



Feeding Ecology of the Large-Scale Triggerfish, *Canthidermis macrolepis* (Boulenger, 1888), from Yemeni Coastal Waters

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ABSTRACT

Information on fish feeding ecology is crucial for understanding trophic interactions, energy flow, and ecosystem dynamics in marine environments. Although the feeding ecology of several balistid species has been well documented, the trophic dynamics of the large-scale triggerfish, *Canthidermis macrolepis*, remain largely unstudied. To address this gap and define its ecological role, we investigated the diet and feeding intensity of *C. macrolepis* harvested from the Yemeni Red Sea coast between June and October 2025. Stomach content analysis ($N = 57$) was performed utilizing qualitative taxonomic identification and quantitative metrics, specifically frequency of occurrence (%F) and volumetric percentage composition (%C). The results characterize *C. macrolepis* as an active pelagic carnivore. The diet was predominantly composed of small teleosts, with zooplanktonic crustaceans serving as a critical secondary resource. Benthic invertebrates (sipunculids and worms), small mollusks, and macroalgae were present only as minor, opportunistic dietary components. Furthermore, feeding intensity was exceptionally high (Fullness Index: 98.25%; Vacuity Index: 1.75%), indicating continuous foraging activity. These findings establish *C. macrolepis* as a pelagic predator, differentiating its ecological niche from that of heavily benthic-dependent reef triggerfishes, and provide essential baseline trophic data to support regional ecosystem-based fisheries management.

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1. INTRODUCTION

Information on fish feeding ecology is crucial for understanding trophic interactions, energy flow, and ecosystem dynamics in marine environments. Comprehensive knowledge of fish diets is essential for successful fisheries management [1, 2], aquaculture species selection [3], and the utilization of specific species for ornamental purposes or biological larval control [4]. Feeding ecology generally encompasses feeding biology, which correlates morphological and physiological traits with food preferences and food selectivity, which explains the mechanisms driving prey choice [5].

Diet analysis is particularly fundamental to this field, providing a direct snapshot of recent feeding activity [6]. It elucidates nutritional requirements, highlights poten-

tial competition, and defines predator-prey interactions [7] and references therein. Ultimately, fish diets integrate various ecological components, including behavior, habitat use, and energy intake [8], while also shaping broader macroevolutionary processes [9]. Furthermore, quantifying diet composition, consumption rates, and prey mortality is necessary to accurately model marine ecosystem dynamics [1]. Because feeding habits directly affect the growth, reproduction, and demographics of both predators and prey [10], understanding these trophic parameters [8, 11] is vital for developing effective conservation strategies, particularly as anthropogenic stressors such as climate change and overfishing deplete global fish stocks [5].

The large-scale triggerfish, *Canthidermis macrolepis*,



belongs to the family Balistidae, whose members are typically associated with tropical and subtropical marine habitats [12] and references therein. It is widely distributed across the Indo-West Pacific, including the Red Sea, the Gulf of Aden, and the Arabian Sea [13–16]. Balistids exhibit diverse feeding strategies, ranging from benthic predation to planktonic foraging. However, unlike many reef-associated triggerfishes, species within the genus *Canthidermis* are primarily epipelagic rather than strictly reef-dwelling, frequently associating with floating objects [17] and exploiting unique offshore feeding niches.

It is worth noting that the feeding ecology, stomach contents, and feeding habits of fishes in Yemeni waters have been poorly investigated. In this context, only a limited number of studies were found; the available studies are [18–21]. Although the feeding ecology of several balistid species is well documented, *C. macrolepis* remains largely unstudied. Historically absent from Yemeni species catalogs, this species has recently transitioned from incidental bycatch to a regular component of coastal commercial catches, signaling its growing economic importance [22]. Consequently, investigating the life history and ecological role of this emerging resource is highly necessary. This study aimed to investigate the diet and feeding ecology of *C. macrolepis* to fill existing knowledge gaps and advance our understanding of its role in the trophic dynamics of Yemeni coastal waters, thereby supporting ecosystem-based fisheries management.

