

# Taxonomic Review of Genus *Lutjanus* (Perciformes Lutjanidae): Species Delimitation and Phylogenetic Insights

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## Abstract

*Lutjanus* comprises many economically and ecologically important reef-associated fishes in the family Lutjanidae and is commonly known as snappers. This review is the taxonomic synthesis of the genus, with an emphasis on the taxonomy, species richness, and key morphological, ecological, and genetic features. *Lutjanus* fishes inhabit warm coastal waters of tropical and subtropical zones, but their density is greatest in the Indo-Pacific region. The genus comprises more than 60 recognized species, but they display marked morphology, colouration, and ecological diversification patterns. This review focuses on the historical and contemporary perspectives of *Lutjanus* taxonomy. It presents morphological diagnostics, meristic counts, and molecular phylogenetics, all of which help to clarify the taxonomic challenges. More emphasis has been placed on assigning keys to identification difficulties stemming from phenotypic plasticity, hybridization, and cryptic speciation within the Genus. Furthermore, information about the biological functions, lifestyles, and ecological functions of *Lutjanus* species and their use in coral reefs and commercial recreation are described. It also highlights the taxonomic knowledge voids that require investigations in future and directions for continuous improvements of integrative taxonomy to provide better insights for resolving phylogenetic relationships and species definitions.

**Keywords:** Taxonomic review (TR), Genus *Lutjanus* (GL), Perciformes (PP), Species Delimitation (SD), Phylogenetic Insights (PI)

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## Introduction

The method of classification of living organisms based on similarities and differences has been discussed under the term of taxonomy. This method has introduced a variety of species and Genus as well. Genus *Lutjanus* is one of those important Genus. This genus is commonly known as snappers and is the main group of marine fish. The classification of this Genus is studied as the kingdom is Animalia, the phylum is Chordata, the class is Actinopterygii, the order is Perciformes, the family is Lutjanidae, and the Genus is *Lutjanus* (Griffiths et al., 2024). Some important characteristics of this Genus differentiate it from other genus of fishes. One of the important characteristics of this genus is that it consists of fish that have a length range of 20 to 100 cm. It means that this genus consists of lengthy marine fishes. These fishes also have compressed bodies and pointed snouts with large mouths. The other important characteristic is that these fishes mostly have cycloid scales. They have special spots or other patterns on the body and show colour variation. These fishes are mostly found in the Atlantic, Pacific, and Indian Oceans in tropical and subtropical water. Some specific fishes belonging to this genus circulate their lifecycles in Marine and freshwater environments. These fishes have specialized modes of nutrition, which are mostly carnivorous. If we talk about the reproductive system of these fishes, we may come to know that these fishes have separate males and females (Pedraza Marrón, 2023). The males are mostly larger than the females. In these fishes, the process and type of fertilization are mostly external, in which spawning occurs, and eggs and sperms are flown into the water, which is carried by water currents. After fertilization, a

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larva is formed, which undergoes development and then settles on some reef. Here, we are going to discuss the Species Delimitation of Genus *Lutjanus*. The term Species Delimitation means defining boundaries among different Species of the same Genus based on various aspects. In a nutshell, it is the process of determining the characteristics of species that differentiate them from other species, which will be helpful in the naming and classification of these species (Litterman et al., 2024). Usually, species Delimitation of Genus *Lutjanus* is complex and complicated because of divergence in morphology and other characteristics. It is usually observed that there is a high degree of similarity among the morphology of these fishes, so there must be some other criteria for species Delimitation of Genus *Lutjanus*. For this purpose, we can use a molecular basis for species Delimitation (Wasik & Pattinson, 2024).

Mitochondria is a special and important organelle present inside the cell. This organelle has its genetic material in the form of mitochondrial DNA. This DNA has a specific gene named cytochrome c oxidase subunit 1, which can be used for species Delimitation of Genus *Lutjanus*. This basis for species delimitation can be useful because it is based on molecular mitochondrial DNA analysis (Marval-Rodríguez et al., 2022). As we know, the main DNA is present inside the nucleus, termed nuclear DNA. The analysis of the molecular structure of this DNA can also provide us with an effective and strong basis for species Delimitation of Genus *Lutjanus*. Although morphology and molecular analysis can be used for species, Delimitative integrative taxonomy is usually preferred these days. Integrative taxonomy means taxonomy on more than one basis. For example, taxonomy is based on morphology and molecular analysis as well. We can use phylogenetic analysis to delimit the species of Genus *Lutjanus*. The phylogenetic analysis means the taxonomy of living organisms by studying their evolution pattern (Veneza et al., 2023). This basis is also beneficial for species delimitation because it will help to understand ancestral descendants' sequences. Recent studies have shown that there are various methods of species delimitation, such as the concept of phylogenetic species, the concept of gene species, and the concept of morphological species. As mentioned, these are based on phylogenetic analysis, gene analysis, and morphological characteristics. There are some important challenges to the species Delimitation of Genus *Lutjanus* (Pedraza-Marrón et al., 2019). The first important challenge is cryptic species. It means such species that are difficult to distinguish because of ambiguous morphological characteristics. The other important challenge for species Delimitation of Genus *Lutjanus* is hybridization, which means that most of the species of Genus *Lutjanus* are hybridized, so these are difficult to distinguish. The next important challenge for species Delimitation of Genus *Lutjanus* is the lack of in-depth research, which means that there is further need for research and development on the taxonomy of this Genus *Lutjanus*. When we discuss phylogenetic Insights of Genus *Lutjanus*, we may know that phylogenetic analysis can provide a better understanding of evolutionary relationships in Genus *Lutjanus* (Halim et al., 2022). A variety of phylogenetic relationships are discovered while studying the taxonomy of Genus *Lutjanus*. The first important phylogenetic relationship is monophyly, which means that all Genus *Lutjanus* species have the same clade. It means that these are derived from the same ancestors. The other important phylogenetic relationship is the sister group. Recent studies have shown that there is also another Genus named Genus *Pinjalo*, which has similar characters to Genus *Lutjanus*, so these are called sister groups (Zhou, 2024).

