

Shark and ray meat consumption as a threat to India's elasmobranchs

Divya Karnad¹, Narayani S¹, Shruthi Kottillil¹, Sudha Kottillil¹, Trisha Gupta¹, Alissa Barnes¹, Andrew Dias¹, and Y. Chaitanya Krishna¹

¹Affiliation not available

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Introduction

Over one-third of chondrichthyan (shark, ray and chimaera) species are threatened with extinction globally. Overfishing driven by human consumption is a key threat for >95% of threatened elasmobranch species (Dulvy et al., 2021). Research on consumption has largely focussed on the shark fin trade, which, as a luxury product, has received considerable conservation attention (Clarke et al., 2006; Dent & Clarke, 2015; de Mitcheson et al., 2016). Recent trends indicate that even as the fin trade continues to imperil threatened species, the international demand for shark fins from South-East Asia is declining (Jeffreys 2016; Jaiteh et al., 2017; Cardeñosa et al., 2022). Meanwhile there is increasing evidence for more complex drivers, such as the local and global trade in other elasmobranch products, such as meat (e.g. Braccini et al., 2020; Karnad et al., 2020). Elasmobranch meat trade is actually higher in volume and value than the fin trade, but remains poorly studied and misunderstood by conservation actors due to the lack of supply chain transparency (Niedermüller et al. 2021; Rangel et al., 2021). The value of the shark and ray meat in the period 2012–2019 comprised 63.41% (US\$ 2.6 billion) of the total shark and ray trade value (US\$ 4.1 billion; Niedermüller et al. 2021). If shark meat suppl chains are mistakenly likened to shark fin supplies, ineffective conservation campaigns result, which don't mitigate the actual, local threats to elasmobranchs (Braccini et al., 2020). With demand for elasmobranch meat, rather than fins, driving their fisheries in some parts of the world, improving our understanding of meat consumption is key to conserving this threatened group of species (Barbosa-Filho et al., 2019; Bornatowski et al., 2017; Karnad et al., 2020).

The northern Indian Ocean is critical for elasmobranch conservation, because fisheries here are a significant threat (Dulvy et al., 2021). This region has an established tradition of local and regional elasmobranch meat consumption (Haroon, 2010; Karnad et al., 2020). For instance, in nineteenth-century India, shark meat was consumed by women after childbirth, and by African sailors (Day, 1889). This practice of consumption continues and includes not only sharks but guitarfish, wedgefish, stingrays and devil rays, in fresh and dried form (Hossain et al., 2013; Haque et al., 2021). Species, such as *Scoliodon laticaudus* (Spadenose shark), *Rhizoprionodon acutus* (Milk shark), *R. oligolinx* (Gray sharpnose shark) and *Himantura uarnak* (Reticulate whipray), are used as lactagogues (enhancing milk production), while *H. uarnak* is also used to treat dysentery, wheezing and bronchitis in Tamil Nadu state (Esakkkimuthu et al., 2018). Consumption was historically limited to the poorer sections of society, including coastal and tribal people in South Asia and Myanmar (Haroon, 2010). The profile of consumers may have changed since elasmobranch meat trade is now economically important enough to justify continued direct/indirect fishing, despite a decline in the fin trade (Karnad et al., 2020). Demand for fresh, salted, and dried elasmobranch meat increased since the 1960's and 1970's in South Asia and globally (Frej & Gustafsson, 1990; Jit et al., 2014). Even deep-sea sharks like *Echinorhinus brucus*, *Hexanchus griseus*, *Alopias superciliosus*, *Centrophorus spp.* and *Squalus spp.* are now involved in the meat trade in India (Akhilesh, 2014). Despite this evidence, there is little research

on patterns of domestic shark meat consumption, particularly in India, which is the third largest harvester of sharks, globally (Gupta et al., 2022; Lack & Sant, 2009).