2. MATERIALS AND METHODS

2.1. SAMPLE COLLECTION

A total of 57 *C. macrolepis* specimens were collected from fish markets in Sana'a, Yemen, between June and October 2025. During this period, the species was observed exclusively in Sana'a markets [22]. According to vendors, the specimens were captured in the Red Sea coastal waters near Al-Hodeidah. Following the acquisition, the fish were immediately transported to the laboratory on ice to halt further digestion.

2.2. LABORATORY PROCESSING

Morphometric data, including total length (TL) and standard length (SL), were measured to the nearest millimeter, and total body weight (W) was recorded to the nearest gram for each specimen. Specimens were then dissected to remove the entire alimentary canal. The gastrointestinal tracts were weighed to the nearest gram and preserved in 5% formalin for subsequent analysis of feeding intensity and dietary composition.

2.3. FEEDING INTENSITY

The degree of stomach fullness was assessed visually using a standardized seven-point categorical scale: empty, trace, $\frac{1}{4}$ full, $\frac{1}{2}$ full, $\frac{3}{4}$ full, full, and gorged [23] and references therein. Stomachs classified as gorged, full, or $\frac{3}{4}$ full were considered indicative of active feeding, whereas those categorized as $\frac{1}{4}$ full or trace indicated poor feeding activity [24]. To quantify overall feeding activity, the vacuity index (VI; the percentage of empty stomachs) and the fullness index (FI; the percentage of stomachs containing food relative to the total examined) were calculated.

2.4. STOMACH CONTENT ANALYSIS

Stomachs were dissected in Petri dishes, and their contents were examined using a dissecting microscope. Dietary composition was assessed both qualitatively and quantitatively.

Qualitative analysis: Prey items were identified to the lowest possible taxonomic level. Due to the advanced stages of digestion often encountered, identification frequently relied on digestion-resistant hard structures, such as teleost bones, otoliths, crustacean appendages, and exoskeleton fragments [25, 26]. Additionally, intestinal contents were examined to supplement the stomach data. Because some intestines contained substantial quantities of intact brown algae and coral fragments, integrating these observations reduced bias against rapidly digested prey items that might otherwise be underrepresented in the stomach [27].

Quantitative analysis: The frequency of occurrence (%F) for each dietary item was calculated to evaluate feeding prevalence using the following equation:

$$\%F = \frac{n_i}{N} \times 100 \quad (1)$$

(where n_i is the number of stomachs containing prey item i , and N is the total number of non-empty stomachs examined).

To quantify the relative volume or bulk of various food items, the volumetric points method (%C) was employed as described by [28] and applied by [29]. The percentage composition by points was calculated as follows:

$$\%C = \frac{P_i}{P_{total}} \times 100 \quad (2)$$

(where P_i is the total points allocated to prey item i , and P_{total} is the total points allocated to all prey items across all stomachs).

2.5. IMPORTANCE OF PREY CATEGORIES

The relative importance of each prey category in the diet of *C. macrolepis* was evaluated graphically by plotting the frequency of occurrence (%F) against the percentage composition by points (%C), following standard graphical

Table 1. Degree of Stomach Fullness in *Canthidermis macrolepis*

Feeding status	Active feeding			Moderate feeding	Poor feeding		Non-feeders
Fullness	Gorged	Full	$\frac{3}{4}$ Full	$\frac{1}{2}$ Full	$\frac{1}{4}$ Full	Trace	Empty
No. of fish	2	5	7	5	18	19	1
%Feeding activity	3.51	8.77	12.28	8.77	31.58	33.33	1.75
Total %Feeding activity	24.56			8.77	64.91		1.75
Fullness index = 98.25%		Vacuity index = 1.75%					

**Figure 1.** Alimentary canal of *Canthidermis macrolepis* collected from Sana'a market, Yemen

representations of feeding strategy.

3. RESULTS

3.1. ALIMENTARY CANAL MORPHOLOGY

Gross anatomical examination revealed that *C. macrolepis* possesses a saccular stomach and intestine of moderate length (Figure 1).

