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Taxonomic Update on Coral Reef Butterflyfishes: Implications for Conservation

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Abstract
The Family Chaetodontidae, which includes coral-feeding butterflyfish, is used to monitor the ecological state of Pacific coral reefs using its abundance, distribution, and behaviour as indicators. The best indicator species are those that are members of the feeding guild of corallivores. They are noticeable and active throughout the day; even inexperienced observers can readily gauge their behaviour. They are long-term, permanent inhabitants of the living coral reef because they tend to be very site-attached, territorial, and predictable in their movement patterns. They are closely related to the reef since they reside, spend the night, and eat living coral there. Reef fishes are movable, but corals are not moving. Therefore, variations in the quantity, location, and behaviour of the coral feeders signify adjustments to the reef's biological circumstances. The technique works well in situations when reef disturbances happen gradually over time. A sensitive indicator approach is not required to identify significant, sporadic alterations to the reef. The technique helps track alterations on a particular reef over time. Comparing conditions on two or more reefs simultaneously is inappropriate because variations in the reefs' butterfly populations may result from other processes like recruitment. It is a low-cost, simple-to-use technique that shows promise for evaluating slow, gradual, but persistent long-term alterations to coral reefs. Research is now being conducted to simulate this sort of shift. The method's application to Caribbean coral reefs is examined.

Keywords: Taxonomic (TT), Coral Reef (CR), Butterflyfishes (BFF), Implications (II), Conservation (CC)

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Introduction

The abundant animals in the coral reefs throughout the world are marine butterflyfishes. These fishes are lovely. These fishes are studied very deeply as they are essential from an ecological point of view. These animals also have commercial Worth, which makes them too valuable. Too many phylogenies are found on behalf of their morphological and molecular data. Still, a well-supported molecular phylogeny can be seen at the species level, while many taxa remain resolved. The molecular phylogeny of butterflyfishes will be presented, and all genera will be included. Genetic data was usually collected for the taxa of the type 71 ingroup and 13 outgroup taxa in which two genes of nuclear type and three of mitochondrial type are involved(Russ & Leahy, 2017). In this stuff, there are 3332 total nucleotides involved. Let's discuss certain methods that will produce a well-supported phylogeny and provide strong support that is fixed for monophyletic Chaetodontidae. In these methods, Bayesian inference, parsimony, and maximum likelihood methods. The following species come under polyphyletic, chaetodon subgenera, resonator, and chaetodon. The Amphichaetodon genus is not considered the basal sister group for the remaining family, as was proposed previously(Liedke et al., 2020). According to a recent report, it has become clear that the volume of butterfly fish covers an area of 6% of the standing biomass of the corals per year. It has a strong influence on the distribution. It also affects the abundance and community composition of corals. The classification of Chaetodontidae is done in such a way that it is classified in the suborder Percoidei according to the 5th edition of fishes throughout the world. But their location is set in such a way that it is placed in an unnamed clade and outside the superfamily Percoidae (Tréhin, 2023). The number

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of families in this clade is seven. A strong relationship can be seen between acanthuroidei, monodactylidae, and Priacanthidae. Scientists believe there are four different classifications of coral reef types(Graham et al., 2009).

These classifications are of the following types: fringing reefs, barrier reefs, atolls, and patch reefs. The location of origin of fringing reefs is near the coastline, which is found around the islands and continents. These locations are separated from the shore by the barrier of narrow and shallow lagoons. Let's discuss certain characteristics of butterflyfishes: the presence of a short, pointed snout and a long fin found in any dorsal position. This fin will separate in the early days and enter the spine. The appearance of butterflyfish is such that it has a silver body. It has dorsal fins of yellow and black. A tail that isn't yellow is round in colo(Samoilys et al., 2022). Vertical black bars can also be seen on their body, which are well distinguished. The location of one is seen on the head that can be seen running towards the eye. Symbiotic relationships can be seen in the ocean, specifically off coral reefs. Types of symbiotic relationships are of three types. These are named mutualism, parasitism, and commensalism. Mimicry is a characteristic that can be seen in organisms on coral reefs very commonly. A symbiotic relationship can be seen between butterflyfishes and coral species. Their feed is usually done in the regions of polyps found in corals. Corals can benefit by removing excess tissue and preventing those overgrowths that are seen potentially(Bellwood & Pratchett, 2013). Corals prove to be a source of food for butterflyfishes (Meira et al., 2022). The classification system is based on the linear system and has eight taxa levels. This is usually done in the sequence of most general to the most specific. This system involves the following: domain, kingdom, phylum, class, order, family, genus, and species. Corals and their types, corals, and anthozoans, are the largest class of organisms, which can be seen in the phylum Cnidaria. It is based on 6000 well-known species. In the group of Anthozoans, sea fans, sea pansies, and anemones can be seen. The impact of conservation can be elaborated as biodiversity, which increases the number of tigers. Such threats also exist, which can degrade biodiversity, like a decrease in poaching. Threats are for behaviours like a decrease in the owners of shops selling parts off tigers. Certain events usually result from an action, like pollution, contamination, and destruction(Nowicki et al., 2013). There are long-term and Short-term ramifications that that will strongly influence the environment. Many adverse environmental effects have a direct relationship with the health of the public and the quality of issues that are about life. Let's discuss certain implications and suggestions for the conservation of energy (Sun & Choi, 2023). The first advantage of energy conservation is that it will protect the environment from the excessive usage of resources and carbon dioxide emissions.

