

CHAPTER 2
REVIEW OF
LITERATURE

2.1 Taxonomy and Systematics

Research on the taxonomy of elasmobranchs in Indian seas has been conducted for centuries. The earliest ichthyologists to study elasmobranchs in Indian waters were Latham (1794), a British naturalist. Latham is credited with being the first to study Indian elasmobranch and described *Anoxypristis cuspidata* from Malabar (Kerala). In 1801 publication *Systema Ichthyologiae*, German naturalists Bloch and Schneider identified multiple new elasmobranch discovered around the Coromandel coast of India, namely *Aetobatus flagellum* and *Rhina ancylostomus*. During the colonial period, several researchers, including Shaw (1803); Russell (1803); Hamilton (1822); van Hasselt (1823); Cuvier (1829); Gray (1832); Henle (1834); Cantor (1837); Müller and Henle (1838-1841); Swainson (1839); McClelland (1841); Blyth (1847); Gray (1851); Jerdon (1851); Dumeril (1852); Bleeker (1853); Blyth (1860); Dumeril (1865); Day (1865); Gunther (1870); Day (1873); Day (1876); Alcock (1889); Alcock (1891); Alcock (1898); Alcock (1899); Lloyd (1908); Lloyd (1909); Annandale and Jenkins (1909) made significant contributions to the understanding of elasmobranch fauna in Indian waters (Bloch and Schneider, 1801).

Early ichthyologists described a number of new chondrichthyans found in Indian waters. However, many of these species have now been synonymized or deemed invalid, such as *Trygon ellioti* (Blyth, 1860), described from India, now serve as synonyms for *Himantura uarnak* (Gmelin, 1789). *Trygon gerrardi* (Gray, 1851), also described from India, is valid as *Maculabatis gerrardi* (Gray, 1851). Additionally, *Zygaena indica* (van Hasselt, 1823), described from India, is now a synonym of *Sphyrna lewini* (Griffith and Smith, 1834).

After 1940, only a few numbers of new species were identified in the Indian waters. Some of these species have a questionable, invalid, or uncertain status, such as *Carcharias watu* (Setna and Sarangdhar, 1946); *Rhinoptera sewelli* (Misra, 1946); *Proscyllium alcocki* (Misra, 1950); *Chiloscyllium confusum* (Dingerkus and De Fino, 1983), among others. The following new species have been described and are deemed legitimate in Indian seas: the deepwater scyliorhinid shark, *Pentanchus investigatoris* (Misra, 1962) found in Andaman waters, and the *Cephaloscyllium silasi* (Talwar, 1974a) discovered in the deep waters off Kollam coast, Arabian Sea. The species

referred to is the deep-sea skate *Rhinobatos variegatus* Nair and Lal Mohan (1973) was found in the Gulf of Mannar, whereas *Heteronarce prabhui* Talwar (1981a) was discovered off the coast of Kollam in the Arabian Sea. Cubelio et al. (2011) introduced a new shark species, *Mustelus mangalorensis*, using specimens obtained from Kochi.

Day (1889) conducted one of the first comprehensive studies on the variety of chondrichthyan species in Indian waters, documenting a total of 69 species. Misra (1947, 1952) documented a total of 52 species found in Indian waters. In a subsequent, more comprehensive study, Misra (1969) confirmed the presence of 114 elasmobranch species. Talwar and Kacker (1984) documented a total of 76 chondrichthyans. Hanfee (2000) documented a total of 98 elasmobranchs. Raje et al. (2002) documented a total of 110 elasmobranch species found in the Indian Seas. The guide published by Raje et al. (2007) provides a comprehensive list of 84 commercially significant elasmobranch species found in India's fishery. The book includes information on their distribution patterns and their relevance in the fishery.

The scope of chondrichthyan taxonomy research conducted by a few researchers was restricted to specific groupings or geographical areas. Alcock (1889, 1898) primarily focused on deep-sea elasmobranchs. Setna and Sarangdhar (1946) conducted research on elasmobranchs found in the waters of Bombay. Jones and Kumaran (1980) conducted research in the waters of Laccadive. Dutta and Roy (1977) presented comprehensive information on the elasmobranchs found in the Sunderbans. Venkataraman et al. (2003) created a manual for recognizing and distinguishing different types of sharks found in the waters of India. Sujatha (2002) presented comprehensive information on the batoids found in Vizakhapatanam. Rajan et al. (2012) highlighted the diversity of elasmobranchs found in the waters of Andaman. Only a limited number of research studies have documented the elasmobranch species present in the fisheries. These include works by Joshi et al. (2008) and Akhilesh et al. (2011a) from Kochi, Mohanraj et al. (2009) from Chennai, and Hanfee (1999) from Tamilnadu and Kerala.