The other important phylogenetic relationship is deep divergence, which shows that the Genus *Lutjanus* has quite diverse characteristics (BAKAR, 2017). There is also divergence in terms of Genus' ancestors. These phylogenetic insights of Genus *Lutjanus* also helped study its biogeographic patterns. Recent studies have shown that the main origin of Genus *Lutjanus* is the Indo-Indo-Pacific region, where these species have evolved. After that, these species dispersed in the Atlantic and Western Pacific regions over time. These studies have also shown that some species of Genus *Lutjanus* are localized, which means these are not dispersed away from their

origin. There are important three types of evolutionary processes related to Genus Lutjanus. Adaptive radiation is the first important evolutionary process (da Silva et al., 2018). This process shows that all the species of Genus Lutjanus dispersed in a radiation-like pattern and then adapted respective environments. The other important evolutionary process is convergent evolution. This process shows that there is a similarity in the morphology of Genus Lutjanus because of the same kind of environmental pressure. The other important evolutionary process is deep divergence, which shows much divergence in the genetic makeup of Genus Lutjanus because of evolution(Silva et al., 2023).

### **Research Objective**

The main objective of this research is to understand the term Genus Lutjanus and its characteristics. These studies have effectively explained species Delimitation and Phylogenetic Insights of Genus Lutjanus.

### **Literature Review**

Scholars tried the taxonomical approval of the bloody Marys genus (Southerly bloody Marys lane snapper purposes; Lutjanus Vivanus; Blackspot Snapper; & pacific rockfish in light of near examination, involving four techniques toward genus demarcation. The sole-Locus phyletic investigation in light of cytb recuperated apiece the reddish marine fish as a very much upheld phylum. Generally, this research gave a Deoxyribonucleic acid-founded approval of the customary morphologic scientific categorization of bloody marys(Silva et al., 2023). Studies explain that the coordination of advances that permit the consolidation of the randomness of chromosome chronicles along phyletic techniques brought about the latest methodologies toward the past situation of genus demarcation. Phyletic-coalescing techniques along the sole edge were more harmonious toward equivalent certain heredities. Then again, calculations with numerous limits will generally device a larger expected genus. Researchers do not embrace individual-spot utilization toward genus demarcation, yet scholars truly support the idea that solitary locus information is adequate to signal numerous issues(da Silva et al., 2018). Studies distinguished an uncertain arrangement (from GenBank), possibly because of crossbreeding among Species or basically on account of an unspecified hub. This research recommended that cytochrome oxidase subunit I is the substantial and solid hereditary pointer to distinguishing Lutjanid conveyed beyond Malayan amniotic fluid.

Prospective modification in circulation examples & variety of investigations for a huge scope with a larger certain tests & various hereditary indicators is expected to occupy such ongoing review's holes(Halim et al., 2022). Studies show that elevated degrees of hereditary variety were noticed pursuing a Panmictic design, presumably connected with the larvae dissemination via the flow drifts and as the Brasileiro shore. Moreover, the two segment past and impartiality trials showed that Lutjanus. Alexandrei has gone through populace extension over the glacial epoch. In this regard, the ocean degree variety hereof interval might have expanded the accessible assets and appropriate environments toward the Brasileiro Snapper(Veneza et al., 2023). Researchers reveal that a phyletic investigation recognized a cladistic bunch framed by Northern Red Snapper & Lutjanus Purpureus, proposing lacking developmental intervals among them. The two otoconium form and atomic investigations recognized contrasts, not among the Northern Red Snapper & Lutjanus Purpureus genus, yet amid their populaces, proposing that west Oceanus Atlanticus bloody marys are encountering a Speciation cycle(Marval-Rodríguez et al., 2022). The outcomes of this study work with monetarily pertinent genus distinguishing proof as well as affirming or testing Species IDs, for example, with information in open data sets. Such discoveries and their uses will help prospective manageability systems and more extensive examination queries encompassing such over-fished and developmentally snared Snapper genus(Literman et al., 2024). Scholars discovered sparse proof toward populace hereditary contrasts while equating inside north & and south