The conservation of energy will reduce the need for new power plants. It will prove beneficial for wildlife and also for natural areas. Even with the application of renewable energy sources, this will remain true. Here, a discussion is done on the infrastructure of butterflyfishes(Pratchett et al., 2013). Motta is a scientist who suggested that butterflyfishes have seen the problem of disproportionate attention compared to all those fishes that belong to other families of coral reefs (Motta, 2012). To support this problem, the number of publications about butterflyfishes is far from those of fishes belonging to other families of nominal reef fishes. The families that haven't been studied extensively are the Pomacentridae, Serranidae, and Labridae. Various diversity can be seen in these groups. Hybridization is the interbreeding of members from two distinct populations that can be distinguished by one or more heritable traits after Harrison. Hybrids have been recognized through intergrading particular traits of the parent species since the 1800s and are identified in corals, plants, and crustaceans. They include gastropods, insects, amphibians, reptiles, animals, birds, and fish(Ehrlich, 1975). About 10% of all animals and 25% of species of plants have been identified as hybrids; however, the actual proportion may be higher because hybridization can be overlooked (Motta, 2012).

Research Objective

The primary purpose of this research is to understand taxonomic updates on coral reef butterflyfishes and their

implications for conservation, with the aim of developing an understanding of butterflyfish infrastructure.

The following traits of butterfly behaviour and biology that are pertinent to the indicator hypothesis are evident from these studies:

1. Many coral-feeding butterfly species reside in heterosexual couples in tiny reef regions known as home ranges or territories. 2. Many of these species are long-term (8–10 years) residents of their native reefs. As a result, their duration is sufficient to see gradual, ongoing changes. 3. They follow well-defined routes for foraging within their social space unit but sometimes take extended forays to isolated reef areas. This is a significant finding, indicating that they know the reef outside their limited home area. They can thus emigrate from their native reef region if conditions are too harsh. M29. 4. There are two types of obligatory coral feeders: generalists and specialists. Unlike specialists who eat preferentially on particular kinds of coral regardless of their abundance on the reef, generalists consume corals in the same proportion as their environmental prevalence. 5. Without harming the coral skeleton's calyx, the jaws and teeth of these species are freely equipped to nip off and eat the coral polyps via suction. The attentive feeding technique enables the coral polyp to reproduce, which in turn keeps the food supplies within the fish's feeding region continuously replenished. 6. Food and competition encroachment are the two criteria defining the area's extent. The area must be large enough to provide food for the two-heterosexual fish in the pair and sufficiently tiny to protect against intruders. 7. Two conceivable outcomes exist when one pair member is removed experimentally. The female vanishes if the male is taken out of the area since she is unable to protect it on her own until a new pair of male’s bonds with her. If the female is taken away, the male may attempt to mate with the female of a nearby pair or leave the area. There aren't many "floater" girls in the population. 8. There are two outcomes when food is experimentally manipulated in a region. The resident couple strives to expand their territory at the expense of their neighbours if food is removed by covering coral heads, which lowers feeding rates and increases the frequency of agonistic interactions. When food is introduced into a region, no instant outcome occurs. To make up for the extra food, the resident couple does not shrink the area of their territory. However, after a day or two, neighbouring couples discover the additional food and try to expand their lands, which increases the frequency of agonistic encounters once more. The corals living on the reef and the coral-feeding butterflyfishes are closely associated. The experimental manipulations show that these alterations disrupt the status quo of their social behaviour. These results allow the following formulation of the study's hypothesis: Coral-feeding butterfly populations modify their numbers, distribution, and behaviour on the reef in response to variations in coral quality and/or quantity. These adaptations may be quickly and readily measured.