Research is revealing the wide range of elasmobranch species in India, and new species are consistently being discovered and added to the community. Only a limited number of articles included comprehensive taxonomic descriptions and identification keys, focusing mostly on taxonomy, morphometric remarks, distributional data, and

unusual occurrences. Notable research on the taxonomy of elasmobranchs in India includes Chaudhuri's (1911) comprehensive examination of freshwater stingrays found in the Ganges. Raj (1914a) presented specific information regarding *Neotrygon kuhlii*. Prashad (1920) presented precise taxonomic information regarding torpedo rays. Setna et al. (1948) described *Scoliodon laticaudus*. Setna and Sarangdhar (1949a) presented a comprehensive description of *Rhizoprionodon acutus*, *Hemipristis elongatus*, and *Torpedo zugmayeri*. Kewalramani and Chhapgar (1957) documented the presence of *Taeniura melanospila*. Silas (1969) and Silas et al. (1969) documented the presence of *Echinorhinus brucus*, *Neoharriotta pinnata*, and *Atractophorus armatus* along the southwest coast. Silas and Prasad (1969) documented the deep-sea shark, *Squalus fernandinus*, along the southwest coast of India. Nair and Lal Mohan (1971) documented the presence of *Echinorhinus brucus* along the eastern coast of India. In 1972, Nair and Lal Mohan documented the presence of *Centrophorus armatus* off the east coast. Silas and Selvaraj (1972) provided a comprehensive account of the characteristics and features of the bramble shark species *Echinorhinus brucus*. Nair and Soundararajan (1973a) documented the presence of the deep-sea stingray *Plesiobatis daviesi* in the Gulf of Mannar. Nair et al. (1974) provided a detailed account of four pelagic sharks belonging to the family Carcharhinidae. Talwar (1974b) presented a systematic description of *Sphyrna lewini* from the eastern coast, focusing on its taxonomy. Nair and Soundararajan (1976) documented the presence of the sting ray species *Dasyatis microps* in the Gulf of Mannar. Rajagopalan and Meiyappan (1976) provided a more detailed description of *Negaprion acutidens* from Lakshadweep. Talwar (1976) presented a taxonomy description of *Rhizoprionodon oligolinx*. Devadoss and Natarajan (1977) documented the presence of the hammerhead shark species, *Sphyrna zygaena*. James (1980) presented a comprehensive taxonomic description of *Himantura maginata* found in the Gulf of Mannar. Silas and Selvaraj (1980) presented taxonomic observations on *Neoharriotta pinnata*. Talwar (1981a) provided a detailed report on electric rays belonging to the genus *Heteronarce* (Torpedinidae) and identified a previously unknown species. Talwar (1981b) conducted research on Indian water torpedoes. Talwar (1981c) provided more details regarding the type specimens of the scyliorhinid shark *Bythaelurus hispidus*.

Compagno and Talwar (1985a) first documented the presence of *Heptranchias perlo* along the Indian coast. Compagno and Talwar (1985b) presented a

comprehensive analysis of the generic connection and status of the *scyliorhinid* catshark, *Cephaloscyllium silasi*. Silas and Selvaraj (1985) initially documented the presence of *Dasyatis centroura* in Indian waters. Devadoss (1987) provided a detailed description of the characteristics and features of *Chiloscyllium griseum*. Devadoss (1988) documented the presence of the fantail ray species *Taeniura melanospila*. Mathew et al. (1991) documented the presence of *Centrophorus granulosus* in the Indian waters. Ramaiyan and Sivakumar (1991) created a manual for identifying the sharks, skates, and rays found around the Parangipettai coast. Sujatha (2002) presented comprehensive information on batoid fishes found at Visakhapatnam. Devaraj and Gulati (2004) published a study on the morphometry of the dusky shark, *Carcharhinus obscurus*, found along the west coast of India. Dholakia (2004) presented a field identification key for seven elasmobranchs. Soundararajan and Roy (2004) documented the presence of deep-sea sharks, specifically *Centrophorus acus* and *Squalus megalops*, in the waters of Andaman. In 2006, Nair reported the presence of *Rostroraja alba* on the west coast of India. Nair (2007) presented a taxonomic description of *Raja miraletus*. Akhilesh et al. (2008, 2009) presented the morphometric features of the stingrays *Pteroplatytrygon violacea* and *Plesiobatis daviesi*. Akhilesh et al. (2010) documented the presence of deep-sea sharks, specifically *Deania profundorum*, *Hexanchus griseus*, and *Centrophorus squamosus*, along the west coast. Deepu et al. (2010) presented a taxonomy description of *Etmopterus pusillus*. Akhilesh et al. (2011b) provided an updated description of *Halaaelurus quagga*, a species found on the southwest coast of India. In their study, Babu et al. (2011) documented the presence of *Hexatrygon bickelli* along the southwest coast of India. In their study, Zacharia et al. (2011) documented the presence of *Pteroplatytrygon violacea* along the east coast of India. Kumar et al. (2012) documented the presence of *Alopias pelagicus* in the Lakshadweep. Suresh and Raffi (2012) documented the presence of *Neoharriota pinnata* in Nagapattinam. Balakrishnan et al. (2012) examined the presence of scalloped hammerhead sharks (*Sphyrna lewini*) in the coastal waters of Kakinada. Akhilesh et al. (2013a) documented the presence of *Zameus squamulosus*, commonly known as velvet dogshark, in the waters of India. Akhilesh et al. (2013b) and Kizhakudan and Rajapackiam (2013) Documented crocodile shark *Pseudocarcharias kamoharai* is found in Kochi and Chennai, respectively. Akhilesh et al. (2014) presented a detailed taxonomic information of *Cephaloscyllium silasi*. Bineesh et al. (2014) validated the presence of *Rhynchobatus australiae*, *Aetomylaeus*

