in the coastal waters of the Persian Gulf, Iran.

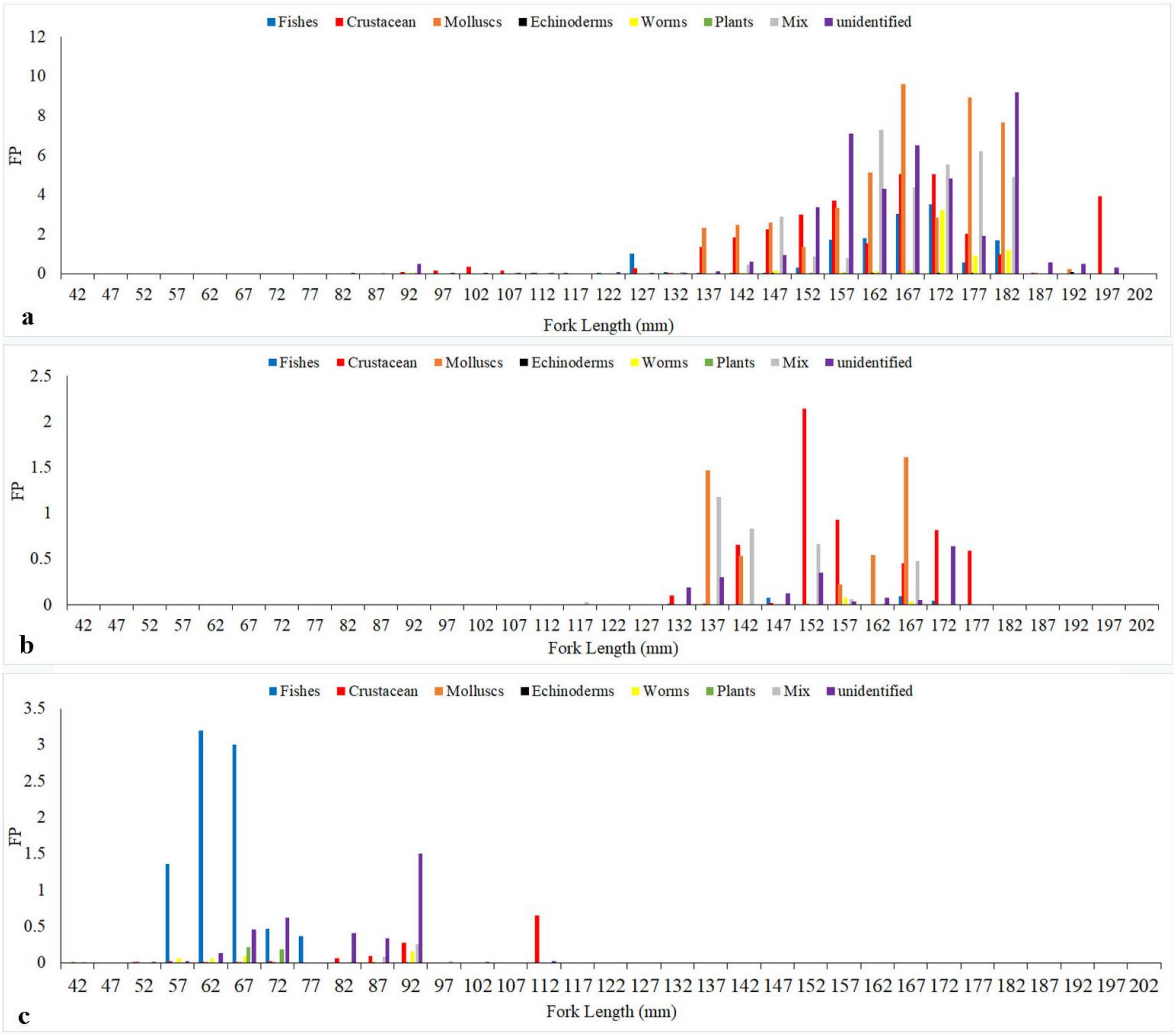

Figure 5. The food preference in different length classes of female (a), male (b), and unknown (c) *P. stridens* in the coastal waters of the Persian Gulf, Iran.

