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Seasonal Variation in Feeding Habits of the Hardnose Shark (*Carcharhinus macloti*) and Comparison of Diet with Other Demersal Sharks in the Northern Arabian Sea of Pakistan

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SUMMARY

In Pakistani coastal waters, the hardnose shark *Carcharhinus macloti* (Müller and Henle, 1839) is known locally as "Bhusa." The study intends to compare the nutritional makeup of the hardnose shark to that of other shark species found in Pakistan's northern Arabian Sea, as well as to analyze seasonal fluctuations in the sharks' feeding habits. Specimens caught with bottom-set gillnets, ranging in size from 68 to 103 cm, were collected to analyze their food items using the frequency-of-occurrence (FO) technique. A total of 80 stomachs from both sexes were analyzed for dietary contents. Teleosts made up 95.00% of the total diet, followed by cephalopods (3.75%) and crustaceans (1.25%). A comparative study with other demersal shark species from the same region and time revealed the dominance of teleosts across all species, though in varying percentages.

Key word: Diet, Sea, Pakistan, Shark

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INTRODUCTION

Shark feeding ecology is examined to better understand their role as apex predators in marine ecosystems and to support conservation and fisheries management. Studying their diets is crucial for developing accurate ecological models, as overconsumption can trigger trophic cascades that affect other populations and the overall health of the ocean. Additionally, studying shark nutrition enhances our understanding of their biology, particularly how different species and age groups interact with their environment. The hardnose shark (*Carcharhinus macloti*), a requiem shark in the family Carcharhinidae, derives its name from the highly calcified cartilages in its snout. A small, bronze-coloured shark with a long, pointed snout and a slender body, it can grow up to 1.1 m in length. The posterior tips of its two modestly sized dorsal fins are noticeably elongated (Rigby et al., 2021).

In the tropical western Indo-Pacific, hardnose sharks are widespread. They can be found in the Indian Ocean between Kenya and Myanmar, as well as in Sri Lanka and the Andaman Islands. They can also be found in Indonesia, off the coast of New Guinea and northern Australia, and from Vietnam to Taiwan and southern Japan in the Pacific Ocean (Voight and Weber, 2011). Although they are often found in

shallow inshore waters, reports of them reaching depths of 170 meters have been made.

The hardnose shark is a common and gregarious predator of bony fish, crustaceans, and cephalopods. Because this species is viviparous, the developing embryos are kept alive until term by a placental connection with their mother. The International Union for Conservation of Nature (IUCN) has classified the hardnose shark as Near Threatened (NT) due to its limited rate of reproduction and widespread meat fishing (Rigby et al., 2021). Fossils of hardnose sharks have been recovered from the United States and Brazil from the lower Miocene period (Höltke et al., 2024).

Hardnose sharks form large groups. The majority of this shark's diet consists of bony fish, with the balance consisting of cephalopods and crabs (Voigt et al., 2018). This species is parasitized by the tapeworm *Otobothrium carcharidis* and the nematode *Acanthocheilus rotundatus* (Schaeffner and Beveridge, 2013). The hardnose shark reproduces sexually. After a twelve-month gestation period, females give birth to one or two pups once every other year. Sexual maturity is reached at 70–75 cm in length, while newborns are 45–55 cm long, with a maximum lifespan of at least 15 to 20 years (Rigby and Derrick, 2021).

Understanding shark feeding patterns is essential for understanding ecosystem resilience, predator-prey interactions, and marine food networks. However, little is known about the seasonal feeding habits of the Hardnose Shark (*Carcharhinus macloti*) in the northern Arabian Sea of Pakistan (Rigby et al., 2021). The majority of previous studies have focused on fish distribution (Altaf et al., 2011a; Altaf et al., 2011b; Altaf et al., 2015; Fatima et al., 2016; Imran et al., 2021; Siddiqui and Javed, 2025), fisheries (Iqbal et al., 2014a; Iqbal et al., 2014b), and diversity (Fatima, 2018; Burbank et al., 2022). Nevertheless, comprehensive nutritional analysis and seasonal variations in feeding patterns are still not well documented. Therefore, this study aims to compare the nutritional composition of the Hardnose Shark with that of other shark species present in Pakistan's northern Arabian Sea and to investigate seasonal variations in the shark's feeding habits. Examining stomach contents, identifying important prey items, evaluating seasonal dietary variations, and comparing and contrasting the diets of different shark species are the objectives of this study.

MATERIALS AND METHODS

Hardnose Shark (Carcharhinus macloti) were collected (Figure 1) at Gwadar and Karachi (Figure 2) between August 2016 and July 2017.

STUDY AREA

The Northern Arabian Sea is connected to the United Arab Emirates, Pakistan, Oman, India, and Iran (Figure 2). The northern Arabian Sea's euphotic zone is between 20 and 60 meters deep, with an average depth of roughly 40 meters. Surface temperatures rise from north to south, ranging from 22.5 to 28.5°C. The temperature is roughly 15°C lower at 1000 meters than it is at the surface. There are multiple eddies and meanders in the flow pattern. The surface layer has a high concentration of inorganic phosphorus, which increases at deeper depths. At the surface, nitrate-nitrogen is modest, but it rises with depth (Qasim, 1982).

Figure 1: Specimen of Hardnose Shark (*Carcharhinus macloti*).