vespertilio, *Dasyatis microps*, and *Himantura granulata* along the southwest coast of India. Ramachandran et al. (2014) documented the presence of *Echinorhinus brucus* in the Lakshadweep Seas. In their study, Gowthaman et al. (2014) documented the presence of *Alopias superciliosus* in the Gulf of Mannar.

Bineesh et al. (2014) confirms the occurrence of *Rhynchobatus australiae*, *Dasyatis microps*, *Himantura granulata*, and *Aetomylaeus vespertilio* in the Arabian Sea coast of India. Sutaria et al. (2015) first time recorded sandbar shark from the Indian waters. Manjaji-Matsumoto and Last (2016) describe two new species *Maculabatis arabica* and *Maculabatis bineeshi* from the northern Indian ocean. Akhilesh et al. (2016) redescribed the *Lamiopsis temminckii* (Müller and Henle, 1839) from the northeastern Arabian Sea. Tyabji et al. (2018) reported twelve species of sharks from the Andaman and Nicobar Archipelago, India. Ranjan et al. (2018) confirms the new distributional records of four rare deep-water shark viz. *Heptranchias perlo*; *Hexanchus griseus*; *Echinorhinus brucus*, and *Neoharriotta pinnata* from the Andaman waters, India. Kizhakudan et al. (2019) confirm the occurrence of *Hemitrygon bennettii* (Müller and Henle, 1841), from the western Bay of Bengal. Roy et al. (2019), reported three species of electric ray *Torpedo sinuspersici*, *Torpedo fuscomaculata* and *Narcine prodorsalis* for the first time from Odisha coast. Bineesh et al. (2020) confirms fifteen new records of Batoids from Andaman and Nicobar Islands, India. Kumar et al. (2021) reports the occurrence of two stingray species: *Gymnura zonura* and *Urogymnus granulatus* from Andaman waters, India. Borichangar et al. (2023a) confirm the occurrence of *Chiloscyllium griseum* from Dholai port, Gujarat. Borichangar et al. (2023b) first time reported *Chiloscyllium indicum* from the Gujarat. Borichangar et al. (2023c) reported *Chiloscyllium griseum* (Müller and Henle 1838) from Southwest Coast of Gujarat. Kumar et al. (2024) recorded rare deep-sea shark *Scymnodon ichiharai* from Andaman Waters, India. Baldaniya and Mankodi (2024) reported *Urogymnus granulatus* from the Gujarat.

Research on the distribution, geographic patterns, depth ranges, migration, and population size of elasmobranchs (sharks, rays, and skates) in Indian waters is scarce. Misra and Menon (1955) provided information on the distribution of elasmobranchs and chimaeras in the Indian region, specifically in relation to the average annual temperature lines. Mathew et al. (1996) presented the distribution pattern and

abundance of elasmobranchs in the Indian Exclusive Economic Zone (EEZ) based on surveys conducted by the research vessel FORV Sagar Sampada. Somvanshi et al. (2009) examined the distribution pattern of the pelagic stingray *Pteroplatytrygon violacea* in the Indian Exclusive Economic Zone (EEZ). Sinha et al. (2010) presented a study on the spatial and temporal patterns of the occurrence, abundance, and variety of oceanic sharks in the waters of the Andaman Sea.