areas however rather tracked areas of strength for down of hereditary separation among north & and south segments, along the Farsi/Bedouin Bay & Ocean of Salalah populaces being exceptionally separated from the Inlet of idun & red Ocean populaces(Griffiths et al., 2024). The discoveries of this study are conflicting along the morpho-species and natural demarcation situations, distinguishing 3 to 4 genera. Studies give an unusual model wherein far-reaching investigations depict fewer Species than recently perceived based on morphologic information solitary. It also features the impact of the geological past like a principal operator of speciation in the gathering(Pedraza Marrón, 2023). Studies suggest that estuaries are vigorous and useful frameworks of tremendous environmental importance, including interesting and naturally different marsh territories. The standardized tag information gives the latest experiences regarding the fishing variety of the Parnaiba estuary, which will be significant toward the advancement of additional exploration of such creature(Guimarães-Costa et al., 2019). Scholars suggest that the bridge genre assumes a huge part as fishery assets in the (Amazon locale). Be that as it may, the guardians' precise order is quite difficult, especially regarding genre demarcation inside specific species. This trouble emerges from articulated morphologic analogies amid genre, presenting snags to precise genre acknowledgement. Subsequently, the sub-atomic apparatuses demonstrated exceptionally powerful Species segregation and distinguishing proof(Lutz et al., 2024). Studies elaborate that in the beachfront nations of Indochina, fishing is basic eating routine & specific fishery genres are nourishment rarities to nearby populaces or economically essential to personal networks. The distinguishing proof of the fishery genre was executed utilizing the sub-atomic portrayal of the mitochondria-targeted hemoprotein c Oxidases fractional monetary unit I genetic indicator, along with a phyletic examination of the lane snapper. This is the principal account recognizing the causal poison in Fish-ensnared ciguatera fish poisoning in Malaya(Dao et al., 2021). The discoveries of this study feature the intricacy of genre demarcation and the worth of hereditary techniques. Also, this review gives important bits of knowledge about saltwater Fish variety from the E-shore of the Malay Peninsula & improves how they might interpret hereditary variety, dispersion, & preservation requirements of environments over genetic code.

By coordinating genetic code along morphologic, scholars provide a far-reaching structure toward prospective exploration to foster protection and the executives' techniques for Malaysian aquatic biological diversity(Zainal Abidin et al., 2024). Studies claim that despite being named as devastated, along with inferior Species extravagance toward the vast majority scientific classifications, B-variety of the north negligible amniotic fluid of the India Sea is viewed as elevated. To work along prospective examination of close coast aquatic creature variety around here, researchers laid out a Cytochrome Oxidase I mention information base toward shoreside comb-tooth gobies & and record the consequences of the principal sub-atomic ordered stock of this gathering as well the north banks of the Iranian Inlet & Salalah Ocean(Mehraban et al., 2021). Studies address the main occurrence of using atomic mentions to investigate the Fish creature with the Mozambique shore. The outcomes of this study demonstrate that genetic identification is a trustworthy method for the ID and depiction of the Fish genre in the amniotic fluid of Mozambican. The genetic identification archives in this exploration will be a priceless resource for propelling the comprehension of Fish variety and directing prospective preservation drives(Muhala et al., 2024). This research aimed to lay out a thorough identification data set of waterfront beam fish in Indochina. The outcomes of this research affirmed that genetic identification is a proficient and solid device for waterfront fish distinguishing proof in Indochina, and it also settled a dependable genetic standardized tag that mentions archives for such fish. Genetic identification will add to prospective endeavours to accomplish the best checking and protection, and the fishery board in Indochina(Thu et al., 2019). Studies show that fish are the biggest gathering of creatures with an exceptional variety of morphologic properties and organic variations. Genre ID is trying to anatomists while confronting the latest biomes. Be that as it may, genetic identification has demonstrated strong now and again wherever the