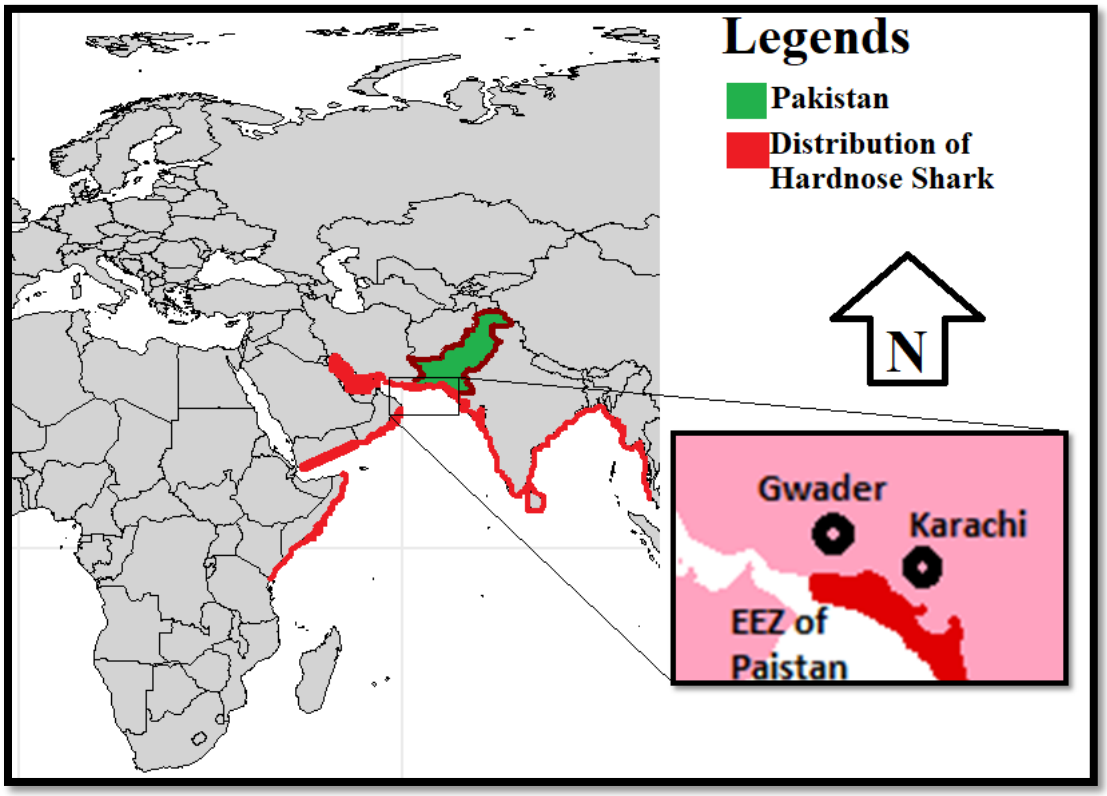

Figure 2: Sample selection sites and distribution map of *C.macloti.*

METHODOLOGY

Studies on shark dietary habits use a variety of approaches, including more conventional ones like stomach content analysis. To identify prey items, researchers physically examine the contents of a shark's stomach. Using an updated fish identification guide, species were identified (Psomadakis et al., 2015). The majority of sharks that arrived in Gwadar or Karachi were brought to a shark yard in Fish Harbor, where their heads, fins, and viscera were removed. Between August 2016 and July 2017, 80 Hardnose-shark stomachs containing food, each measuring 68 to 103 cm, were removed from the yard and brought to the Marine Fisheries Department's Biological Laboratory for stomach examination. There, pointed scissors were used to

dissect them, and a petri dish was used to hold the material. Food items were classified into three groups: teleosts, cephalopods, and crustaceans, after group-level identification. A number of pictures showing the contents of the stomach were labeled with the date. The lowest taxonomic level was used to identify the food item. Frequency of occurrence (FO) was the method employed (Hyslop, 1980).

STATISTICAL ANALYSIS

Data were analyzed and graphs were designed with the help of MS Excel 2010.

RESULT

The remaining 170 empty stomachs were discarded after it was found that 80 of the 250 stomachs—55 female and 25 male—were on a diet. All food items are categorized into three groups: teleosts, cephalopods, and crustaceans, which dominated both female and male sharks. Teleosts, in terms of the combined percentage of food items found, were the most dominant in the stomachs of hardnose sharks (Figures 3 and 4). There was a dominance of the family Dorosomatidae (sardines) in teleosts, which was observed in females (Figure 5), whereas males were dominated by Carangidae (Indian scad) (Figure 6). Squids (*Uroteuthis duvaucelii*) clearly dominated over *Sepia* spp. in the cephalopod group (Figure 7). Stomatopods were found in the combined percentage of crustaceans, which were observed in females only once, with no crustaceans found in males (Figure 8). Except for January, the majority of the dominant food items were found in all months (Figure 9). In females, no food items were found in August, January, and April (Figure 10), but in males, food items were found in August, November, March, and April, while other months were empty (Figure 11). Spring, summer, autumn, and winter were dominated by teleosts, with a high amount found in summer (Figure 12). Other research conducted in many parts of the world revealed that this species' main food source is teleosts (Figure 13). The feeding habits of hardnose sharks were compared with those of other demersal sharks from the same period of time and region (Pakistan's Northern Arabian Sea), and it was discovered that teleosts were the sharks' preferred source of nutrition, although in different amounts (Figure 14).