2.2 The Indian Fishery

India has a lengthy historical record of elasmobranch fishery. In 1863, Day provided an initial report on the fisheries, noting the presence of many species of sharks and rays, such as dog sharks, carcharhinids, hammerhead sharks, and occasionally huge sharks. The observed species included *Myliobatis* sp. and *Pristis* sp. Sharks are captured with hooks and lines and are seldom consumed in their raw state. Instead, they are commonly preserved by salting and drying. Shark meat is believed to have beneficial effects on pregnant women, and it is commonly referred to as milk shark or Palsoora due to its reputed ability to enhance lactation.

According to Day (1863, 1865), shark and ray livers were utilized for the production of oil. This oil was then employed as a substitute for cod-liver oil in Government hospitals. Elasmobranch liver oil production was initially located in Cochin but later moved to Calicut. According to Day (1863), shark fishing was a significant occupation for both the residents of the Bombay region and those living along the west coast of India. Sharks caught from various locations around the coast were transported to Bombay and subsequently exported to China and other regions worldwide (Anon, 1856). Prior researchers such as Day (1878), Günther (1880), Thurston and Rangachari (1909), and Thurston (1913) have also documented the elasmobranch fishery in Kerala. They noted that products such as dried fish, fish maws, shark fins, and fish oil were exported to Sri Lanka, Southeast Asia, China, Japan, and Europe.

Several researchers have presented a comprehensive analysis of elasmobranch fishery. Ayyangar (1922) given a detail of Lakshadweep Sea fishery. Hornell (1925, 1938) provided details regarding the elasmobranch fisheries along the Coramandal and Malabar coast. Pillay (1929) provided an analysis of the elasmobranchs observed in the

fishing around the Kerala coast. Sorley (1932) presented comprehensive information regarding the fisheries in Bombay. John (1946) presented specific information regarding shark fishing in the vicinity of Madras. Devanesan and Chidambaram conducted research in 1948 and 1953 provided a comment about the fishery in Madras. Chidambaram and Menon (1946) talked about the shark fishing of Madras. In 1951, Bal and Banerji claimed that in 1949, 15% of the total capture consisted of rays from Cuddalore, Tamil Nadu. Chopra (1951) provided a comprehensive list of the primary species found in the Indian fishery. Bhimachar and Venkataraman (1952) presented a comprehensive account of the species found along the Malabar coast and noted that *Scoliodon laticaudus* is the prevailing species. Jones and Sujansingani (1954) presented specific information about elasmobranchs in the Chilka lake fishery. In 1956, Panikkar stated that elasmobranchs accounted for 4.16% of India's total marine productivity from 1950 to 1954. Gokhale (1957) provided an analysis of the fishing equipment used in the Saurashtra region. John et al. (1959) documented the elasmobranchs that were captured during fishing trials conducted near Madras. Jones and Kumaran (1959) talked about the fishing sector of Minicoy Island.

Kaikini (1960) provided a comprehensive account of the fisheries in Malwan. Thyagarajan and Thomas (1962) provide comprehensive information on the crafts and gear employed in elasmobranch fishing in Madras. Balasubramanyan (1964) presented a comprehensive account of the specific types of bait employed in the elasmobranch fishery. In 1966, Nagabhushanam provided information on the elasmobranch resources found around the coasts of Andhra and Orissa. Deshpande et al. (1970) presented comprehensive information on shark longlining in Veraval. According to James (1973), sharks, rays, and skates have the potential to be utilized as fishing resources in the eastern coast of India. Kartha et al. (1973) conducted a study on the bottom drift long line fisheries near Veraval. Pai and Pillai (1973) presented the catch and effort data from trawl surveys conducted in the south-eastern coast, categorized by geographical areas. Jhingran (1975) provided a detailed description of commercially significant elasmobranchs. Devadoss (1978) conducted a study on the batoid fisheries in Cuddalore. Pillai and Honma (1978) investigated the seasonal dispersion of pelagic sharks captured by tuna longliners in the Indian Ocean.

