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Chapter 1

Introductory Chapter: The Elasmobranchs as a Fishery Resource

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1. Introduction

The elasmobranchs (sharks, rays, and skates) represent one of the most ancient vertebrate lineages, which have survived a number of different mass extinction events over the past 400 million years [1]. Approximately 1200 elasmobranch species are currently found in the world's oceans [2]. These fishes have a cartilaginous skeleton, with five to seven branchial clefts [3, 4].

However, the full diversity of the elasmobranchs is still unclear, and a number of species have been described in recent years, principally from the waters of Asia and Oceania [5–8]. In one of the most recent taxonomic reviews, the sharks were defined as a group with 8 orders, 34 families, and approximately 500 species. The rays include 5 orders, 20 families, and around 574 species [9, 10]. In recent years, the application of molecular tools in combination with morphological analyses has led to a significant increase in the known diversity of elasmobranch species [6, 11]. One of the most important molecular tools is the DNA barcode [12], which provides a rapid and reliable approach for the identification of taxonomic groups, especially those which may contain cryptic species, that is, taxa that are morphologically indistinguishable, but genetically distinct, highlighting the need for systematic reviews [7, 13, 14].

Recent studies of elasmobranch diversity have focused primarily on the Asian domain and have included the description of new species [5, 7, 15], the re-organization of some families [11], and the re-establishment of others [8]. All these diversities have been "discovered," thanks to the systematic combination of molecular and morphological approaches, with molecular tools being especially useful for the delimitation of groups or species thought to contain cryptic diversity [16, 17] or that need internal review [18]. Morphological analyses, in turn, provide the basic parameters necessary for the identification and description of taxa [8].

This introductory chapter highlights the gaps in our understanding of the diversity of the Chondrichthyes and provides important background for the understanding of the central issues that will be discussed in this book.

2. Elasmobranchs and fisheries

The trade in fishery resources, such as elasmobranchs, has long been an important economic activity of coastal populations, which exploit not only the meat of these fishes but also a number of subproducts derived from these animals [13, 14, 19, 20]. Worldwide, however, the exploitation of this resource has increased at an alarming rate in recent years and often involves unsustainable practices, which have led many species to the brink of extinction [21]. Overfishing is a major cause of the decline of fish stocks around the world, and the populations of sharks and rays have declined drastically in many regions [22, 23].

Industrial fisheries are estimated to have reduced the biomass of large fish by approximately 10% [24]. As a result of overfishing, the stocks of many elasmobranch species have declined steadily around the world, and they are now at risk of extinction. A number of factors have contributed to this decline, including the degradation of habitats essential to the development of the species and bycatch [25–29].

The reduction in the availability of other fishery resources has also led to an increase in the consumption of elasmobranchs. While the meat of sharks and rays demands a lower market price than that of most other marine fish species, there is an enormous market for shark fin, which is highly valued [30, 31]. The high price of shark fin stimulates the practice of finning, in which the fins are extracted and the shark carcass is discarded. The thriving Asian market for shark fin stimulates high prices for the byproduct and favors predatory fishery practices [27, 28, 32, 33].

In a recent global study of fishery catches of the Chondrichthyes, [34] demonstrated that these fishery practices, combined with the increasing demand for byproducts, have resulted in a decline in stocks of approximately 20% over the past decade, highlighting the association between fishing pressure and impacts on the ecosystem. In addition to predatory fishery practices, the biological characteristics of the elasmobranchs, which are *K* strategists, underpin the vulnerability of this taxon to fisheries. Species that are *K* strategists typically have a low reproductive output and delayed sexual maturation, which contribute to the potential risks of fishery exploitation [35].

3. Biological data vs. fisheries

The internal reproductive system is one of the characteristics that have contributed to the evolutionary success of the Chondrichthyes [36]. However, the reproductive characteristics of this group also result in low rates of population expansion, extended longevity, slow growth,

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late sexual maturation, and the production of relatively few offspring. Together, these characteristics represent a high level of investment on the part of the female in the reproductive process and in each individual offspring, resulting in a progeny relatively small in number but high in quality, with an extended life expectancy, which may compensate for natural rates of mortality [3, 4, 37].

The ongoing growth in the commercial exploitation of the elasmobranchs has reinforced the need for more adequate public policies and management strategies designed to guarantee the sustainability of this fishery resource. The development of measures of this type is increasingly difficult, given the general lack of data, not only on the biology of most shark and ray species but also on the fisheries that target these species [38]. Given this, understanding the biological and demographic features of the target species, as well as the effects of fisheries on their populations, will be fundamentally important for the development of adequate management programs [39].

Perhaps, the most interesting aspect of the life history strategy of the elasmobranchs is their reproductive biology, which is geared to the production of small progenies. In most species, progenies contain between 2 and 20 offspring [39–41]. Breeding is not always annual, given that the gestation period of some species may exceed 1 year, while in others, there is an extended pause between gestations [42–44].

These characteristics of the reproductive biology of the chondrichthyans, such as the small size of the progeny, impose both biological (abundance) and economic limitations on the potential for the exploitation of this fishery resource [37]. The late maturation of many species, which may take decades to reach adulthood, and the long gestation periods, of up to 2 years in some cases, further compound these limitations [45].