Literature Review

Researchers reveal that limited information is available regarding the fish species found in the SCS. Various research studies on the species of Malaysian island revealed the presence of coralfish species on this island. the techniques employed for coral reef identification were Stero-DOVs(Afiq-Firdaus et al., 2023).to study ecological behaviour, the use of the biological variables among different fish species is assessed. coral reef affects habitat conditions. In Hawaii, the coral *pocillopora grandis* is found(Brush, 2024).Studies show that various resources are required for the survival and management of species. managing the process of spice survival enhances their biodiversity. the dietary requirements for the butterflyfish fishes are identified by the DNA met barcoding process(Coker et al., 2023).Studies reveal that oceans and islands are natural laboratories that allow the identification of marine species. Seamounts sudsy provide evidence about the connectivity and relation among different fish species. Using underwater monitoring gadgets provides insight into the coral fish species of the Australian coral sea(Galbraith et al., 2024). Studies made on the USVI provide evidence of the benthic species found in the sea. NCRMP talks about the coral reef species of US islands. the data is collected

using the biological systems that monitor the fish population of Virgin Island (Grove et al., 2023).Studies reveal that a bar coding-based library has been established to study the COI sequences of teleost fish species. The Philippines is the HUB of teleost marine species, and the biodiversity of these species in the Philippines Sea is determined through the DNA barcoding method(Huang et al., 2023).scholars suggest that coral reefs are regarded as the main component that maintains the biodiversity of aquatic ecosystems. However, these species are facing great threats due to changing climatic conditions. The effect of anthropogenic factors on coral reefs is the decline in their population.by studying butterflyfish's migration or movement patterns, their survival rate increases(Islands, 2024).studies claim that fish species in the marine ecosystem comprise a diverse range of colourful species. The cooler patterns observed in the aquatic species reveal their evolutionary history. the colour exhibited by coral reef species is influenced by certain genetic factors(Karan, 2023).studies claim that the depletion of natural resources has resulted in the depletion of some important coral reef species. The chances of coral reef competitor recognition increase due to resource depletion, so species coexistence becomes difficult(Keith et al., 2023).studies predict that the disturbances in the biodiversity of coral reefs are associated with changes in the coral reef survival conditions. developing conservation methodologies improve the process of restoration of coral reefs. The restoration strategies are implemented using the assessment process. The assessment procedure provides data about the fish species at different stages. The results of studies reveal that restoration of the coral reef species saves coral reef and their nearby pollution from depletion(Krimou et al., 2024).studies show that human activities impact the coral reef species to a great extent. Activities like overfishing and water pollution result in a rapid decline in coral species. studies on the fish community of herbivores in coral reefs provide information about the factors that result in the loss of habit of this coral species. the ecological functioning of coral reef species gets lost due to the negative impact of human activities(Leitão et al., 2023). Most conservation strategies adopted for Coral reef protection are based on preserving their spatial distributive patterns and distribution in the auric ecosystem. the assessment of the taxonomic behaviour of species is studied before the implementation of conservation strategies. The g-F measurement index provides knowledge related to the diversity of coral species in the south of China Sea (Li et al., 2023).Studies claim that the conservation strategies are implemented after all the areas comprising coral reefs are mapped (Reinhart & Christopher, 2023). The mapping of coral reefs improves the effectiveness of conservation strategies. The database regarding aquatic species is obtained through a mapping process. The database provides detailed data on about seven thousand coral reef species in the Indian Ocean. Also, the distribution patterns of coral species in the Indian Ocean are assessed through the database of mapped coral species(McClanahan et al., 2024).studies predict that in the West Pacific Ocean, the presence of Neptune’s cup sponge is identified. The marine ecosystem surveys made by SCUBA divers reveal that iconic species are old species that require species that require effective conservation strategies for their survival(Mehrotra et al., 2023).Studies conclude that butterfly species in marine ecosystems consist of diverse aquatic species. The rate of hybridization in these diverse species is higher because of their evolutionary status. A Many data is valuable regarding the phylogenetic lineage of butterflyfish species, but very little information is available regarding the karyotype(Molina et al., 2024). Studies made on jellyfish explain that their interactive behaviour with the food chain is studied deeply to understand the predator-prey relationship. However, due to the poor smiling process, their tropic-level interaction has not been fully studied. From the Zapata marine reserves, the *chaetodon capristatus* of butterflyfish is studied to understand its predatory behaviour. Moreover, the behavioural assessment of jellyfish revealed that the tropical interactive ability of this species is altered due to environmental factors. this assessment process emphasizes the need to develop conservation strategies for monitoring the species of marine ecosystems (Morejón-Arrojo & Rodríguez-Viera, 2024).studies reveal that coral reef species are structurally complex, making their classification a bit difficult. Studies made on coral reef species indicate nocturnal substrate's association with