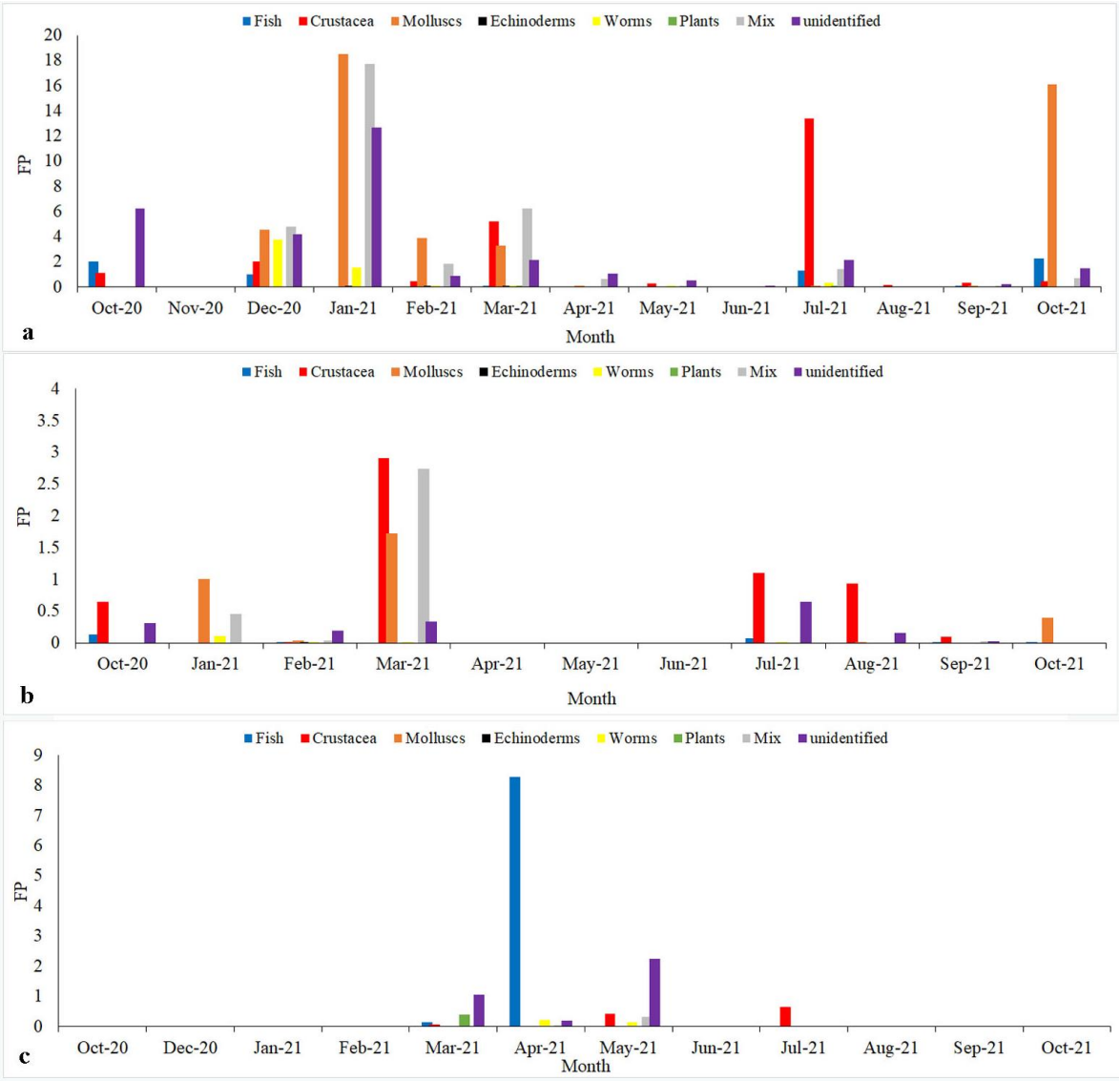

Figure 6. The monthly differences in food preference of female (a), male (b), and unknown (c) *P. stridens* in the coastal waters of the Persian Gulf, Iran.

of the quantity and frequency of their food items. In a study by Safi et al. (2013), the diet food groups included semi-digested materials (46.51%), crustaceans (14.53%), mixed (14.32%), molluscs (11.57%), fish (11.1%) and polychaetes (1.99%) for *P. stridens* in the coastal waters of Karachi, Pakistan. They also stated that the number of food groups in young fish differs from adults, and the preferred food of young fish was crustaceans, however, in the current study, fish was the preferred meal for juvenile *P. stridens*. The food preference of *P. kakkan* was reported to include crab (39.8%), shrimp (7.07%), other crustaceans (27.4%), fish (4.58%), sea cucumber (4.18%), squid (1.77%), and octopus (0.88%), respectively (Kamali et al., 2011). Furthermore, Valinassab et al. (2011) observed in the Persian Gulf and Oman Sea, this species preferred crustaceans 77.7%, fish 32.1%, molluscs 28.6%, and echinoderms 18.8%. They noted that this fish is a relatively frugal species that feeds primarily on crustaceans and has adapted itself to the ecological changes of the Persian Gulf. According to Rodríguez-Preciado et al. (2014), *P. panamensis* in the Gulf of California showed a preference for shrimp, mysids, and lobster. The study revealed that the feeding preferences of this species did not change significantly by month, sex, or size. The main food of *Pomadasys corvinaeformis* in the Gulf of Caragua, southern Brazil, was reported to be crustaceans and molluscs (Denadai et al., 2013). According to the previous research and the current study, *P. stridens* is a carnivorous species with a preference for crustaceans, molluscs, and fish. Its food preferences may vary at different stages of growth and may also be influenced by food availability, geographical differences in habitat, fish size, and their reproductive cycle. The diets of species in the genus *Pomadasys* are also nearly identical (Kamali et al., 2011; Valinassab et al., 2011; Safi et al., 2013; Denadai et al., 2013; Rodríguez-Preciado et al., 2014; Vahabnezhad et al., 2015; Tüzün & Gücü, 2023).

Conclusion

The striped piggy fish, *P. stridens* is a carnivorous fish that prey on molluscs, crustaceans, fish, worms, and a very small number of echinoderms and plants. The young *P. stridens* prefer fish, but adults prefer crustaceans and molluscs. The crustaceans made up a significant portion of *P. stridens'* diet. Notably, Penaeid shrimps were the most prevalent in this fish's stomach contents. The relationship between prey and predator is one of the factors that influences the amount of each stock, which can significantly affect their exploitation potential in the region.

Ethical Statement

The authors declare that the species used in this research is not an endangered species and all instructions about using animals in research, have been respected.

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Author Contribution

Esmaeil Farjadzadeh: was involved in collecting data, carrying out statistical analysis, and helping draft the manuscript.

Mohsen Safaie: was involved in conceptualizing and supervising the study and critically revising the manuscript.

Leila Abdoli: was involved and participated in the design of the study and helped draft the manuscript.

Conflict of Interest

The authors declare that they have no conflict of interest.

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