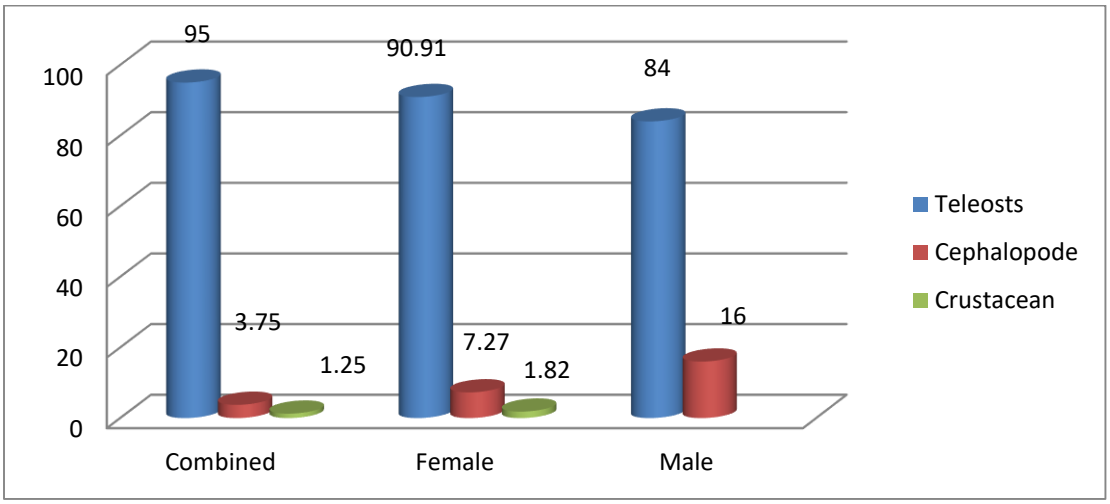

Figure 3: Percentage of diet of *C. macloti.*

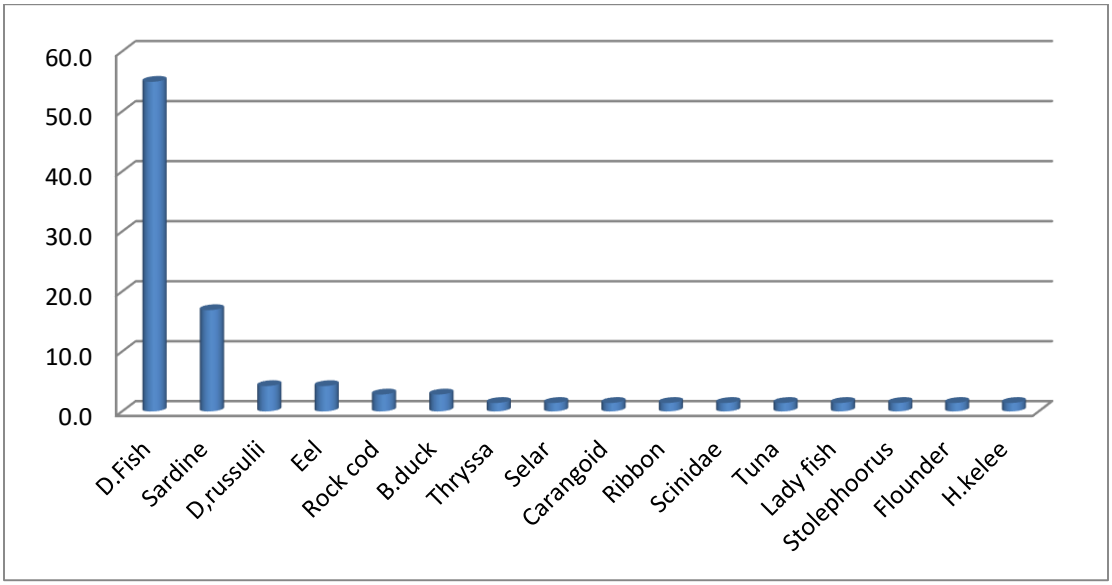

Figure 4: Combined percentage of teleosts in *C. macloti.*

TELEOSTS

This food item was dominant throughout the year in the stomach of the hardnose shark. Overall, the teleost (bony fish) rate was 95.00%; the female rate was 90.91%, while the male rate was 84.00% (Figure 3), dominated by the family Dorosomatidae. Fishes belonging to 12 families, including Dorosomatidae (*Sardinella* spp., *Hilsa kelee*), Muraenidae (*Muraenesox* spp.), Engraulidae (*Stolephorus indicus*, *Thryssa* spp.), Carangidae (*Decapterus russelli*, *Selar crumenophthalmus*), Synodontidae (*Harpadon nehrius*), Epinephelidae (*Epinephelus diacanthus*), Sillaginidae (*Sillago sihama*), Sciaenidae (*Johnius* spp.), Trichuridae (*Lepturacanthus savala*), Cynoglossidae (tongue sole), Bothidae (flounder), and Scombridae (tuna) were found in the stomach (Figure 4).