Understanding elasmobranch meat trade and consumption as an important driver of harvests in India is crucial. Such research will allow us to identify leverage points for changing unsustainable behaviours (Verissimo et al., 2020). Restaurants are an important driver of, and mirror, household seafood consumption patterns in India (Karnad et al., 2021). Restaurants have also been implicated in promoting elasmobranch meat consumption, such as in China (Fabinyi & Liu, 2014). Research on restaurant menus offer insight into shifts in fisheries landings, supply chains and consumer preferences (Van Houtan et al., 2013). Therefore this research examines the sale and consumption of elasmobranch meat in India’s restaurants. We identify the prevalence and availability of elasmobranch meat in restaurants within urban and tourist centres across nine coastal states in India. We explore the species groups involved, the demand from specific clientele, and the key characteristics of restaurants that serve elasmobranchs through a detailed study in the state with the highest elasmobranch availability in restaurants. Specifically, we examine whether tourism is driving elasmobranch meat consumption. We also investigate elasmobranch meat prices, whether demand is created through a restaurant’s recommendation, and the factors that might promote restaurants’ switching to alternatives to elasmobranch meat.

METHODS

To evaluate the prevalence and availability of elasmobranch meat in restaurants, we conducted surveys of online restaurant menus in two cities each of nine coastal states (and one union territory) between October 2020 and December 2021 (Figure 1 and Table 2). The chosen cities had the largest population of cities in that state. Details of how these surveys were conducted are available in Table 1 and Appendix 1. Restaurants were classified based on price as high (>9 USD), medium (USD 3-9) and low (<3 USD).

To explore the species involved, the clientele and demand, and the key characteristics of restaurants we conducted semi-structured interviews in English and local languages, with restaurant owners and managers, over the phone and in person, The procedure and questions are detailed in Appendix 1 and 2 respectively. We ensured to interview people from at least three restaurants in each price category per city. Due to the high number of restaurants advertising elasmobranchs in Goa we interviewed forty three percent of Goa restaurants whose online menus featured elasmobranchs, as well as 21 restaurants with offline menus featuring elasmobranchs

To corroborate responses about supply-demand and provide context from the trade perspective, we opportunistically (since elasmobranch trade is in some cases illegal and otherwise contentious in India) identified three male, highly experienced traders who targeted elasmobranchs as key informants for qualitative interviews. We also conducted a focus group discussion with three experienced restaurant owners in Goa who did not participate in interviews to explain and verify data about demand and alternatives to shark meat.

Data from the online menus were analysed using RStudio (version 1.0.44) and Microsoft Excel. Since prices of the same dish vary between restaurants in the high, medium and low price categories, elasmobranch dish prices were standardised as a proportion of the average cost of other seafood at each restaurant. Descriptive statistics were produced from interview data. Monte Carlo simulations (1000 iterations; Ulam and Metropolis, 1949) were used to quantify the reported elasmobranch meat served in a subset of restaurants. Classification trees helped to identify the characteristics of elasmobranch meat consumers in Goa.

RESULTS

Prevalence and availability

We identified 2649 seafood restaurants with online menus (Table 2), of which 292 mention shark meat on their menus. No restaurant specifically identified rays on their menu, although traders (n=3) report the substitution of less expensive ray meat for shark meat in restaurants. The state of Goa (33.5%) had the highest proportion of elasmobranch meat selling restaurants, followed by Tamil Nadu (34.6%) and Maharashtra(4.6%). Restaurants in Gujarat, West Bengal and Odisha did not feature elasmobranchs on the menu

(Karnad 2022b). There was only one restaurant out of 2649 that served shark fin soup as part of its Chinese cuisine. All restaurants only advertised shark meat.