Silas et al. (1984) emphasized the significance of small-scale fisheries and elasmobranch resources in the context of the drift gillnet fishery off Kochi. Dholakia and Vasavda (1985) presented specific information regarding the shark catch in Saurashtra, Gujarat. A deep-sea shark fishery was documented in the waters of Andaman in 1984, as reported by Mustaffa (1986). Appukuttan and Nair (1988) provided commentary on the elasmobranch resources found along the east coast. Devadoss et al. (1989) discussed the current state and potential future of elasmobranch fisheries in India. Kumaran et al. (1989) documented the presence of drift long lines, referred to as 'Bayp' by the local community, with the purpose of capturing sharks and other large fishes are found in all the islands except Minicoy. Harpoons are employed to capture rays (*Manta birostris*, *Aetobatus narinari*, and *Dasyatis sp.*) and sharks in the open waters surrounding the islands. Sukumaran et al. (1989) presented comprehensive information on shark longlining activities in Malpe.

Kasim (1991) provided a thorough account of the shark fishery that takes place along the Veraval coast. Dahlgren (1992) stated that there is a specific shark fishery on the east coast that is influenced by the timing of the seasons and the presence of the target species. Mathew (1992) gave details about the *Scoliodon laticaudus* fishery in the waters of Maharashtra. Joel and Ebenezer (1993) discussed the practice of specifically using long-line fishing to catch sharks. Vivekanandan and Zala (1994) conducted a study on the whale shark fisheries in Veraval. Devadoss (1996) provided an observation on the practice of shark fishing in India. Rao (1998) documented the fishing activity for sharks using hooks and lines in Janjira-Murud (Maharashtra) by fishermen who had migrated from Kanyakumari. Pravin et al. (1998) highlighted on commercial fishing of whale shark, Gujarat. Devadoss et al. (2000) presented comprehensive information on the elasmobranch resources found in India. Pillai and Biju (2000) presented comprehensive information on the pelagic shark fishery in the Indian water emphasising on their exploitation and trade.

Bhargava et al. (2002) discussed the issue of unintentionally catching pelagic sharks while fishing for tuna using longline methods. Jayaprakash et al. (2002) conducted a study on the drift gillnet fisheries targeting large pelagic fish and the incidental capture of pelagic sharks in Kochi. Raje et al. (2002) provided a comprehensive description of the elasmobranch fishery in India. In certain areas of

Tamil Nadu coast large meshed bottom set gillnets called Thirukkuvalai are operated for ray (Thirukkai) fishing (Raje et al., 2002). Nair and Venugopal (2003) documented on targeted shark fishery in Kerala. John and Neelakandan (2003) examined the issue of unintentionally catching oceanic sharks in tuna longline fishing. Raje and Joshi (2003) provided account of the shark fishery in India. D'Cruz (2004) presented a comprehensive analysis of the historical and social factors related to fishers. Dholakia (2004) presented a comprehensive overview of the Indian elasmobranch fisheries, with a particular focus on Gujarat. Srinath et al. (2006) documented the annual capture data of elasmobranchs from Indian coastal states starting in 1985. Varghese et al. (2007) conducted research on the incidental capture of sharks in surveys using tuna longline fishing methods. Joshi et al. (2008) provided their insights on the evolving shark fisheries in Kochi. Vivekanandan and Sivaraj (2008) presented comprehensive information on the fisheries of elasmobranchs in India. John and Varghese (2009) documented the decrease in catch per unit effort for marine sharks in the Indian Exclusive Economic Zone (EEZ).

Mohanraj et al. (2009) conducted a study on the elasmobranch fisheries in Chennai. Zacharia and Kanthan (2010) presented specific information regarding the fisheries of skate and ray species in Tuticorin. Akhilesh et al. (2011a) presented a report on the practice of fishing for deep-sea sharks off the southwest coast. Kar et al. (2011) presented information on the incidental capture of elasmobranchs in the tuna longline fishing around the Andaman and Nicobar Islands. Rajan et al. (2012) presented the species composition of the elasmobranch fishing in the Andaman Islands. Sajeevan and Sanadi (2012) conducted a study on elasmobranchs, which are significant marine resources in the Andaman Islands, as previously mentioned by John and Somvanshi (2000), John et al. (2005), and Somvanshi et al. (2009). Akhilesh et al. (2013c) presented data on the landing of the deep-sea shark, *Echinorhinus brucus*, in Kochi.