morphologic scientific classification is practically nothing toward the reason for genre distinguishing proof(Zhang & Hanner, 2011). Studies outcomes demonstrate autonomous attacks toward the aqua segment by genealogical benthal heredities in significant maritime bowls. Such transformative changes are constantly connected along focalized aggregates, where profound corporal benthal structures along shorten caudate flippers more than once advance toward slim deep scattering layer Species along ramify caudate flippers(Rincon-Sandoval et al., 2020). Studies expect to explore the ongoing condition of fish barcodes, advances, and prospective headings of genetic identification in fish scientific disciplines. The ongoing condition of barcode surveys regarding Fish scientific classification in Hindustan has been assessed, and an itemized survey of the current writing has been done at the territorial, public, and worldwide degrees. The review outcomes clarified that the genetic identification survey of aquatic spineless creatures is even in its earliest stages in Hindustan(Sachithanandam & Mohan, 2020). Researchers explain that because of the natural obtrusive capacity and the utilization of the genre as an important embryology pattern, the striped eel catfish genre requires additional consideration. Generally speaking, this review presents a reasonable structure toward prospective similar investigations of *Plotosus lineatus* people caught from various environments(Froufe et al., 2024). Studies give huge phyletic proof to obscure ancestries inside this intricate and affirm that enigmatic heredities of *Sepioteuthis cf. Lessoniana* happens in allopatry at the two little and enormous dimensional levels. Moreover, it proposes that two firmly associated Co-happening mysterious heredities have articulated contrasts in the populace framework, suggesting that fundamental distinctions in environment and vitality past might work with co-event(Cheng et al., 2014). Studies feature the significance of extended haul and constant checking of the salmon shoal environment at the best conceivable ordered degree to completely uncover sluggish yet urgent modifications in Fish networks and also to identify indications of networks' corruption to make opportune rebuilding moves(Lin et al., 2021). This exploration's outcomes recommend that choice plays a significant part in creating hereditary contrasts in *L. Guttatus*.

A movement hallway was distinguished that corresponds to the Arris Ricki Waterfront Momentum that streams from Focal US toward the Bay of Golden State, permitting the homogenization of the north populace(Mar-Silva et al., 2023). Scholar studies reveal that phyletic interval among salmon shoal Fish genre might act like a prerequisite for hybridization to happen, lie among admittance & conceptive incongruence. Researchers as well present an original component, along maritime flows compelling significant interval larvae scattering occasions, moving wanderer genre to geologically distant dips to keep up along half-breed affluent districts(Ng et al., 2022). Scholars featured in what way the moderate use and examination of a neighborhood succession information base may assist with settling ID clashes. In general, this intended procedure empowers and assists in ordered distinguishing proof of Fish hatchlings, adding toward the upgrade of the mentioned scanner tag data sets and possibly the best comprehension of Fish availability(Chan et al., 2024). Studies determined that exceptional notice has been committed toward a double methodology alluding to the two the buyer's well-being and the preservation of undermined Species, along with a unique spotlight on the plausibility of the other hereditary & and genome procedures corresponding toward the two logical targets & and passable expenses to get dependable discernibility(Filonzi et al., 2023).

## Applications

As a systematic review of published information, the study is a rich and important reference for ichthyologists, marine ecologists, and conservationists to develop a body of knowledge for the management and conservation of *Lutjanus* species in light of growing pressures on marine resources. The genus *Lutjanus*, commonly known as snappers, holds significant importance in marine ecosystems and fisheries due to several key factors:



**Figure 1:** Ecological Importance

## **Ecological Importance**

### **Predator Role**

Snappers are a staple component of predatory ecosystems within the marine habitat due to their capability to control the preyed species' population. This makes it easier to moderate the populations of small fish hence preserving the conditions of reefs by avoiding overgrazing by algae. Animal carcasses are an unheralded but ASM crucial food and nutrient source for animals and plants," said co-author Joseph Bump, a professor at the University of Minnesota College of Food, Agricultural, and Natural Resource Sciences. Cougars, bears and wolves, being the principal predators, have a signature of when, where and how many carcasses there are in a particular ecosystem at a given time of the year despite the fact that animals die and their carcasses hit the ground all year round from various causes of mortality such as diseases and human hunting. The researchers also point out that it is critical to define all the functions that predatory species perform and preserve populations of such species and their prey. "People like to believe that they can replace predators, and thus, it is probably fine to have some places without large predators," explained Sean Johnson-Bice, the author of the study and a Ph.D. candidate at the University of Manitoba. "However, our work shows that there is such a range and variety of how a single individual predator influences the system that we could never realistically mimic the presence of the predators in ecosystems. The authors of the research hope that the study may help improve the conservation and the population management of many predators globally, which are declining due to factors such as habitat loss, human interference, hunting and poaching, and climate change (Figure 1).

### **Habitat Association**

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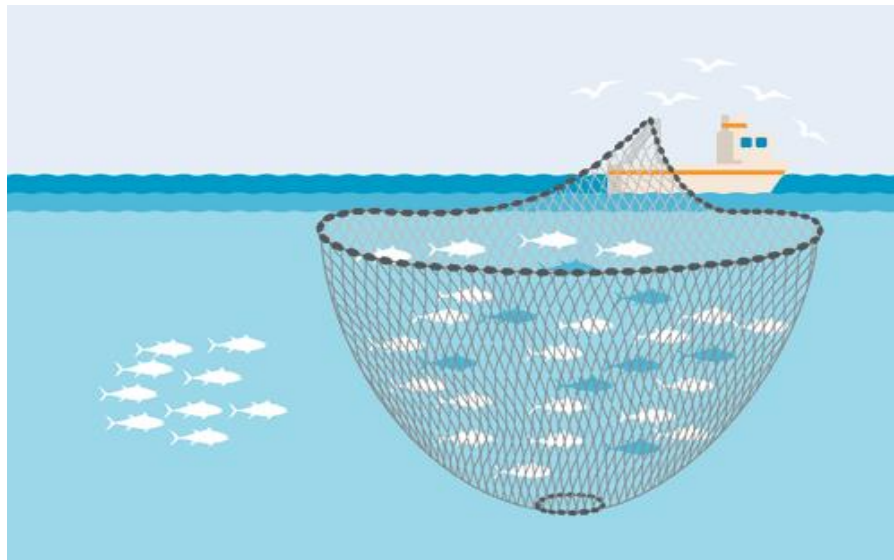
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**Figure 2:** Commercial Fisheries