Prices for elasmobranch meat dishes in restaurants were available only for the cities of Chennai, Hyderabad, Mumbai, Puducherry and Thane (Figure 2). Most restaurants that served elasmobranchs were in the medium and low price category with the average price being USD 2.6 ± 0.5 per dish. The highest prices for elasmobranch dishes were in Chennai (9.72 USD) and the lowest prices in Hyderabad (2.01 USD) (Figure 2). The mean quantity of shark meat reportedly sold in restaurants varied from 0.25–10.9 (± 4.8) kg per restaurant per week. Assuming average sales throughout the year, we calculated that restaurants, outside Goa, with online menus featuring elasmobranchs could sell 124.6 (± 15.5) tonnes of elasmobranch meat sales per year, which is about 41533 sharks weighing 3kg (average weight of small-bodied sharks) and is equivalent to 5.2% of the annual landings (MPEDA, 2020).

Species involved, clientele and demand across India

A total of 102 phone interviews across the rest of India and 65 interviews (44 phone & 21 in person) were conducted in Goa. More interviews were conducted in the North Goa district (65%) where more restaurants (69%) are located. Majority of the interviewees in Goa were from medium priced restaurants (48.4%) followed by high (21.8%) and low (14%) priced restaurants. For consistency, responses for all questions are presented as a percentage of total interviews unless specified otherwise.

Species: None of the interviewees distinguished species but most (92%) preferred “baby sharks”, i.e. small-bodied sharks and juveniles of large-bodied sharks. Of these, in Goa, interviewees preferred sharks weighing 1–2kg (32%, n=65), followed by 5–7kg (12%, n=65). In Chennai and Puducherry, all interviewees preferred Milk Shark (*Rhizoprionodon acutus*; Vulnerable (IUCN, 2021)) bought whole with fins intact. However, they were unable to distinguish between the Milk Shark and several similar looking species. Interviewees in Mumbai (37%, n=49) also bought elasmobranchs whole (small-bodied sharks and juveniles of large-bodied sharks) to sell as “baby sharks” or as boneless pieces (50%). In Goa (n=65) thirty seven percent served “baby shark”, while others (15%) served hammerhead sharks (*Sphyrna spp.*), sharks whose fins had black-tips (12%), and “white shark” (3%).

Clientele and Demand: In all cities surveyed, elasmobranch meat was primarily sold in restaurants serving regional and coastal cuisine (99%, n=292). Interviewees explained that elasmobranch meat was a signal of “traditional” regional, coastal cuisines, and a symbol of authenticity. Consequently restaurants that had elasmobranchs on the menu also used local language names for other dishes e.g. *Meen Kuzhambu* instead of fish curry on an English language menu in Chennai and Puducherry. *Sura putt* (minced shark) was the only elasmobranch dish listed in Chennai and Puducherry. An interviewee from Chennai explained “*Sura putt* is the most famous dish... [Other dishes] are an acquired taste that does not cater to many customers.” *Mori* or *Mushi* curry and fry, as well as “Baby shark masala” were the only elasmobranch dishes in Mumbai and Thane (n=61). These dishes were found in restaurants that served Malvani (62%), Konkani (27%), Maharashtrian (29%) or Goan (4%) cuisine. *Sraavu Varutharacha* curry was the name for elasmobranch meat dishes in Kerala.

Most (65%) restaurants in Goa (n=65) began serving elasmobranch meat to meet the high demand from customers, because it was “traditionally part of Goan cuisine” (18%). Shark meat was specifically ordered by customers (69%), but Goa restaurants (17%) also recommended fresh shark. The two main groups who specifically ordered shark meat dishes were locals from Goa (63%, henceforth Goans), who preferred shark *Ambotik* (46%, n=44), a Goan dish. and foreign tourists (60%). Russians, British, Germans and Israelis in Goa preferred butter garlic shark (23%) and shark fry (22%). Foreign tourists reportedly preferred shark meat for its distinct, acquired taste (58%), because it was easy to eat with soft bones (15%), was a part of their diet at home (12%), but not easily available in their home country (9%). Shark meat was not preferred by domestic tourists in Goa (15%); who were reluctant to try shark meat even when it was recommended. The classification tree analysis (CP = 0.05, R squared = 0.72) showed that shark meat was very popular during the tourist season in Goa (November to March, Figure 3), although over one third (38%) felt that

there was no seasonality and that restaurants in high tourist zones would feel the financial impact of removing sharks from the menu (21.5%). The focus group discussion confirmed this, saying, “*there really is no alternative for boneless shark meat*”. Ten restaurants in Goa had stopped serving shark meat, because it was expensive (n=4) or had no demand (n=4). Only 2 interviewees reported substituting other seafood with elasmobranch meat.