These reproductive traits characterize the elasmobranchs as typical *K* strategists [46], which implies a series of problems for the exploitation of this group as a fishery resource, given that one principal characteristic of *K* strategists is their dependence on relatively stable habitats and resources, including productive feeding grounds, to guarantee their reproductive success over the long term [39]. These characteristics of *K* strategists hamper considerably the maintenance of elasmobranch stocks in the context of human interference. Urban and industrial processes in the coastal zone have an intense impact on the habitats of many elasmobranch species. In addition, fisheries compete increasingly with sharks for the same resources (prey fish) and are harvesting growing numbers of elasmobranchs, either as target species or as bycatch [47].

As mentioned above, the biological characteristics of the group make the cartilaginous fish highly vulnerable to exploitation by fisheries [25]. In fact, overfishing has been identified as the principal threat to this group [42, 48] and many stocks have declined abruptly in recent years, with some populations being reduced by more than 90% [42, 48, 49]. Estimates of mortality indicate that intense fishery pressure will lead large sharks and many other species with similar biological characteristics to extinction within the near future [50]. In this sense, the elasmobranchs can be considered to be one of the planet's most endangered groups of vertebrates [27].

Given this, research initiatives that aim to contribute to the sustainability of marine species are hampered by the lack of data on the biology of the species and the status of their stocks [29]. In the specific case of sharks and rays, the reliable assessment of stocks is hampered by severe deficiencies in the fishery statistics [51], in particular, the assignment of captured specimens to general groups rather than specific species [52]. The adequate assessment of stocks and the development of effective management measures and even the conservation of species will require more precise data on the diversity of the species harvested and landed [29]. This will permit the development of appropriate conservation measures to guarantee the sustainability of populations over the long term [29, 53].

Many of the chondrichthyan species being exploited by commercial fisheries are not reported in official catch statistics, due in particular to the difficulties of identifying species reliably [54]. One of the principal factors that impede the reliable identification of species is the fact that most individuals are landed as headless carcasses with no tail or fins [53] and thus lack the morphological characteristics necessary for the identification of the species [55].

These problems are exacerbated by the lack of data on the diversity of the elasmobranch fauna of many regions of the world [56, 57]. In recent years, there have been considerable efforts in the Asian region, with wide-ranging phylogenetic and morphological inferences [5, 6], as well as the description of new species [7, 11, 15] and the reinstatement of a number of families [8].

An important step in the understanding of elasmobranch diversity is the identification of species. One of the principal difficulties for the identification of cartilaginous fish is the fact that most specimens are landed in processed form, such as the fins only, for example, which impedes the identification of the species based on morphological traits [4]. Given this, molecular markers are widely used for the identification of species, as in many other types of organisms of economic interest [58, 59].

In fact, molecular tools have become an essential approach for the identification of species, providing a systematic means of circumventing the difficulties imposed by the lack of diagnostic morphological traits [60]. Molecular identification is now used widely in research on elasmobranchs, based on a variety of genetic techniques [14, 32, 60–64]. The most widely used approach, which is both simple and effective and provides a good diagnosis of most animal taxa, is DNA barcoding [12], which is based on the analysis of a small fragment of the mitochondrial *Cytochrome Oxidase subunit I* (COI) gene of approximately 648 nucleotides. This diagnostic tool was developed with the ultimate objective of storing information on all known organisms in a universal database (the BOLD platform—http://www.boldsystems.org/) to be used for the identification of species [12].

The molecular identification of the different species of hammerhead shark (genus *Sphyrna*) provides an excellent example of the utility of these molecular tools for the conservation and management of these organisms [65]. In these sharks, the head is the principal diagnostic trait for the morphological determination of species, although it is invariably removed prior to the landing of catches, impeding the reliable identification of specimens encountered in fish markets. This problem can be overcome by using molecular tools for the identification of specimens, providing an important mechanism for the monitoring of the shark trade, as well as contributing to the development of management plans for the stocks of the different species.

Overall, then, the application of molecular tools for the identification of shark species and the analysis of their genetic diversity will be fundamentally important for the development of effective management plans for the stocks of the different shark species exploited by fisheries in northern Brazil. The genetic monitoring of fishery stocks is seen as a fundamental prerequisite for the sustainability of harvests, as well as the re-establishment of depleted stocks [14].

4. Conclusions

Predatory fishing practices have been fundamental to the inclusion of a large number of chondrichthyan species in the red list of endangered species. The conservation of the Class Chondrichthyes, which includes all cartilaginous fish (sharks, rays and chimeras), has provoked increasing levels of concern in recent years. Fisheries that target elasmobranchs have also increased their activities in recent years, impacting the stocks of these fish on a global scale. Despite this, the diversity, ecology, behavior, and many other characteristics of these species remain virtually unknown, which is a major cause for concern. This chapter provides researchers and other readers interested in this group of fish, not only with information on the Chondrichthyes but also an overview of the current status of this group and in particular the biological characteristics of these fish and their role as a fishery resource. A review of these features, combined with new research on the chondrichthyans, compiled in the chapters of this book, provide an essential source of detailed information on this important vertebrate group.

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