### **Commercial Fisheries**

Commercial fishing is harvesting fish and other seafood species for profit, mostly from stocks in the wild. The industry offers a significant amount of food to many countries across the globe, but those who exercise it as an industry in mind have to, in many cases, seek the in the deep sea under rather unpleasant weather conditions. Industrial fishing is defined as mass or commercial fishing (Figure 2). Major industries of the fishing sector are big corporate companies and families. To enhance revenue from the reduced fish populations and the prevailing demand, some commercial fishing companies have lowered the sustainability of the catch by targeting species in the lower order. This is worrying for fishery managers and researchers, as they continue to point out, they say that for those reasons, the sustainability of the marine ecosystems is at risk of hitting the wall. They catch numerous of species usually associated with commercial fishing. Yet, most of the world's fish stocks are derived from a very limited number of species; herring, cods, anchovy, tuna, flounders, mullets, squids, shrimps, salmon, crabs, lobsters, oyster and scallops. All but these last four yielded a world catch of over one million metric tonnes in 1999 and together herring and sardines accounted for 22 095 963 metric tonnes of the total catch in 1999. Other species are other fished in a less proportionate manner. Of the total global fish production in 2016 of 171 million tonnes, more than 151 million tonnes or 88 percent of the catch were used for human consumption. This share has raised even in the recent decades, and from the 1960's it was 67 percent. Of the 12 percent utilized for non-food uses in 2016, the highest proportion, about 74 percent or 15 million tonnes, was processed to fishmeal and fish oil while the majority of the 5 million tonnes was directly used as material for feeding in aquaculture, raising of livestock and fur animals or cultured fish fry, fingerlings or small adults for on growing, as bait or for use in the pharmaceutical industries and as ornaments.



**Figure 3:** Fishing Methods

### **Fishing Methods**

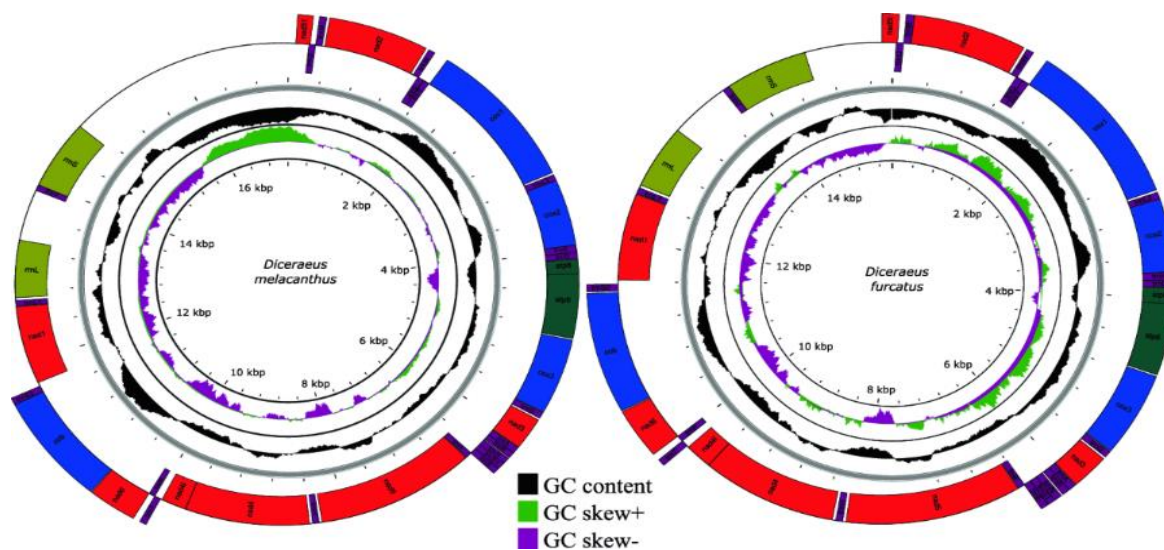
They are also frequently captured through line fishing, traps and including netting. They are popular fishing destinations, and therefore attract fishing activities, both national and international (Figure 3). Fishing methods are strategies used to fish. The term may also be used in respect of techniques for capturing other water creatures including mollusks (bivalves, cephalopods, gastropods), and other edible marine invertebrates. Gathering which entails chasing the target animals and catching them using the bare hands is another method of fishing practicing today spear fishing, netting, angling and trapping are also forms of fishing. angling Articles and fishers employ distinct equipment's and methods of fish, catching recreation, commercial and artisanal fishers use different techniques and at times the same ones. One more can be distinguished between the recreational fishers that fish merely for fun or as a sport and commercial fishers that fish for business. Small scale fishers employ rudimentary equipment since they operate in less developed societies or out of cultural ethnic practices in other societies. Mainly, sport fishers practice angling techniques, while gear fishers– commercial fishers, employ netting techniques. It becomes quite easy to unravel that there is a complex relationship between different methods of fishing and information on the fish and their activities such as migration, feeding and their preferred habitats. Lack of this additional knowledge can hamper the successful application of methods of fishing. That is, it is still possible to note that which techniques are appropriate is defined mainly by the target species and by its dwelling place. There is a difference between fishing techniques and fishing tackle. Tackle is the equipment used in fishing while techniques is the way, method or approach used while fishing.