Thirty five percent of Goa interviewees rated shark meat within the top six best-selling dishes, but twenty three percent rated it unpopular. Shark dishes were ranked as both profitable (42%) and unprofitable (29%), and key informants explained that profits depended on fluctuating availability and price. Whole sharks were preferred to fillets or pieces (79%). Important source markets in Goa were the Panjim jetty (29%), Madgaon fish market (31%) and smaller local markets (22%). Only six percent bought elasmobranchs from other states, including Karwar, Karnataka and Kollangodu, Kerala. Many (32%) found no changes in size, abundance, demand or price of elasmobranchs over time. Only a few respondents noticed increased price (18%), reduced quantity (17%), and reduced demand (6%).

Alternatives to elasmobranch meat

Most respondents (66%, n=65) felt removing elasmobranchs from their menu would have no significant impact on profits. Nearly one third of respondents (31%) were open to alternatives, such as *Scomberomorus spp.*, *Lutjanus spp.* and sea catfish. But thirty four percent of respondents felt that they couldn't substitute shark meat without a significant impact on their profits, because the authenticity of Goan dishes like *Ambotik* would be lost, and because elasmobranch meat had a unique taste (32%).

DISCUSSION

Elasmobranch meat consumption is unevenly distributed and is concentrated in restaurants serving regional and coastal cuisines. Over 40,000 sharks, the equivalent of only 5% of annual catch, could feed the demand from this sample of restaurants, suggesting many more feed demand from households and restaurants without online menus. This is corroborated by the fact that states like West Bengal with a high quantity of landings and trade in elasmobranch meat (MPEDA 2020), don't feature elasmobranchs on restaurant menus although anecdotal reports suggest regular household consumption.

In India, where over 80% of elasmobranchs are in the IUCN threatened categories, (Dulvy et al. 2021), similar to the fin trade (Cardenosa et al. 2022), we find that threatened species could be disproportionately affected by the meat trade. In addition to the large bodied sharks threatened by the shark fin trade, our study suggests that small-bodied and juvenile sharks are at risk from the meat trade. Large-bodied sharks and rays may also be threatened by meat markets, due to mislabelling and demand for boneless seafood. However because specific demand exists for small-bodied and juvenile sharks the suite of species threatened by the meat trade is likely to be different from those threatened by the fin trade and needs further research.

Tourism is an emerging source of demand for elasmobranch meat alongside demand from coastal culinary cultures and traditional medicine. The case study in Goa suggests that high prices and reduced demand can push some restaurants to remove elasmobranchs from their menu. Therefore policies such as levying higher taxes on the trade of elasmobranch meat, and thus raising prices could aid efforts to eliminate elasmobranch meat on restaurant menus. Economic shocks such as the COVID-19 economic shutdowns demonstrated the volatility of foreign tourism as a source of demand for shark meat, and current events such as the Russia-Ukraine war may also impact demand for elasmobranch meat due to reduced numbers of Russian tourists. However longer term solutions need to be found to ensure that elasmobranch meat does not become fettered for tourists especially in Goa.