3.2. FEEDING INTENSITY

Visual assessment of stomach fullness indicated high overall feeding activity, with a fullness index (FI) of 98.25% and a vacuity index (VI) of only 1.75% (Table 1), representing a single empty stomach in the sample. Among the stomachs containing food, feeding intensity varied: 64.91% were classified as poorly active (trace to $\frac{1}{4}$ full), 8.77% as moderate feeders ($\frac{1}{2}$ full), and 24.56% as active feeders ($\frac{3}{4}$ full to gorged). Of the stomachs containing food, 64.91% belonged to females and 33.33% to males, reflecting the underlying sex ratio of the sampled population.

3.3. DIET COMPOSITION

Dietary items recovered from *C. macrolepis* stomachs were classified into six primary categories: (1) small teleosts/juveniles and associated remains (bones, spines, skin, scales, and vertebrae); (2) crustaceans, pri-

marily zooplanktonic forms, including copepods, mysids, decapod larvae (Brachyura zoea), *Lucifer* spp., and unidentified crustacean fragments; (3) small mollusks, specifically bivalves and gastropods; (4) benthic invertebrates (sipunculids and annelid worms); (5) macroalgae; and (6) unidentified items (highly degraded larvae, soft-bodied prey, and unidentifiable digested matter).

Comparing stomach and intestinal contents revealed differential digestion rates across prey taxa (Figure 2). For instance, fish remains occurred less frequently in the intestines (23.34%) than in the stomachs.

Conversely, the intestines exhibited higher frequencies of crustacean remains (48.21%), unidentified matter (17.68%), and mollusks (10.71%). Highly digested matter was prevalent, occurring in 96.36% of the intestines examined. Notably, the intestines of three specimens (5.36%) were entirely gorged with brown algae (*Sargassum* spp.), and coral fragments were also observed in 5.36% of the total intestines examined.

3.4. QUANTITATIVE DIETARY ANALYSIS

Frequency of occurrence (%F) data (Table 2) indicated that fish and teleost remains were the most prevalent prey, present in 51.79% of all stomachs. Crustaceans ranked second in occurrence (32.14%), followed by unidentified items (19.64%). Other dietary components appeared infrequently: worms and benthic invertebrates occurred in 5.36% of stomachs, while mollusks and algae each occurred in only 1.79%. Highly digested matter was present in 92.86% of the stomachs.

The volumetric percentage composition (%C) demonstrated that highly digested matter constituted the bulk of stomach contents (48.21%). Among identifiable prey, fish were the predominant dietary component by volume (36.12%), followed by crustaceans (7.54%) and unidentified items (3.51%). Benthic invertebrates and mollusks constituted 1.64% and 1.49% of the diet, respectively, whereas worms (0.45%) and algae (0.15%) represented negligible volumetric contributions.

The relative importance of specific prey items was evaluated by plotting %F against %C (Figure 3). The graphical representation clearly isolates fish and teleost remains as the dominant prey category, exhibiting the highest values for both occurrence and volumetric contribution.