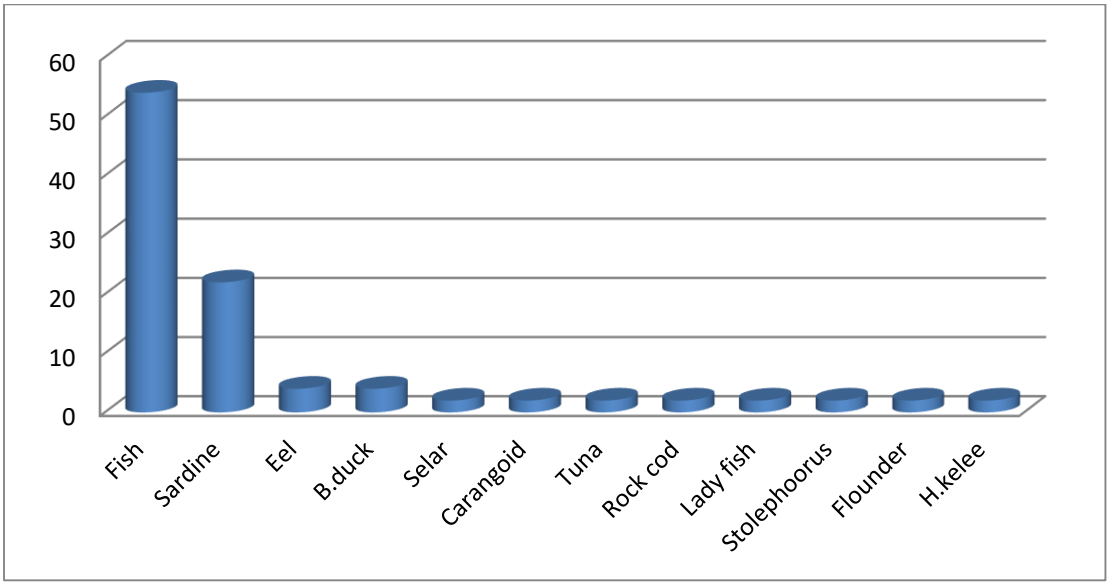

Figure 5: Percentage of teleosts of female in *C. macloti.*

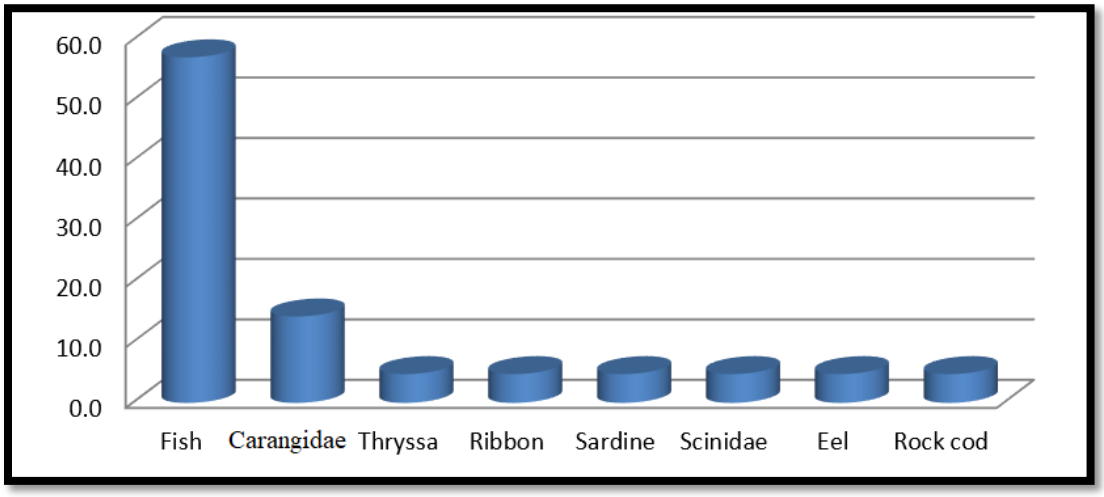

Figure 6: Percentage of teleosts of male in *C. macloti.*

An almost similar pattern was found in females, where 12 families, including Dorosomatidae (*Sardinella* spp., *Hilsa kelee*), Muraenidae (*Muraenesox* spp.), Engraulidae (*Stolephorus indicus, Thryssa* spp.), Carangidae (*Decapterus russelli, Selar crumenophthalmus*), Synodontidae (*Harpadon nehrius*), Epinephelidae (*Epinephelus diacanthus*), Sillaginidae (*Sillago sihama*), Sciaenidae (*Johnius* spp.), Trichuridae (*Lepturacanthus savala*), Cynoglossidae (*Cynoglossus semilaevis* Tongue Sole), Bothidae (flounder), and Scombridae (tuna) were found in the stomach (Figure 5). In males, only 7 families of teleosts, including Dorosomatidae (*Sardinella* spp.), Muraenidae (*Muraenesox* spp.), Engraulidae (*Thryssa* spp.), Carangidae (*Decapterus russelli*), Epinephelidae (*Epinephelus diacanthus*), Sciaenidae (*Johnius* spp.), and Trichuridae (*Lepturacanthus savala*), were found in the stomach (Figure 6). In combination, except for January, teleosts dominated in all months (Figure 9). In females, except for August and April, teleosts were found in all months (Figure 10). In males, teleosts were found only in the months of August, November, March, and April (Figure 11).