2.3 Post-Harvest processing

Processing is a crucial post-harvest procedure in the fishery industry that provides significant advantages to millions of people and generates substantial economic gains. The first recorded evidence of the elasmobranch liver oil industry in India dates back to 1852 (Iyengar, 1950; Chopra, 1951). The main species targeted for their liver include *Galeocerdo cuvier*, *Carcharhinus melanopterus*, *Sphyrna blochii*,

and *Anoxypristis cuspidatus*. Day (1889) documented the establishment of the shark liver oil industry on the west coast at Calicut in 1854, which involved the extraction of oil from sharks and sawfish. Rajagopal (1942) documented the presence of vitamin A in shark liver oil. Aiyar (1943) provided a comprehensive account of sharks and the shark-liver oil industry in India. John (1943) presented specific information regarding the shark liver oil industry in India. Gajjar (1944) conducted research on the chemical composition of shark liver oil obtained from Bombay. Kini and Chidambaram (1947) conducted studies on the liver oils of elasmobranchs found in southern India. Samuel (1951) documented elasmobranch fisheries and provided information regarding the shark liver oil industry. Pathak et al. (1952) examined the fatty acid composition of Indian shark liver oil. Gupta et al. (1953) conducted a study on the unsaturated fatty acids found in the liver oil of *Galeocerdo cuvier*. Setna (1954) presented comprehensive information on the sharks and the shark liver oil industry in India. Ghanekar and Bal (1955) conducted research on the enzymes found in elasmobranchs from Bombay. Bal and Ghanekar (1956) conducted research on the lipases of *Scoliodon sorrakowah* and *Rhynchobatus djiddensis*. Ghanekar et al. (1956) investigated the amylases of *Scoliodon sorrakowah* and *Sphyrna blochii*. Ambe and Sohoni (1957a, b, c) conducted research on the proteins found in sharks and skates and provided an analysis of their nutritional worth. Bose et al. (1958) documented the technique of shark flesh processing. Kamasastri (1959) conducted research on the chemical characteristics and alterations that occur in the ray liver oils after preservation. Kandoran et al. (1965) documented the process of preserving sharks and rays. Kamdar et al. (1967) conducted research on shark liver oil and the substances remaining after its extraction. Sastry and Ramachandran (1965) examined the protein constituents of Elastoidin. Mathen (1970) conducted research on the characteristics and durability of dehydrated shark products. Ramachandran et al. (1974) provided a description of shark fin processing processes used to extract fin rays. In 1978, Solanki and Venkataraman provided a detailed account of the freezing properties of both fresh and brined shark fillets. Chandran (1980) documented the methods used for the handling and processing of sharks in the Lakshadweep region. Devadoss (1984c) provided an analysis of the nutritional content of sharks, skates, and rays found along the Portonovo coast. Parab and Rao (1984) examined the distribution of TMAO in sharks. Dholakia and Vasavda (1985) documented the process of manufacturing shark liver oil for commercial use in Gujarat.

Ghadi and Ninjoor (1989) provided an explanation on the biochemical and sensory assessment of shark spoilage.

Ramachandran and Solanki (1991) examined the processing and storage properties of semi dried shark products. Sankar and Solanki (1992) investigated the alterations in nitrogen components inside the fillets of elasmobranchs that occurred throughout the process of salting. Venugopal et al. (1994) investigated the process of gelation in shark myofibrillar proteins using weak organic acids. Venugopal et al. (1997) provided a detailed description of a heat-resistant mixture of water and shark meat and explained how it used for making protein powder. Ramachandran (1990) and Sankar (1992) provided a detailed account of how elasmobranch fillets are processed and the specific properties of their frozen storage. Vannuccini (1999) and Varma (1999) provided commentary on the processing and trading of sharks. Mathew and Shamasundar (2002) conducted a study on the impact of ice storage on the functional characteristics of proteins derived from the meat of the shark species *Scoliodon laticaudus*. Mathew et al. (2002) conducted research on the impact of water washing on the protein composition of *Scoliodon laticaudus* shark meat. Mathew et al. (2008a, b) conducted research on the pain-relieving and anti-inflammatory effects of liver oils from four shark species found in the Indian Exclusive Economic Zone (EEZ). They also analysed the lipid profile of liver oil from *Neoharriota pinnata*, a species found in the Arabian Sea. Ravitchandirane and Yogamoorthi (2008) conducted a study on the pain-relieving and anti-inflammatory effects of raw extracts from the stingray species *Dasyatis zugei*. Ravichandirane et al. (2012) examined the analgesic and anti-inflammatory effects of crude extracts from the ray species *Narcine brunnea*. Sathyan et al. (2012) discovered a potential antibacterial peptide called Himanturin in the round whip ray species *Himantura pastinacoides*. Ravitchandirane et al. (2013) conducted a study to analyze and describe the bioactive chemicals found in sting ray species known as *Dasyatis jenkinsii*. Kalidasan et al. (2014) conducted a study on the antibacterial and anticoagulant properties of the stingray species *Himantura imbricata*.

2.4 Trade

Günther (1880) provided one of the earliest records of elasmobranch trade, stating that in 1845-46, a total of 446.4 tons of shark fins were exported from Bombay to China. Day (1878) documented the exportation of sawfish fins from India to China.