Crustaceans occupy the position of secondary prey,

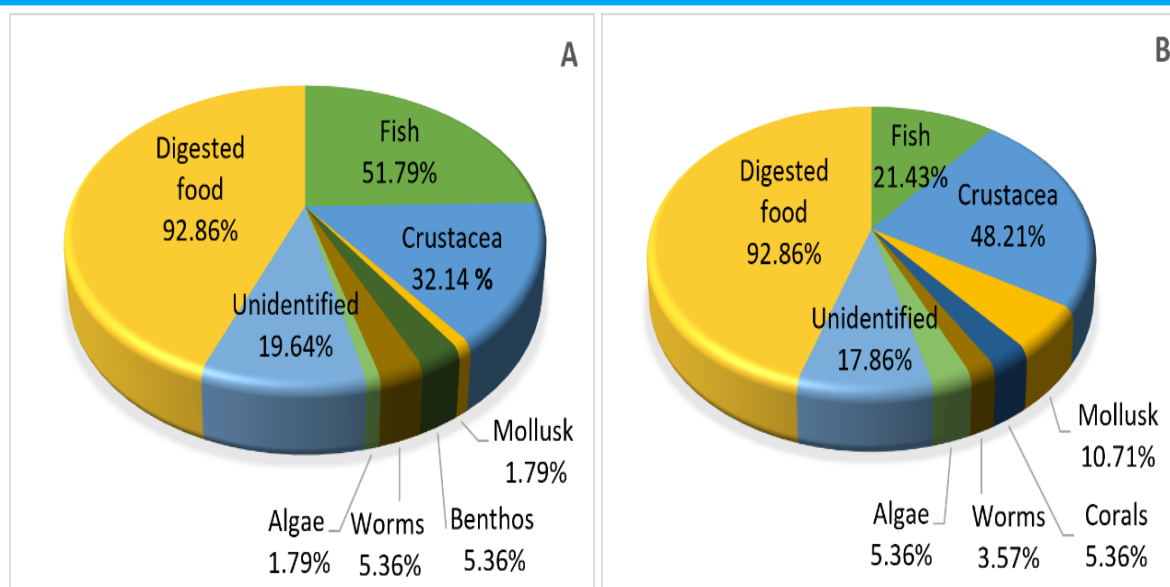


Figure 2. Comparison of the % frequency of Occurrence of different food items: (A) stomach, (B) intestine

Table 2. Food composition and frequency of occurrence of *Canthidermis macrolepis*

	Fish	Crustacea	Mollusk	Benthos	Worms	Algae	Unidentified	Digested food
% F	51.79	32.14	1.79	5.36	5.36	1.79	19.64	92.86
% C	36.12	7.54	1.49	1.64	0.45	0.15	3.51	48.21

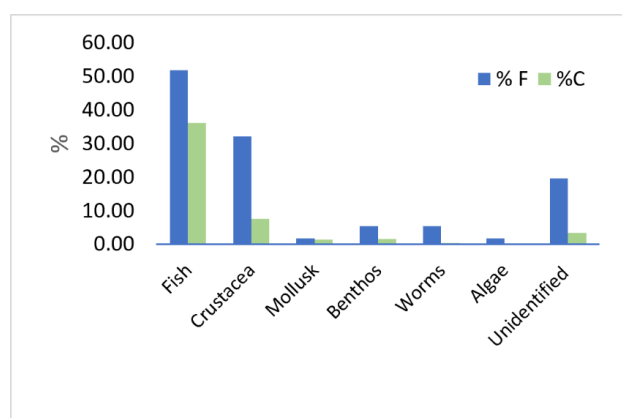


Figure 3. Comparison between %F and %C of various food categories

characterized by a high occurrence but relatively lower volumetric contribution. Conversely, mollusks, benthic invertebrates, worms, and algae exhibited very low values for both %F and %C, categorizing them as minor or incidental prey.

4. DISCUSSION

The morphological characteristics of the *C. macrolepis* alimentary tract present functional ambiguity: the saccular stomach suggests a carnivorous trophic niche, whereas the moderate intestinal length implies an omnivorous tendency. Dietary analysis effectively resolves this anatomical ambiguity, confirming that the species is predominantly carnivorous.

Despite advanced digestion in the majority of stomachs (92.89%), identifiable remains, including whole juvenile teleosts, flesh, spines, vertebrae, and crustacean appendages, provided a clear trophic profile. Synthesizing the frequency of occurrence (%F) and volumetric composition (%C) confirms that *C. macrolepis* primarily preys on small teleosts (dominant prey), supplemented by pelagic crustaceans (secondary prey). Minor items, such as small mollusks and benthic invertebrates, contribute negligibly to the overall dietary volume and can be classified as incidental or opportunistic intake.

The trace presence of macroalgae in the diet likely represents incidental ingestion during foraging, rather than targeted herbivory. Furthermore, the microscopic worms observed in a limited number of specimens are likely parasitic nematodes, common in marine teleosts, and represent a parasitic load rather than true dietary components. The high prevalence of highly digested matter (48.21% by volume) across nearly all stomachs is largely attributable to the rapid digestion rates typical of pelagic fishes, exacerbated by the inevitable delay between capture and preservation.