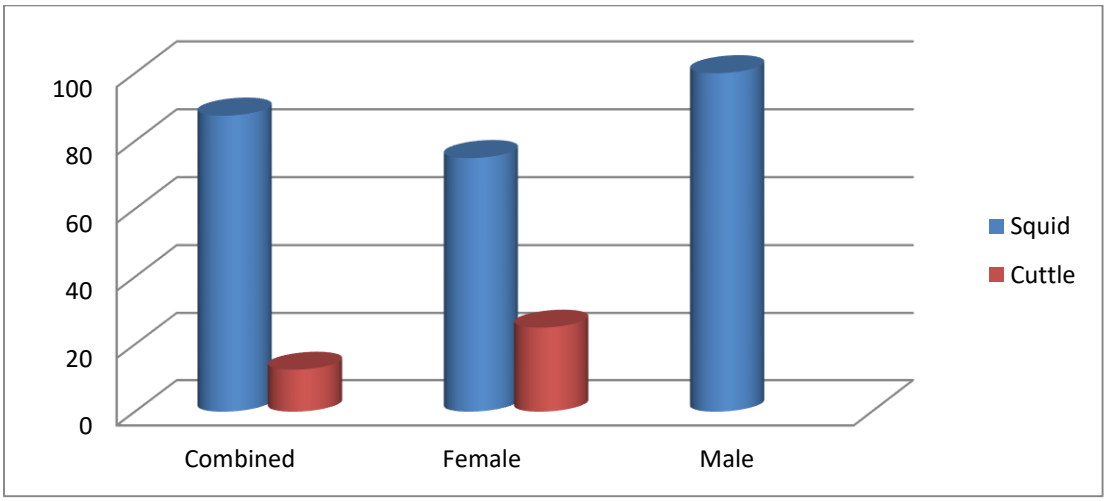

Figure 7: Percentage of cephalopod in *C .macloti.*

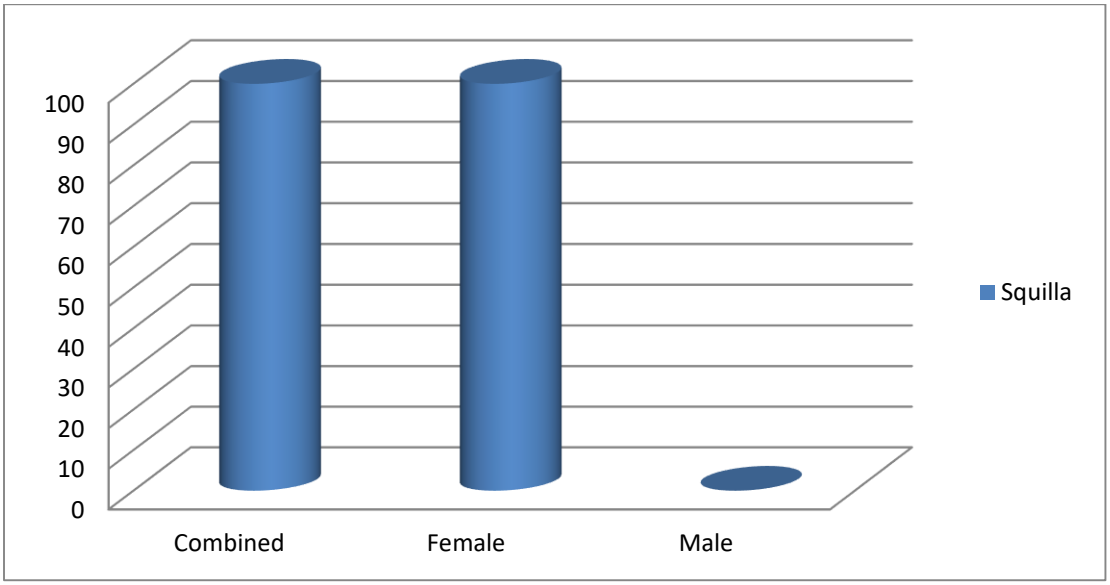

Figure 8: Percentage of crustacean in *C. macloti.*

CEPHALOPOD

The second dominant group combined percentage of cephalopods was 3.75% of the total diet in hardnose sharks; including females, it was 7.27%, whereas in males it was 16.00% (Figure 3). In the combined data, squid (*Uroteuthis duveseli*) was dominant with 87.5%, followed by *Sepia* spp. with 12.5% (Figure 7). In females, the percentage of squid (*Uroteuthis duveseli*) was 75.0% and *Sepia* spp. was 25%. In males, squid (*Uroteuthis duveseli*) accounted for 100%, with no other items found (Figure 7). The most dominant months were September, February, and March (Figure 9). A similar pattern was found in female dominance observed in September, February, and March (Figure 10). In males, cephalopods were found only in March (Figure 11).