In 1872, fins of sharks and rays, as well as fish-maws, were shipped from Karachi to Bombay and then re-exported to China. Shark fins were utilized in the making of soup, a highly esteemed culinary delicacy in Southeast Asia. Grades were employed during the export process, with black is used for pectoral, ventral and anal fins which is of low price and white for dorsal fin which has more gelatin and price. The skins of *Pastinachus sephen* and certain species of sharks were transformed into shagreen, as documented by Day (1889). Shark meat was eaten on the Malabar coast and was seen as nutritious for postpartum mothers. In Bombay, it was mostly bought by African sailors (Day, 1889).

John (1943) presented comprehensive information on the shark liver oil industry in India. Jones and Sujansingani (1954) documented the trade between Chilka and Bengal in 1949. Since the 1960s, there has been a significant demand for fresh, salted, and dried shark meat in the South Indian states of Kerala and Tamil Nadu (Frej and Gustafsson, 1990).

Hanfee (1996) conducted a study on the trade of sharks and shark goods in India. Hausfather (1999) examined the number of sharks caught and recorded by focusing on the export of shark fins. Vannuccini (1999) provided a comprehensive description of the use of sharks in India. Varma (1999) provided information about the specifics of the Indian shark fishery sector. Rajapackiam et al. (2007) studied the use of gill rakers in the feeding behaviour of the lesser devil ray *Mobula diabolus*. Dhaneesh and Zacharia (2013) provided a commentary on the shark fishery in India.

The Marine Products Export Development Authority (MPEDA), a department under the Ministry of Commerce, Government of India, consistently gathers data on the export of marine products from the country. Unfortunately, comprehensive data regarding the quantity, value, product details, species and destination country for elasmobranch exports from India is largely unavailable due to the export of processed items.

2.5 Bibliometric Analysis of Indian Elasmobranch Research from Scopus Database

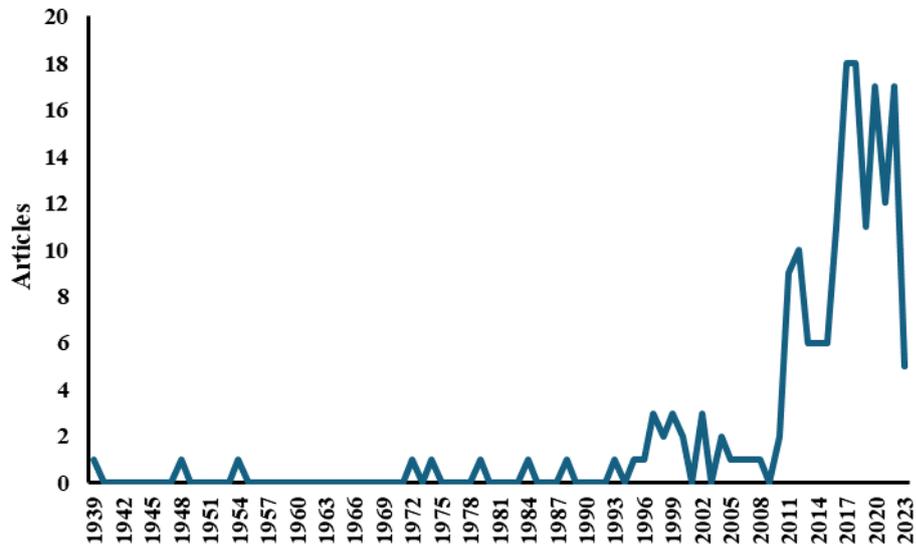


Figure 2.1: Annual scientific production

The data spans from 1939 to 2023 and illustrates a substantial evolution in article publications (Fig. 2.1). Initially, from 1939 to 1971, publication activity was minimal, often with zero or only one article per year. Notably, in 1972, 1974, and 1979, one article was published each year, with similar occurrences in 1984 and 1988. The mid-1990s marked a turning point, with a significant surge in annual articles from 1996 onwards. This trend continued into the 21st century, peaking at 18 articles in both 2017 and 2018. While recent years show some fluctuations, the data overall signifies a remarkable increase in research output, reflecting heightened scientific activity in Elasmobranch research.