Feeding intensity data further elucidate the foraging behavior of the species. The exceptionally high fullness index (98.25%) and corresponding low vacuity index (1.75%) indicate that active feeding is nearly continuous in the sampled population. However, the predominance of stomachs containing only trace or small quantities of food (64.91%) suggests rapid food turnover. This may also be influenced by post-capture digestion or environ-



mental factors, such as temperature and salinity fluctuations, which are known to dictate metabolic and gastric evacuation rates [6]. Ultimately, the distinct reliance on small teleosts and zooplanktonic crustaceans strongly indicates that *C. macrolepis* operates as a pelagic predator, exploiting the available resources in the offshore water column [30].

Trophic plasticity is a recognized hallmark of the family Balistidae, which is heavily influenced by habitat and resource availability [31]. A comparative review of balistid feeding ecologies reveals a clear divergence between reef-associated and pelagic genera. Reef-dwelling triggerfishes, such as *Balistes vetula*, *B. capriscus*, and *Canthidermis sufflamen*, primarily exploit benthic habitats, utilizing their robust dentition to prey heavily on hard-shelled invertebrates, such as brachyuran crabs, bivalves, barnacles, and sea urchins (*Diadema* spp.) [7, 32–34]. Conversely, other balistids exhibit highly adaptable omnivory; for instance, *Melichthys niger* relies heavily on macroalgae and detritus [35], while *Odonus niger* and *Balistes polylepis* function as generalist omnivores [36, 37].

Within its own genus, *C. macrolepis* demonstrates a dietary profile highly comparable to that of the rough triggerfish, *C. maculata*, which is also recognized as a pelagic carnivore heavily dependent on amphipods, copepods, and teleosts [38]. The findings of the present study confirm that *C. macrolepis* deviates from the benthic invertebrate-dominated diets of reef triggerfishes and instead exploits a distinct pelagic food web.

5. CONCLUSION

This investigation establishes that the large-scale triggerfish, *Canthidermis macrolepis*, functions primarily as a pelagic carnivore in Yemeni coastal waters. Its diet is dominated by small teleosts, with zooplanktonic crustaceans serving as a critical secondary food source. Although the species opportunistically ingests minor quantities of mollusks, benthic invertebrates, and algae, these do not represent primary energetic pathways. Because the spatiotemporal scope of this sampling period was limited, further seasonal and multi-site investigations are warranted to capture the full ontogenetic and temporal feeding dynamics of *C. macrolepis*, ultimately supporting the ecosystem-based management of this emerging fisheries resource.

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DECLARATIONS

ETHICAL APPROVAL

Not applicable.

CONFLICT OF INTEREST

The authors declare no competing interests.

COMPETING INTERESTS

The authors have no financial or proprietary interests in any material discussed in this article.

AUTHORS' CONTRIBUTIONS

The first author contributed to the study conception and design, data analysis, and writing the first draft. All authors performed the simulations, data collection, and commented on the present version of the manuscript. All authors read and approved the final manuscript.

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The authors confirm that informed consent was obtained for the publication of the data contained in the article.

CONSENT TO PARTICIPATE

Informed consent was obtained from all authors.

DECLARATION OF AI-ASSISTED TECHNOLOGIES

The authors declare that artificial intelligence (AI) tools were used only for limited purposes, such as language editing, grammar improvement, and formatting assistance. All scientific content, data analysis, interpretations, conclusions, and final manuscript revisions were reviewed and verified by the authors, who take full responsibility for the integrity and originality of the work.