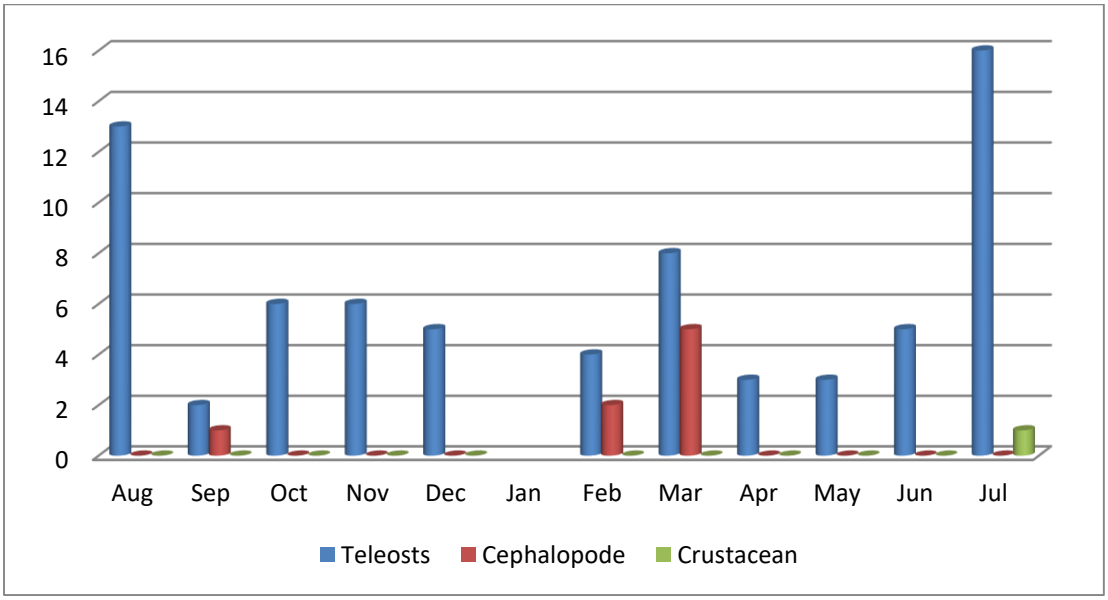

Figure 9: Monthly combined diet composition in *C. macloti.*

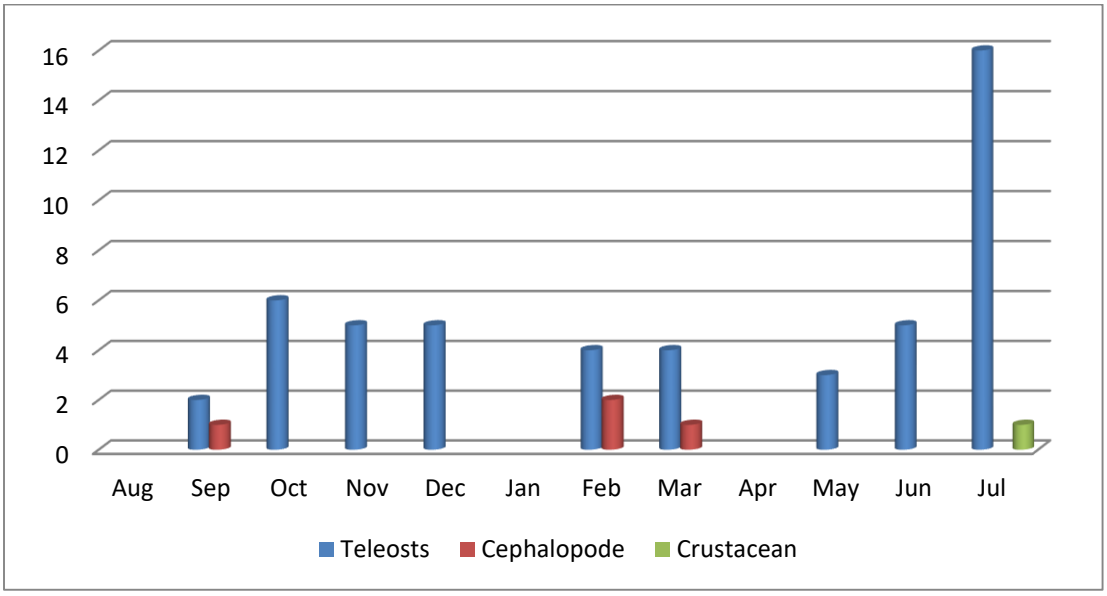

Figure 10: Monthly female diet composition in *C. macloti.*

CRUSTACEAN

This is the third dominating group's combined percentage, which was 1.25% of the total diet, including female 1.82% and male 0.00% (Figure 3). In the combined data, Squilla was found only once, at 100% (Figure 8). A similar pattern was observed in females, where Squilla was found on one occasion and was also 100% (Figure 8). No crustacean items were found in males (Figure 8). In the combined data, Squilla was found in July (Figure 9), and a similar model was observed in females, where crustaceans dominated in July (Figure 10). None were found in males (Figure 11).

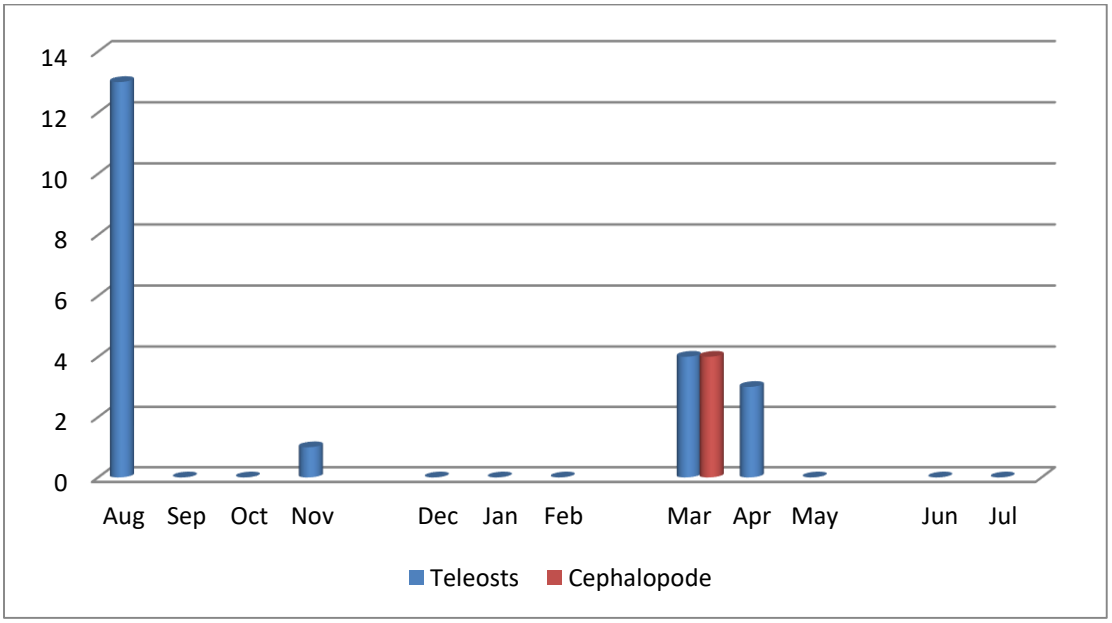

Figure 11: Monthly male diet composition in *C. macloti.*

DIET COMPOSITION OF FOUR SEASONS

A combined diet composition of both sexes across the four seasons studied showed that teleosts were the most common food item in the summer at 42.5%, followed by crustaceans at 1.25%. In the spring, teleosts dominated with 17.5%, followed by cephalopods at 6.25%. In autumn, teleosts again dominated with 17.5%, while cephalopods accounted for 1.25%. In the winter, teleosts made up 11.5%, and cephalopods 2.5% (Figure 12).