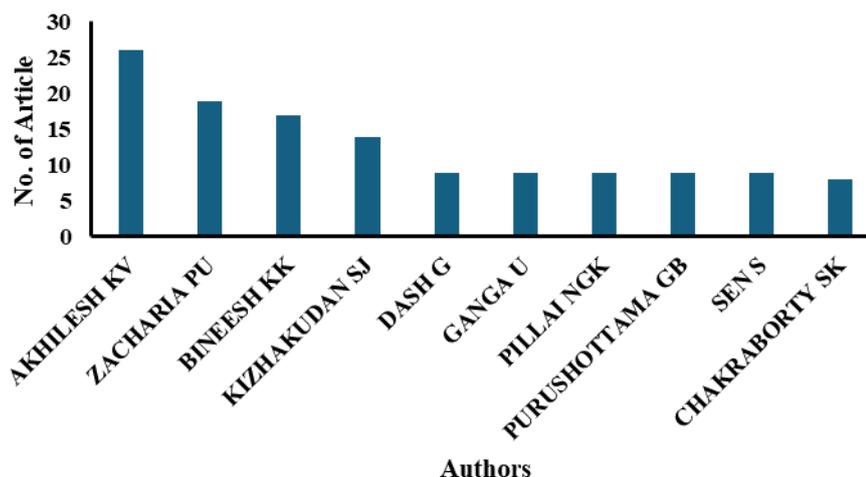


Figure 2.2: Most Relevant authors

The data reveals the research contributions of various authors (Fig. 2.2), notably highlighting Akhilesh K V with 26 articles and Zacharia P U with 19 articles, demonstrating significant research output. Bineesh KK follows closely with 17 articles, while Kizhakudan SJ has contributed 14 articles. several authors, including Dash G, Ganga U, Pillai NGK, and Purushottama GB, have each authored 9 articles, underlining consistent contributions. Sen S aligns with this group, emphasizing the productivity of these authors. Chakraborty SK has contributed 8 articles. in summary, this data underscores the active and productive research activities of these authors, with Akhilesh KV leading in terms of the number of articles authored, collectively representing significant contributions into the Elasmobranch research.

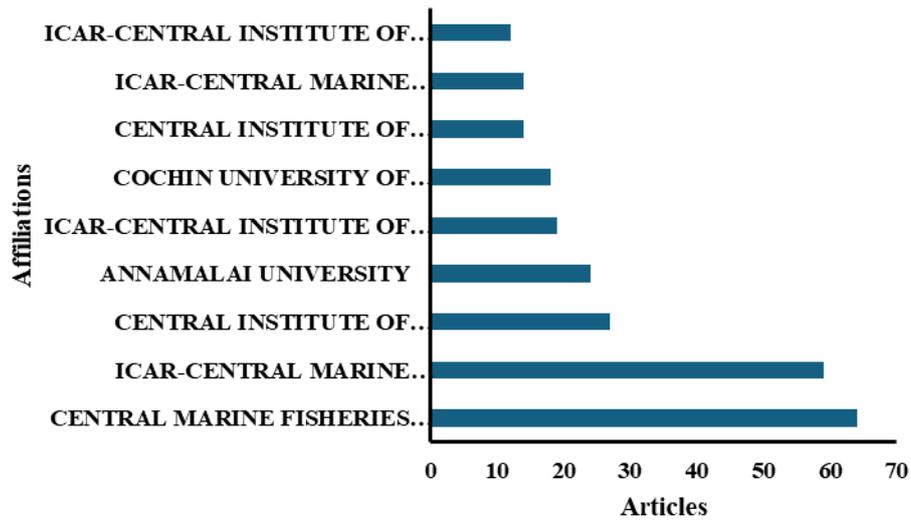


Figure 2.3: Most Relevant Affiliations

The exported data reveals the affiliations of research articles (Fig. 2.3), with "Central Marine Fisheries Research Institute" leading the list with 123 articles, followed by "Central Institute of Fisheries Education" with 46 articles, and "Annamalai University" also make substantial contributions with 24 articles. "Cochin University of Science and Technology" with 18 articles. These affiliations represent significant centres of research in the field of marine fisheries, emphasizing their contributions to this area of elasmobranch research.

ORIGIN OF STUDY

Based on the limited knowledge available in the literature concerning the diversity and fishery of elasmobranch fishery in the Gujarat maritime zone, there is an urgent need to generate more reliable data on these species. This information is crucial for developing sustainable fishing practices and effective fishery management policies. Recognizing the significance of Elasmobranch fishes, the present study aims to systematically investigate the diversity and fishery status of elasmobranchs in the Maritime Zone of Gujarat state.

The present study was conducted with the following objectives.

1. To Study the Species Diversity and Molecular Characterisation of Elasmobranch Fishes from Maritime Zone of Gujarat.
2. Elasmobranch Fishery Data Analysis.
3. Post Harvesting Utilization of Elasmobranchs.