REFERENCES

- [1] S. F. Mehanna, F. I. El-Gammal, U. M. Mahmoud, and S. M. El-Mahdy, "Food and feeding habits of two-bar seabream, *acanthopagrus bifasciatus* (forsskal, 1775) from southern Red Sea, egypt," *Egypt. J. Aquat. Biol. Fish.*, vol. 21, no. 2, pp. 67–78, 2017. DOI: [10.21608/EJABF.2017.3534](https://doi.org/10.21608/EJABF.2017.3534)



- [2] S. Nadeem, K. N. Waheed, M. Zafarullah, M. Ashraf, S. Sherzada, and H. Nadeem, "Food and feeding habitat analysis of various fish species collected from River sutlej, Punjab in relation to physico-chemical water quality parameters," *Int. J. Biosci.*, pp. 252–264, 2020. DOI: [10.12692/ijb/16.2.252-264](https://doi.org/10.12692/ijb/16.2.252-264)
- [3] M. Manon and M. Hossain, "Food and feeding habit of *cyprius carpio* var. *specularis*," *J Sci Found.*, vol. 9, no. 1–2, pp. 163–169, 2013. DOI: [10.3329/jsf.v9i1-2.14658](https://doi.org/10.3329/jsf.v9i1-2.14658)
- [4] C. B. Ndome and R. Victor, "Food and feeding habits of *epiplatys senegalensis* (Pisces: Cyprinodontiformes; Cyprinodontidae) in a black water pond in Benin City, Southern Nigeria," *West Afr. J. Appl. Ecol.*, vol. 3, pp. 105–117, 2002. DOI: [10.4314/wajae.v3i1.45574](https://doi.org/10.4314/wajae.v3i1.45574)
- [5] Y. Bakhtiyar, S. Nissar, M. Yasir Arafat, and R. Mushtaq, "Feeding ecology of fishes – a mini review," *bpas-zoo*, vol. 42, no. 1, pp. 190–213, 2023. DOI: [10.48165/bpas.2023.42A.1.17](https://doi.org/10.48165/bpas.2023.42A.1.17)
- [6] S. K. Saikia, "Food and feeding of fishes, what do we need to know?" *Transylv. Rev. Syst. Ecol. Res.*, vol. 17, no. 1, pp. 71–84, 2015. DOI: [10.1515/trser-2015-0049](https://doi.org/10.1515/trser-2015-0049)
- [7] K. M. Dance, J. R. Rooker, J. B. Shipley, M. A. Dance, and R. J. D. Wells, "Feeding ecology of fishes associated with artificial reefs in the northwest Gulf of Mexico," *PLoS ONE*, vol. 13, e0203873, 2018. DOI: [10.1371/journal.pone.0203873](https://doi.org/10.1371/journal.pone.0203873)
- [8] S. R. Chipps and J. E. Garvey, "Assessment of food habits and feeding patterns," in *Analysis and Interpretation of Freshwater Fisheries Data*, C. S. Guy and M. L. Brown, Eds., Bethesda, Maryland: Am. Fish. Soc., 2007, pp. 473–514.
- [9] I. Ng, D. R. Bellwood, J. M. Strugnell, V. Parravicini, and A. C. Siqueira, "The rise of dietary diversity in coral reef fishes," *Proc. R. Soc. B*, vol. 291, no. 2029, p. 20241004, 2024. DOI: [10.1098/rspb.2024.1004](https://doi.org/10.1098/rspb.2024.1004)
- [10] R. D. Brodeur, B. E. Smith, R. S. McBride, R. Heintz, and E. Farley, "New perspectives on the feeding ecology and trophic dynamics of fishes," *Environ Biol Fish*, vol. 100, no. 4, pp. 293–297, 2017. DOI: [10.1007/s10641-017-0594-1](https://doi.org/10.1007/s10641-017-0594-1)
- [11] P. U. Zacharia and K. P. Abdurahiman, "Methods of stomach content analysis of fishes," in CMFRI, 2004, pp. 148–158.
- [12] A. Pradhan, B. K. Mahapatra, and D. Maji, "On the occurrence of masked triggerfish *sufflamen fraenatum*," *J. Bombay Nat. Hist. Soc.*, vol. 116, pp. 116–123, 2019. DOI: [10.17087/jbnhs/2019/v116/108659](https://doi.org/10.17087/jbnhs/2019/v116/108659)
- [13] D. Golani and S. V. Bogorodsky, "The fishes of the Red Sea—reappraisal and updated checklist," *Zootaxa*, vol. 2463, pp. 1–135, 2010. DOI: [10.11646/zootaxa.2463.1.1](https://doi.org/10.11646/zootaxa.2463.1.1)
- [14] P. Paolo, "Annotated checklist of fishes of the family Balistidae," *IJZI*, vol. 7, no. 2, pp. 647–672, 2021. DOI: [10.33745/ijzi.2021.v07i02.049](https://doi.org/10.33745/ijzi.2021.v07i02.049)
- [15] Manilo and S. Bogorodsky, "Taxonomic composition, diversity and distribution of coastal fishes of the Arabian Sea," *J. Ichthyol.*, vol. 43, no. 1, pp. 75–149, 2003.
- [16] U. Zajonz, E. Lavergne, S. V. Bogorodsky, F. N. Saeed, M. S. Aideed, and F. Krupp, "Coastal fish diversity of the Socotra Archipelago, Yemen," *Zootaxa*, vol. 4636, no. 1, pp. 1–108, 2019. DOI: [10.11646/zootaxa.4636.1.1](https://doi.org/10.11646/zootaxa.4636.1.1)