Highly targeted conservation interventions, such as policies that prevent shark finning, permit a supply driven trade of elasmobranch meat. Similar to reports from Brazil (e.g. Barbosa-Filho et al., 2019), elasmobranch meat is increasingly becoming expensive in India. It is likely therefore that this will see a similar transformation from low value, to high value and highly in-demand meat. To stem such demand and protect threatened elasmobranch species, India needs policies to regulate the meat trade in addition to those focussed on redu-

cing the shark fin trade. Domestic policy to regulate trade in elasmobranch meat and other elasmobranch products is key. Further given low levels of policy compliance in India (e.g. Karnad et al., 2014 in fisheries and Nagarajan, 2021 about consumers) conservation efforts need to prioritize building grassroots support for such policy in Goa, Tamil Nadu and Maharashtra, where elasmobranchs regularly feature on restaurant menus. Such grassroots efforts can take the form of raising consumer awareness about the risks from increased heavy metal concentrations in elasmobranch tissues (Kim et al., 2019; Souza-Araujo et al., 2021). Given that species, such as the hammerheads (*Sphyrna spp.*) and Blacktip sharks (*Carcharhinus limbatus*) with higher levels of heavy metal toxicity are also more commonly harvested, and were mentioned by respondents, such an approach could not only safeguard shark populations but also human health (Garcia-Barcia et al., 2022). Additionally research on why consumers choose to eat these species could provide insights on the measures needed to change consumer behaviour and reduce demand for elasmobranch meat (Veríssimo et al., 2020).

Shark meat trade is now known to surpass shark fin trade (Niedermüller et al., 2021) and commonly consumed, often in local levels, in Asia, South America and Europe (Gracia-Barcia et al., 2022). As the first assessment of the elasmobranch meat trade in a top shark fishing nation, India, this study demonstrates the urgent need for regulations on this trade, even while more research is needed on the topic. While blanket bans on the shark meat trade, and also shark fishing are unlikely to be successful, especially since they have been previously unsuccessful in India (Hausfather, 2004), a more nuanced approach combining top-down policy and grassroots action is required. Holistic conservation measures that combine fisheries, wildlife and trade regulations, both domestically and internationally are the need of the hour to tackle the multiplicity of elasmobranch products that are now being traded (Dent & Clarke, 2015). More research is needed to support such policy and conservation action due to key lacunae in our understanding of the drivers of elasmobranch fishing. For instance, there is no data on household elasmobranch consumption, nor on the role of local markets in fuelling the trade in elasmobranch meat. Traceability and transparency of movement of elasmobranch meat through the market, right from the time of capture to trade and consumption is important to stop illegal trade and to keep consumption at manageable levels (Niedermüller et al. 2021). While CITES regulations have prevented the export of fins in particular from India, a combination of international treaties and domestic policy is needed to address the rising threat from the elasmobranch meat trade.

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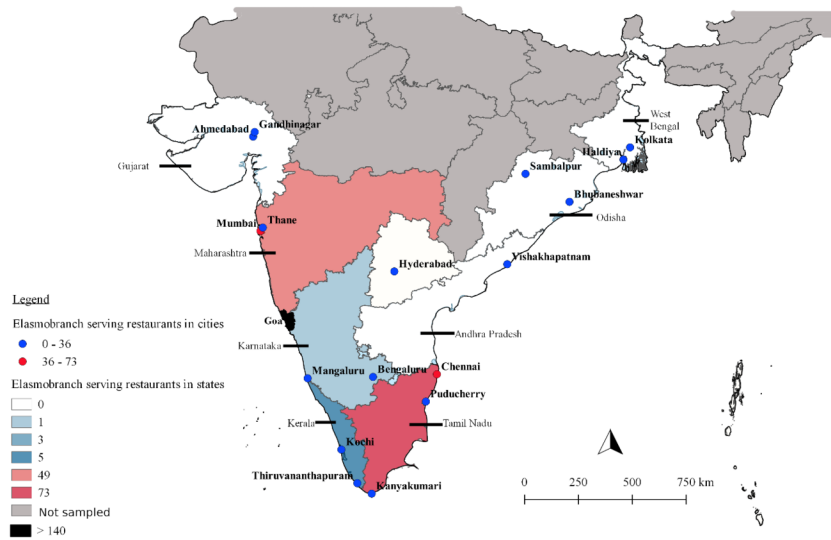