### **Cultural Significance**

In the Burra Charter context cultural significance refers to something that is of 'emotional, historical, scientific or social significance for the past, the present or the future generations. Cultural importance is a theory that can assist in making out the worth of areas. The most interpretations could single out the place that was useful in orientation with the past or valuable in the contemporary world and beneficial to the future community. The meaning of these terms as well in relation to cultural importance include Aesthetic value that includes those characteristics of sensory appreciation for which criteria formula, size, color, surface texture, style and material used in fabric is relevant; Historic value which encompasses things done by historical personalities, events, periods and processes. Where there is in-situ documentation of an association or event, or the setting remains principally undisturbed, significance should be rated higher in this category than in cases where the setting has



been altered and the evidence obliterated. Credible scientific value refers to the research capability of a specific area or the extent to which a particular area is able to contribute more to an understanding of an area. Social value supports the attributes which make a place an object of the spiritual, political, national and or other culture identity and one that, with equal measure, has value to a particular local or larger social group. The division into aesthetic, historical, scientific and social significance is always modified by the frequency of the item in the given category. Spiritual value is one of the newest additions to the framework of Burra Charter as it falls under things that are formally intangible or non-material.



**Figure 4:** Species Delimitation and Phylogenetic Insights

### Species Delimitation and Phylogenetic Insights

Many earlier attempts to differentiate species within the genus *Lutjanus* have been based on morphological features such as meristic count, color patterns and body shape (Figure 4). However, the genus has several cumbersome factors including inherent variability, similar physical characters, and merely concealed species. Such factors distort a classical matrix and make it difficult to accomplish a definite taxonomical decision and avoid a mistake. In the years of effective molecular phylogenetics, the necessary information for the elucidation of the evolutionary trends in *Lutjanus* has been elicited. Mitochondrial loci include the cytochrome C oxidase I gene (COI), the cytochrome b gene (Cyt b), and nuclear markers such as the internal transcribed spacer (ITS) region and the 7th intron of the evolutionarily conserved gene S7, which have widely been used in molecular taxonomy and DNA barcoding for delimitation of genetic lineages. Some synchronic variants are shown to have arisen through cryptic speciation and phylogenetic affinities concerning the contacts of morphological convergence had been industrialized. A combination of molecular and conventional taxonomic morphology and ecology has been developed into a useful framework for species identification. These methodologies have identified different subpopulations within otherwise widespread species; therefore, may be suggesting underestimation of species richness in the genus. For instance, molecular analyses have recognized separate cryptic species in the *Lutjanus flimflammer* species groups, showing the value of gene-based procedures to expose previously overlooked richness. Further, the phylogenetic analysis has revealed much about the evolutionary processes of the genus, including a biogeographical history proposed due to dispersal-vicariance. These findings further amplify the knowledge of the diversification patterns and special adaptations of this genus in different marine ecosystems. Nevertheless, there are still important gaps in the existing knowledge concerning this subject. The need for further taxonomic work involves sequencing an entire genome of observed species, sampling more broadly across the genus' geographic range, and investigating more details of other ecological

and behavioral characteristics to achieve the finer species clarification and clarify the evolutionary relationships. Closing these gaps will lead to improved taxonomic assessments for the species and help in the overall conservation and management of the species, due to its importance in economy and ecology.

## Conclusion

As a consequence, the genus *Lutjanus* carries great significance not only from the ecological point of view to the functions performed as a part of marine ecosystems but for sustaining the fishery and people's livelihoods as well. Appropriate management measures must be put into practice so as to achieve sustainable use and conservation of these *Lutjanus* species with regard to future generations. The genus *Lutjanus* embraces a wide variety of reef-associated fishes which provide crucial roles in marine communities and which can be valuable in the framework of the global capture fishery production. This review focuses on the advances as well as the limitations of the taxonomy of *Lutjanus*, specifically on evaluating the merits of the traditional morphological approach with the advances in molecular systematics for correcting the taxonomic dilemmas and for recognizing the hidden species diversities. However, some important problems arise in connection with the study of relationships within this genus, such as Species Problem, problems related to the influence of hybridization, and the problems of the impact of environmental factors on phenotypic variability. Hence, it is asserted that future research guarding this genus should involve multi-disciplinary methods of research, including genetics, morphometrics and ecological data. The biological and economic importance of *Lutjanus* species have added further importance to taxonomy for proper management and conservation of the fish species. Increasing environmental impacts in marine organisms makes evidently clear taxonomic demarcation as essential for optimum utilization as well as conservation of the species. Therefore, the proposed increase of taxonomy of the *Lutjanus* is not only a scholarly exercise, but a necessary step towards the conservation of aquatic life during the global changes that are currently occurring.