- [17] K. Matsuura, "Taxonomy and systematics of tetraodontiform fishes: A review focusing primarily on progress in the period from 1980 to 2014," *Ichthyol Res*, vol. 62, no. 1, pp. 72–113, 2015. DOI: [10.1007/s10228-014-0444-5](https://doi.org/10.1007/s10228-014-0444-5)
- [18] N. A. Salman, H. M. A. Heba, and G. J. Al-Mahdawi, "Feeding ecology of Al-Naqim (*pomadasys maculatus*) from the Red Sea coast of Hodeidah, Yemen," *J. King Abdulaziz Univ. Mar. Sci.*, vol. 14, no. 1, pp. 65–75, 2003. DOI: [10.4197/mar.14-1.5](https://doi.org/10.4197/mar.14-1.5)
- [19] M. K. Hassan Ali, A. Belluscio, D. Ventura, and G. Ardizzone, "Feeding ecology of some fish species occurring in artisanal fishery of Socotra Island (Yemen)," *Mar. Pollut. Bull.*, vol. 105, no. 2, pp. 613–628, 2016. DOI: [10.1016/j.marpolbul.2016.01.051](https://doi.org/10.1016/j.marpolbul.2016.01.051)
- [20] N. A. M. Al Kamel and M. H. Kara, "Diet composition and trophic interactions of nine fish species from Mocha water, southern Red Sea, Yemen," *Reg. Stud. Mar. Sci.*, vol. 29, p. 100693, 2019. DOI: [10.1016/j.rsma.2019.100693](https://doi.org/10.1016/j.rsma.2019.100693)
- [21] K. A. Baaom, T. S. Salem, and E. A. Al-Nawi, "Stomach contents and feeding habits of *diagramma pictum* and *pomadasys argenteus* (Family Haemulidae) from coasts of Aden Governorate–Yemen," *HUJNAS*, vol. 20, no. 1, pp. 15–23, 2023.
- [22] E. F. Shamsan, "Record of *canthidermis macrolepis* (Family: Balistidae) in the Local Markets of Sana'a City, Yemen: A Preliminary Study," *PSM Vet. Res.*, vol. 11, no. 1, pp. 1–6, 2026. [Online]. Available: <https://psmjournals.org/index.php/vetres>
- [23] E. F. S. Shamsan, "Ecobiology and fisheries of *sillago sihama*," Ph.D. dissertation, Goa University, 2008.
- [24] L. M. Rao and P. S. Rao, "Food and feeding habits of *glossogobius giuris* from Gosthani estuary," *Indian J Fish*, vol. 49, no. 1, pp. 35–40, 2002.
- [25] R. Baker, A. Buckland, and M. Sheaves, "Fish gut content analysis: Robust measures of diet composition," *Fish Fish*, vol. 15, pp. 170–177, 2014. DOI: [10.1111/faf.12026](https://doi.org/10.1111/faf.12026)
- [26] G. J. Pierce and P. R. Boyle, "A review of methods of diet analysis in piscivorous marine mammals," *Ocean. Mar. Biol. Annu. Rev.*, vol. 29, pp. 409–486, 1991.
- [27] S. H. Bowen, "Quantitative description of the diet," in *Fisheries Techniques*, B. R. Murphy and D. W. Willis, Eds., 2nd ed., Bethesda, MD, USA: American Fisheries Society, 1996, pp. 513–522.
- [28] T. V. R. Pillay, "A critique of methods of stomach content analysis," *J. Zool. Soc. India*, vol. 4, pp. 185–200, 1952.
- [29] V. Mahesh, A. P. Gop, and R. J. Nair, "Stomach content analysis techniques in fishes," in *Recent Advances in Fishery Biology Techniques for Biodiversity Evaluation and Conservation*, R. J. Nair, A. P. Gop, and V. Mahesh, Eds., Kochi, India: Central Marine Fisheries Research Institute, 2018, pp. 104–115.
- [30] B. Hayden, M. L. D. Palomares, B. E. Smith, and J. H. Poelen, "Biological and environmental drivers of trophic ecology in marine fishes - a global perspective," *Sci Rep*, vol. 9, no. 1, p. 11415, 2019. DOI: [10.1038/s41598-019-47618-2](https://doi.org/10.1038/s41598-019-47618-2)
- [31] H. Moosleitner, "Feeding associations with triggerfishes (Balistidae) in the Red Sea and in the Indian Ocean," *Bull. Fish Biol.*, vol. 12, no. 1/2, pp. 71–77, 2010.
- [32] D. Schiller and C. B. Garcia, "Observations on the diet of *balistes vetula*," *Bol. Invest. Mar. Cost.*, vol. 29, pp. 35–40, 2000.
- [33] S. Clemente, J. Hernández, A. Rodríguez, and A. Brito, "Identifying keystone predators and the importance of preserving functional diversity in sublittoral rocky-bottom areas," *Mar. Ecol. Prog. Ser.*, vol. 413, pp. 55–67, 2010. DOI: [10.3354/meps08700](https://doi.org/10.3354/meps08700)
- [34] S. F. Goldman, D. M. Glasgow, and M. M. Falk, "Feeding habits of 2 reef-associated fishes, red porgy (*Pagrus pagrus*) and gray triggerfish (*balistes capriscus*), off the southeastern United States," *FB*, vol. 114, no. 3, pp. 317–329, 2016. DOI: [10.7755/FB.114.3.5](https://doi.org/10.7755/FB.114.3.5)