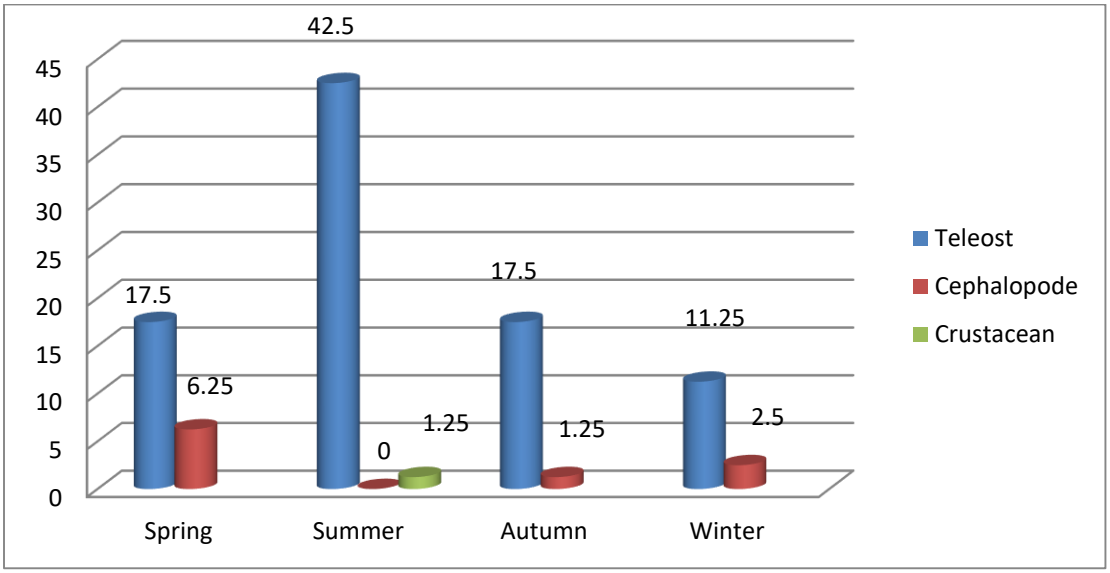

Figure 12: Percentage of diet composition in four seasons in *C. macloti.*

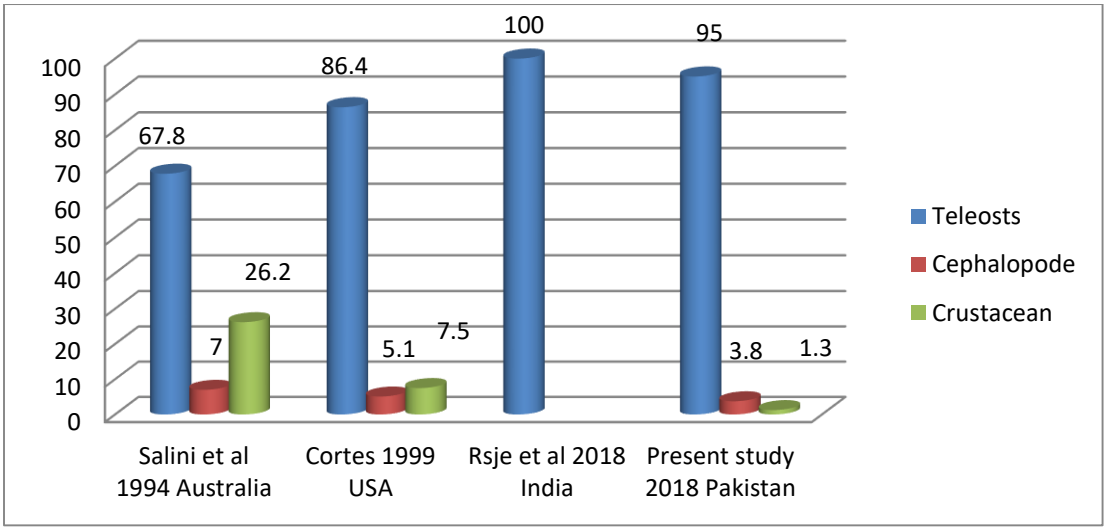

Figure 13: Comparison with other study in percentage of *C. macloti*.

COMPARISON OF FEEDING HABIT WITH OTHER DEMERSAL SHARK

Between 2016 and 2017, a series of all demersal sharks studied were brought from the EEZ of Pakistan (Northern Arabian Sea) in the same area. It appeared that teleosts

were the most dominant item in all demersal sharks, with different percentages. Smaller sharks depended on their diet of slow-moving animals like crustaceans, whereas larger species primarily consumed teleosts. *Scoliodon laticaudus* (spadenose shark), size range 32-52 cm, consumed teleosts 50.5%, crustaceans 46.4%, and cephalopods 2.4% (Osmany et al. 2018). *Rhizoprionodon oligolinx* (grey sharpnose shark), size range 49-63 cm, consumed teleosts 72.8%, cephalopods 16.9%, and crustaceans 10.3% (Kashifa et al. 2025). *Rhizoprionodon acutus* (milk shark), size range 67-101 cm, consumed teleosts 77.6%, crustaceans 14.1%, and cephalopods 8.3% (Imran et al. 2025). *Carcharhinus macloti* (hardnose shark), size range 68-103 cm, consumed teleosts 95.0%, cephalopods 3.75%, and crustaceans 1.25% (Figure 14).

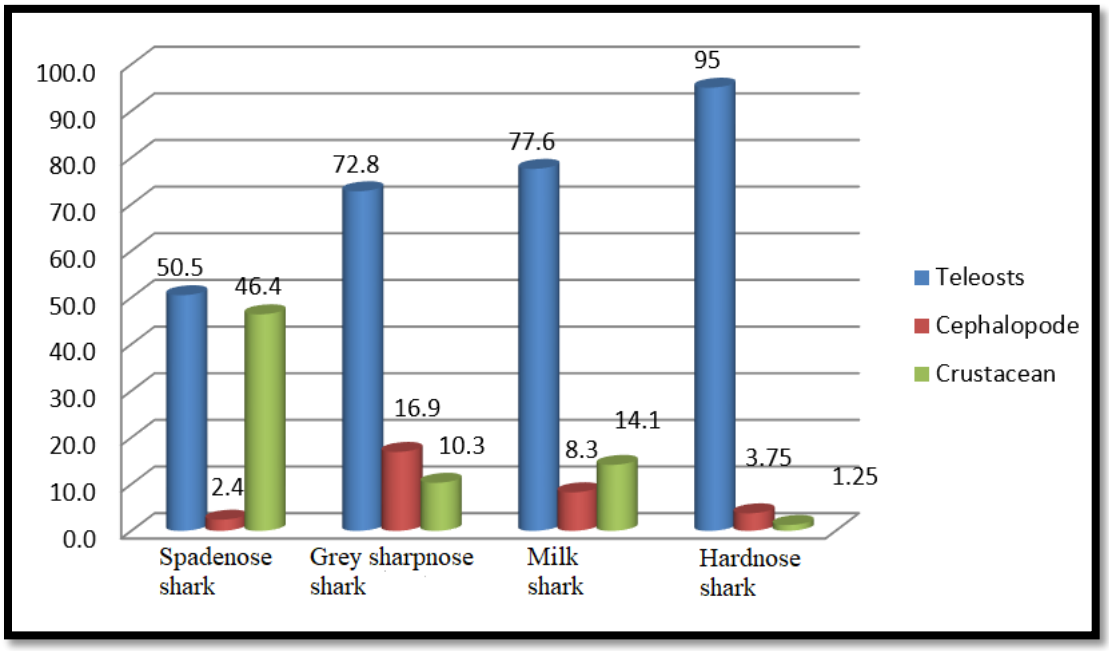

Figure 14: Comparison of diet composition of all demarsal shark in 2007.