the coral species' structural characteristics (Nanami, 2024).Scholars claim that social and economic developmental programs are increasing in the coastal areas of the Singaporean Sea. The implementation of technology-assessed techniques is promoted to protect the coral reef population near the coastal areas. Technology-based monitoring plays an integral role in maintaining the diversification of coral reef species in coral areas(Ng et al., 2024).studies predict that certain species of coral reefs act as a cleaner for the Mexican Sea. The cleaner coral reef species are abundantly found in areas where the impact of human activities is highest(Ramírez-Ruiz et al., 2023).scholar claims that the feeding behaviour of different coral reef species is diverse in different critical ecosystems. the diversity in a certain variety of butterfly fish is because of the variation in their genome. their genomic factors control the potential of butterflyfish species to function properly. the pigmentation-producing ability of butterflyfish is controlled by gene type 3. This gene imparts different colours to various reef species, making them diverse. also, the development of the jaw in the *C.Rostratus* species is controlled by the cell one gene. the study of the expression of this gene provides insight into the genomic diversity of reef species that are mostly influenced by evolutionary processes(Zhang et al., 2023).

Implications for Conservation

It becomes clear that there are more coral-feeding butterflyfishes in an area with more live coral. It is less evident how coral diversity and butterflyfish diversity relate to one another. Six common kinds of coral are found at both sites in the Kaho'olawe research. Despite the fact that the transects were positioned in what looked to be coral-rich regions at both locations, the Iow sediment site (Hakioawa) has more coral cover than the high sediment site (Kuheeia). Therefore, this analysis ignores the Kuheeia site's valleys filled with sediment. However, only Chaetodon multicinctus is expected in the Kuheeia site; at the less disturbed location, four species of corallivores are found, with C. multicinctus being the most frequent. Despite having a greater coral cover, the low sediment Hakioawa location had surprisingly bigger territory sizes for C. muiticinctus. This might be because the fish in the low-silt location are bigger. It could also reflect the other coral feeders at this location whose home ranges and territories overlap. An examination of initial data suggests more agonistic chasing encounters between adjacent territorial pairs of C. mzdticinctus at the high sediment location. More solitary, unpaired juveniles are also present, and the f~h are smaller. One explanation might be because the C. multicinctus population at this location is more erratic, with recently arrived recruits developing pair bonds and attempting to establish territories. Therefore, rather than food availability, invader interactions may be a more critical factor in determining territory size at this time. It is evident from the data gathered from episodic events like storms and crown-of-thorn damage to coral reefs that these occurrences influence the fish assemblages connected with them, particularly the butterflyfishes that are part of the corallivore trophic guild. The indicator hypothesis assumes that the f/h can sense the corals' declining condition, possibly due to a decrease in the lipid content and caloric value of the polyps. Therefore, this result is critical to using these coral-feeding butterflyfishes as indicator species.