- [35] T. C. Mendes, J. P. Quimbayo, H. F. Bouth, L. P. S. Silva, and C. E. L. Ferreira, "The omnivorous triggerfish *melichthys niger* is a functional herbivore on an isolated Atlantic oceanic island," *J. Fish Biol.*, vol. 95, no. 3, pp. 812–819, 2019. DOI: [10.1111/jfb.14075](https://doi.org/10.1111/jfb.14075)
- [36] N. K. Suyani, M. Rajesh, and K. M. Rajesh, "First report on the diet and reproductive biology of *odonus niger* (Ruppell, 1836) from the south-eastern Arabian Sea," *J. Mar. Biol. Assoc. U. K.*, vol. 101, no. 5, pp. 827–837, 2021. DOI: [10.1017/S0025315421000771](https://doi.org/10.1017/S0025315421000771)
- [37] T. Acosta-Pachón et al., "Diet of the finescale triggerfish, *balistes polylepis* (Steindachner), in the Gulf of California," *Mar. Freshw. Res.*, vol. 74, pp. 712–724, 2023. DOI: [10.1071/MF22266](https://doi.org/10.1071/MF22266)
- [38] T. Senta, M. Kimura, and T. Kanbara, "Predation of fishes on open-ocean species of sea-skaters (*Halobates* spp.)," *Jpn. J. Ichthyol.*, vol. 40, no. 2, pp. 193–198, 1993. DOI: [10.11369/jji1950.40.193](https://doi.org/10.11369/jji1950.40.193)