## References

- BAKAR, A. B. A. (2017). DNA barcoding of Malaysian marine fish, phylogenetics and phylogeography of the snappers (Perciformes: Lutjanidae). *Universiti Sains Malaysia.*, 165.
- Chan, W. W. R., Chang, J. J. M., Tan, C. Z., Ng, J. X., Ng, M. H. C., Jaafar, Z., & Huang, D. (2024). Eyeing DNA barcoding for species identification of fish larvae. *Journal of fish biology.*
- Cheng, S., Anderson, F. E., Bergman, A., Mahardika, G., Muchlisin, Z., Dang, B., Calumpong, H., Mohamed, K., Sasikumar, G., & Venkatesan, V. (2014). Molecular evidence for co-occurring cryptic lineages within the *Septeuthis* cf. *lessoniana* species complex in the Indian and Indo-West Pacific Oceans. *Hydrobiologia*, 725, 165-188.
- da Silva, R., Peloso, P. L., Sturaro, M. J., Veneza, I., Sampaio, I., Schneider, H., & Gomes, G. (2018). Comparative analyses of species delimitation methods with molecular data in snappers (Perciformes: Lutjaninae). *Mitochondrial DNA Part A*, 29(7), 1108-1114.
- Dao, H. V., Uesugi, A., Uchida, H., Watanabe, R., Matsushima, R., Lim, Z. F., Jipanin, S. J., Pham, K. X., Phan, M.-T., & Leaw, C. P. (2021). Identification of fish species and toxins implicated in a snapper food poisoning event in Sabah, Malaysia, 2017. *Toxins*, 13(9), 657.
- Filonzi, L., Ardenghi, A., Rontani, P. M., Voccia, A., Ferrari, C., Papa, R., Bellin, N., & Nonnis Marzano, F. (2023). Molecular barcoding: A tool to guarantee correct seafood labelling and quality and preserve the conservation of endangered species. *Foods*, 12(12), 2420.
- Froufe, E., Gomes-dos-Santos, A., Matos, A., Wilson, J., Malakpourkolbadinezhad, S., Pereira, D. D., Singer, R., & Castro, L. F. C. (2024). How complex is the hidden species diversity of the teleost *Plotosus* genus? *Ichthyological Research*, 71(1), 163-173.
- Griffiths, M. H., Wade, C. M., D'Agostino, D., Berumen, M. L., Burt, J. A., DiBattista, J. D., & Feary, D. A. (2024). Phylogeography of a commercially important reef fish, *Lutjanus ehrenbergii*, from the coastal waters of the Arabian Peninsula. *Biological Journal of the Linnean Society*, 170.
- Guimarães-Costa, A. J., Machado, F. S., Oliveira, R. R., Silva-Costa, V., Andrade, M. C., Giarrizzo, T., Saint-Paul, U.,