DISCAUSSION

Sharks are a variety of predators, and depending on their species and size, their diet can include anything from enormous marine mammals to microscopic plankton. The main food sources for bottom-dwelling (benthic) sharks are small bony fish that live on or close to the seabed, mollusks (squid, octopuses, clams), and crustaceans (crabs, lobsters, squilla, and shrimp). Sharks utilize highly acidic fluids and enzymes to break down food in their J-shaped stomach after swallowing their prey whole or in large pieces. Partially digested food enters a short intestine with a spiral valve that expands the surface area available for absorbing nutrients after this initial breakdown. Some sharks have the ability to evert (turn inside out) their stomach through their mouth in order to expel indigestible items. The diets of hardnosed sharks have not been thoroughly studied. Scientists found that the hardnosed sharks primarily feeds on small bony fishes, teleosts, cephalopods, and crustaceans (Devadoss et al., 1987; Jalali et al., 2008; Last and Stevens, 2009).

Salini et al. (1994)studied teleosts (67.8%), cephalopods (7%), and crustaceans (20.2%) in Australia. During a study in Mumbai, Raje et al. (2021) described that teleosts comprised 100%. Moazzam and Osmany (2022) studied the stomachs of 15 specimens and reported teleosts, crustaceans, cephalopods, and annelids. The current study's specimens were obtained from different parts of Pakistan's EEZ, and the results showed that the stomach of the hardnose shark contained teleosts (95.00%), cephalopods (3.8%), and crustaceans (1.3%) (Figure 13).

In all studies, it has been established that the most preferred food item of the hardnose shark is teleosts, which are available in different varieties and percentages. Raje et al. (2021) described the diversity of teleost families such as Apogonidae, Carangidae, Dorosomatidae, Cynoglossidae, Platycephalidae, Sciaenidae, and Trichiridae in the stomach of the hardnose shark in their study of the eastern Indian Sea. Moazzam and Osmany (2022) reported families of Dussumieriidae, Ariidae, Synodontidae, and Platycephalidae, along with crab species like *Arcania erinacea*, *Philyra* spp., and *Charybdis helleri*, as well as other crustaceans like *Squilla* and *Sepia* spp. in cephalopods.

Any species' dietary habits are greatly influenced by the structure of its teeth. The teeth of hardnose sharks are tiny and thin, with smooth, non-serrated bottom teeth and powerful cusplets on the top teeth. The upper jaw has 29–32 front row teeth, whereas the lower jaw has 26–32 front row teeth (Figure 15). The current study discovered a variety of food items in various months, such as teleosts, cephalopods, and crustaceans (Figure 16).

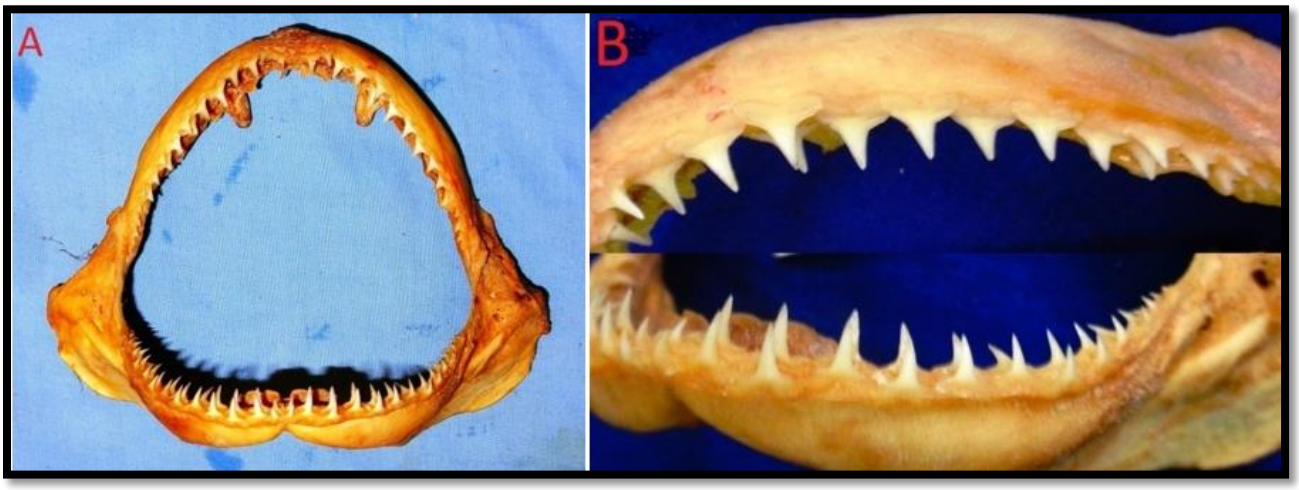

Figure 15: Jaw of *C. macloti.*

Like other requiem sharks, the hardnose shark is viviparous; once the embryos run out of yolk, the empty yolk sac forms a placental link that allows the mother to feed the young. After a twelve-month gestation period, females give birth to one or two pups once every other year. Sexual maturity occurs at 70–75 cm in length, while newborns are 45–55 cm long. The maximum lifespan is at least 15 to 20 years (Compagno and Niem, 1998; Rigby et al., 2021). In the current study, pups were found in the month of April wit h a size range of 39–40 cm (Figure 17), and no food was found in the stomach of a female in this month (Figure 10).

Figure 16: Stomach contain of *C. macloti.*

CONCLUSION

Studying hardnose shark feeding habits is beneficial for managing marine ecosystems, developing effective conservation strategies, and comprehending the fundamental biological roles of this species. Additionally, the latest study, which was carried out between August 2016 and July 2017, confirms other studies on hardnose sharks undertaken worldwide, which discovered that teleosts are the primary food source in the northern Arabian Sea, followed by cephalopods and crustaceans.

Concurrently studying the feeding habits of multiple shark species in the same area and time can provide significant information on resource partitioning and social relationships in the environment.

Figure 17: Pups of *C. macoti*.

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