Figure : A map of the study area indicating cities sampled within different states of India and the number of restaurants with elasmobranchs on the menu in each

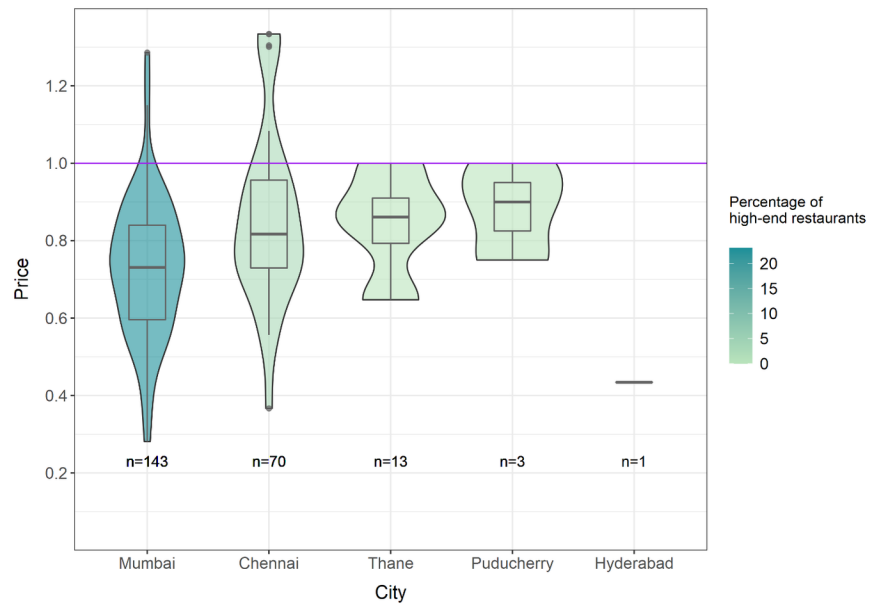


Figure : Prices of elasmobranch dishes in five cities as a proportion of the average price of other seafood (purple line). The numbers in the graph refer to the total number of restaurants sampled (n) in each city. The colour indicates the percentage of high-end restaurants in each city, based on the price. Width of each part of the violin plot indicates the relative number of restaurants with that price (y-axis) for each city. Most restaurants, except in Mumbai, were in the medium to low price range. Prices for shark dishes in Puducherry and Thane did not exceed average seafood prices.

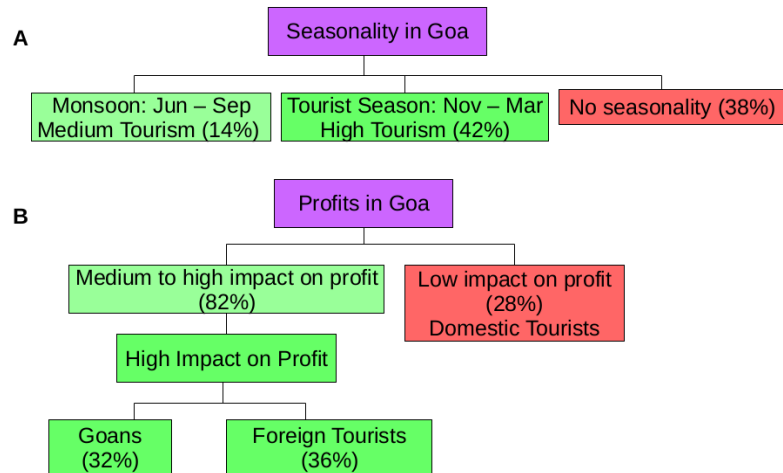


Figure : Classification tree analysis. Figure 3A depicts that elasmobranch demand was highest in the tourist season. Figure 3B depicts that removal of elasmobranchs from the menu was expected to have the highest impact on profit in restaurants serving Goans and foreign tourists.