The theory also postulates that, at first, the fish attempt to enlarge their areas, which alters feeding rates, agonistic encounters, and territorial sizes. Fish depart from the dead reef when the social order of the reef collapses, and the costs of protection outweigh the trophic advantages, eventually making territorial behaviour unprofitable. A note of caution is required. The indication concept is only valid when applied to a particular reef area that is thought to be experiencing low levels of gradual, chronic disturbance, even if the above-described scenario turns out to be accurate. The ability to monitor the recovery of a specialised coral reef should also be included. The idea is useless when comparing coral reefs because unrelated variables like recruitment may cause variations in the coral feeder assemblage on various reefs. The employment of coral-feeding butterflyfish in the Indo-Pacific faunal region shows tremendous promise. Still, caution must be taken to use only those species that

are both M33 abundant and frequent on the reef that will be examined and obligate coral feeders. Indicator hypothesis: How general is it for coral reefs outside the Indo-Pacific faunal region? Because they are not required coral feeders, butterflyfishes are probably not ideal choices as indicator species for the Caribbean. However, since some species of angelfish eat sponges and are a vital part of Caribbean reefs, angelfish could be a potential alternative.

Habitat and Biology

Down to 60 meters (200 feet) below the surface, stony and coral reefs are home to reef butterflyfish. Its tiny, protractile mouth is an additional adaption to help it discover food within the coral. Its compressed body allows it to feed by darting in and out of the coral. The teeth in the mouth are long and thin, flattened, and slightly recurved at the points. Polychaetes, prawns, and amphipods are minute invertebrates that can be scraped and nibbled. Additionally, it is said to consume the sergeant major's eggs (Abudefduf saxatilis). When eating, it may be fairly agile, often swimming upside down to get prey that is lurking in cracks. The adult reef butterflyfish are usually found in couples, and they have a strong pair relationship and may even be monogamous. Spawning occurs around dark after a protracted and vigorous courting in which the birds circle before swimming upward and releasing the eggs and milt. Each spawning, a female will release between three and four thousand eggs. Within twenty-four hours, the tiny, transparent, pelagic eggs hatch, giving rise to tiny, translucent, silvery larval fish. Together with scats, butterflyfish larvae are unique in that they have armour. Bony plates form this armour on the head and body, referred to as the tholichthys stage. When the larvae settle on the substrate at night, the holiday stage lasts until the larvae achieve a length of 20 millimetres (0.79 in). When the following day comes, they have matured into juveniles and will hide in cracks until they are big enough to be safe from predators. Afterwards, they will emerge into shallow water along ledges or channels. The reef butterflyfish faces several predators, primarily bigger fishlike groupers, snappers, and moray eels. While it usually runs away from attacks, it will assume a defensive stance and confront its attacker by lowering its head and raising its dorsal fin spines. Unlike other butterflyfish species found in the Western Atlantic, the reef butterflyfish possesses an oval body that is firmly compressed and has a more rectangular form. Its mouth is at the end of its short, pointed nose, which lacks cheekbones. The head and upper torso are yellow, fading to white as they approach the lower head and abdomen. A black bar that is vertical passes across the eye, and there is another one that runs along the back of the body, between the dorsal and anal fins. The caudal fin, together with the remaining dorsal and anal fins, are yellow. The youngsters may only have two spots on their less pronounced black band in the back. There are three spines and seventeen to nineteen soft rays on the anal fin, compared to thirteen or fourteen on the dorsal fin. The largest length this species may reach is 15 cm. Chaetodon sedentarius, the reef butterflyfish, derives its name from its fluttering habits about the reef and its stunning colour pattern, which mimics the look and motions of the insect. Being a highly compressed species, reef butterflies are not meant for endurance swimming, but rather for agility and quick bursts of speed. This is the perfect body plan for moving about the coral reef. Its long dorsal fin splits into spines at the beginning and has a small, pointed snout.

Colouration

The dorsal fin of the reef butterflyfish is black and yellow, and its tail is yellow. Its body is silver. On the body, there are two distinct vertical black bands. One passes through the eye and is located on the head. The other one passes through the back of the body, including the backs of the anal and dorsal fins. The two circular spots seen when the black posterior portion of juvenile reef butterflyfish fades differ in colour. Reef butterflies are similar to spotfin butterflyfish (Chaetodon ocellatus), except that the former lacks the rear body bar and has a tiny black spot on the back of its dorsal fin (Figure 1).

Figure 1: Reef butterflyfish

Food Habits

The living on the reef is ideal for the reef butterflyfish. Due to its compact body, it can quickly dart in and out of coral. The protractile, tiny mouth is designed for eating in tight spaces. Its long, thin teeth are flattened and slightly curled at the points, making them ideal for scraping and nibbling at the minute invertebrates that make up its food, including amphipods, polychaete worms, and prawns. When eating, reef butterflyfish may be pretty acrobatic, swimming upside down to enter cracks where potential food may hide.