- Sampaio, I., & Schneider, H. (2019). Fish diversity of the largest deltaic formation in the Americas—a description of the fish fauna of the Parnaíba Delta using DNA Barcoding. *Scientific Reports*, 9(1), 7530.
- Halim, L. J., Rahim, I., Mahboob, S., Al-Ghanim, K., Asmiaty, A., & Naim, D. M. (2022). Phylogenetic relationships of the commercial red snapper (*Lutjanidae* sp.) from three marine regions. *Journal of King Saud University-Science*, 34(2), 101756.
- Lin, Y.-J., Roa-Ureta, R. H., Basali, A. U., Alcaria, J. F. A., Lindo, R., Qurban, M. A., Prihartato, P. K., Qasem, A., & Rabaoui, L. (2021). Coarser taxonomic resolutions are informative in revealing fish community abundance trends for the world's warmest coral reefs. *Coral Reefs*, 40, 1741-1756.
- Literman, R. A., Matos, M. P., Handy, S. M., & Deeds, J. R. (2024). An empirical DNA-based identification of morphologically similar snappers (*Lutjanus campechanus*, *Lutjanus purpureus*) using a versatile bioinformatics workflow for the discovery and analysis of informative single-nucleotide polymorphisms. *Frontiers in Marine Science*, 11, 1342509.
- Lutz, Í., Martins, T., Santana, P., Ferreira, C., Miranda, J., Matos, S., Muhala, V., Sampaio, I., Vallinoto, M., & Evangelista-Gomes, G. (2024). Marine catfishes (Ariidae—Siluriformes) from the Coastal Amazon: mitochondrial DNA barcode for a recent diversification group? *PeerJ*, 12, e17581.
- Mar-Silva, A. F., Diaz-Jaimes, P., Domínguez-Mendoza, C., Domínguez-Domínguez, O., Valdiviezo-Rivera, J., & Espinoza-Herrera, E. (2023). Genomic assessment reveals signal of adaptive selection in populations of the Spotted rose snapper *Lutjanus guttatus* from the Tropical Eastern Pacific. *PeerJ*, 11, e15029.
- Marval-Rodríguez, A., Renán, X., Galindo-Cortes, G., Acuña-Ramírez, S., Jiménez-Badillo, M. d. L., Rodulfo, H., Montero-Muñoz, J. L., Brulé, T., & De Donato, M. (2022). Assessing the speciation of *Lutjanus campechanus* and *Lutjanus purpureus* through otolith shape and genetic analyses. *Fishes*, 7(2), 85.
- Mehraban, H., Zarei, F., & Esmaeili, H. R. (2021). A prelude to the molecular systematics and diversity of combtooth blennies (Teleostei: Blenniidae) in the Persian Gulf and Oman Sea. *Systematics and Biodiversity*, 19(5), 438-452.
- Muhala, V., Guimarães-Costa, A., Macate, I. E., Rabelo, L. P., Bessa-Silva, A. R., Watanabe, L., Dos Santos, G. D., Sambora, L., Vallinoto, M., & Sampaio, I. (2024). DNA barcoding for the assessment of marine and coastal fish diversity from the Coast of Mozambique. *Plos one*, 19(2), e0293345.
- Ng, I., Bellwood, D. R., & Siqueira, A. C. (2022). Do currents shape global patterns of hybrid richness in coral reef fishes? *Global Ecology and Biogeography*, 31(12), 2524-2540.
- Pedraza-Marrón, C. d. R., Silva, R., Deeds, J., Van Belleghem, S. M., Mastretta-Yanes, A., Domínguez-Domínguez, O., Rivero-Vega, R. A., Lutackas, L., Murie, D., & Parkyn, D. (2019). Genomics overrules mitochondrial DNA, siding with morphology on a controversial case of species delimitation. *Proceedings of the Royal Society B*, 286(1900), 20182924.
- Pedraza Marrón, C. d. R. (2023). Bridging Micro-and Macro-Evolution In Tropical Fishes.
- Rincon-Sandoval, M., Duarte-Ribeiro, E., Davis, A. M., Santaquiteria, A., Hughes, L. C., Baldwin, C. C., Soto-Torres, L., Acero P, A., Walker Jr, H., & Carpenter, K. E. (2020). Evolutionary determinism and convergence associated with water-column transitions in marine fishes. *Proceedings of the National Academy of Sciences*, 117(52), 33396-33403.
- Sachithanandam, V., & Mohan, P. (2020). A review on DNA barcoding on fish taxonomy in India. *DNA barcoding and molecular phylogeny*, 153-175.
- Silva, D., Veneza, I., Silva, R. D., Sampaio, I., & Evangelista-Gomes, G. (2023). Molecular delimitation methods validate morphologically similar species of red snappers (Perciformes: Lutjanidae). *Anais da Academia Brasileira de Ciências*, 95(suppl 2), e20210997.
- Thu, P. T., Huang, W.-C., Chou, T.-K., Van Quan, N., Van Chien, P., Li, F., Shao, K.-T., & Liao, T.-Y. (2019). DNA barcoding of coastal ray-finned fishes in Vietnam. *Plos one*, 14(9), e0222631.
- Veneza, I., da Silva, R., Ferreira, C., Mendonça, P., Sampaio, I., & Evangelista-Gomes, G. (2023). Genetic connectivity and population expansion inferred from multilocus analysis in *Lutjanus alexandrei* (Lutjanidae—Perciformes), an endemic snapper from Northeastern Brazilian coast. *PeerJ*, 11, e15973.
- Wasik, S., & Pattinson, R. (2024). Artificial Intelligence Applications in Fish Classification and Taxonomy: Advancing Our Understanding of Aquatic Biodiversity. *FishTaxa-Journal of Fish Taxonomy*, 31.
- Zainal Abidin, D., Nor, S., Seah, Y., Ali, M., & Jamaluddin, J. (2024). A Rahim M, Zulkifly NS, Tan MP, Md Zain K, Mat Jaafar TNA. 2024. In (Vol. 63): An.
- Zhang, J.-B., & Hanner, R. (2011). DNA barcoding is a useful tool for the identification of marine fishes from Japan. *Biochemical Systematics and Ecology*, 39(1), 31-42.
- Zhou, X. (2024). Analyzing the Impact of Digital Finance on Farm Household Income in the Agricultural Sector: Mechanisms and Challenges. *Journal of Commercial Biotechnology*, 29(1).