Reproduction

Reef butterflyfish adults are typically seen in couples, which suggests that the species is monogamous and devoted to its partners. They mate after a long, intense courtship that ends in the dark. The two fish swim around one another, head to tail, until one snaps and dashes away, trailed closely by the other. After swimming upward, the couple releases the sperm and eggs. During spawning, the female releases between three and four thousand eggs. The tiny, transparent, pelagic eggs hatch into tiny, translucent, silvery-grey larvae in less than a day. Unlike any other fish species, butterflyfish larvae are distinct from other fish species. Massive bony plates stretch rearward from the skull, and the head is covered in bone armour. Once these "tholichthys" larvae reach a size of around 20 mm, they spend the night settling on the bottom. They have already transitioned into their juvenile stage by daylight. Their colour now resembles the adult's colour rather closely. After transforming and evading predators, the larvae will hide in cracks until they grow to a size where they may be reasonably safe. The juveniles frequently live in shallow places, such as ledges or channels, right next to deeper water (Figure 2).

Figure 2: Reproduction

One species of butterflyfish in the Chaetodontidae family is the mirror butterflyfish, also known as the oval-spot butterflyfish (Chaetodon speculum). It may be found in the Indo-Pacific area, which stretches southward to Papua New Guinea and the Great Barrier Reef from Indonesia to Japan. There have also been reports of the species from Mauritius, Réunion, and Madagascar. It may reach a maximum length of 18 cm (7 in). The dorsal fin has 14 spines and 17–18 soft rays, whereas the anal fin has three spines and 15–16 soft rays. With a large black splotch under the dorsal fin and a vertical black bar passing through the eye, the body colour is brilliant to orange-yellow. French anatomist Georges Cuvier (1769–1832) initially formally described the mirror butterflyfish in 1831, citing Jakarta as the type site. It is a member of the subgenus Tetrachaetodon, together with other angular yellow butterflyfish with black eyestripes and a single patch of a different colour (except in the basal Blue-lashed Butterflyfish, C. Bennett). It appears to be especially similar to the Zanzibar butterflyfish (Chaetodon zanzibarensis) in this group, which has horizontal stripes on its sides and a smaller black blotch. The subgenus Tetrachaetodon would belong in Megaprotodon if Chaetodon were divided. At depths of three to thirty meters, coral reefs are home to Mirror Butterflyfish. It prefers sea anemones and hydroids-rich coastal reef slopes. Coral thickets are where little juveniles hide. This species is usually solitary and relatively rare. They consume invertebrates and coral polyps for food (Figure 3).

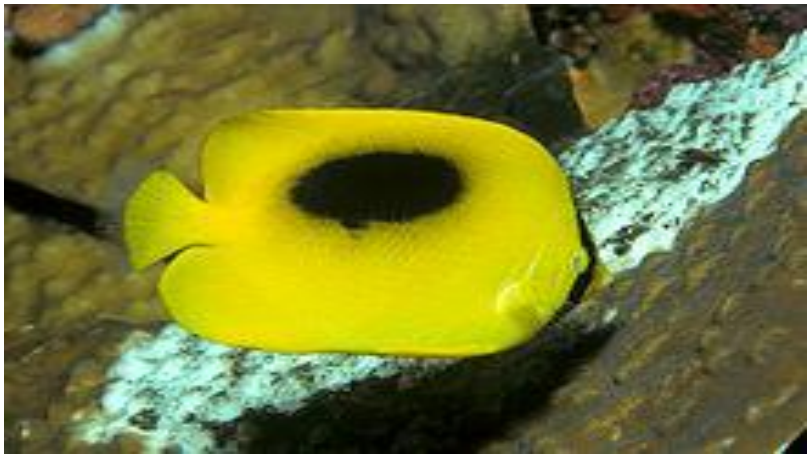

Figure 3: Oval-spot butterflyfish

Although banded butterflyfish are commonly seen as foraging predators who idly scour the coral surface for food, they employ several feeding techniques. Some do feed on the reef's surface, frequently in couples. Some group together to create more prominent schools that hunt microscopic plankton in the water column above the reef with their eyes. Others have been observed to exhibit cleaning behaviour, in which a bigger fish—possibly belonging to a species that consumes Banded butterflyfish—approaches a group of this species to rid itself of parasites. Fish scientists are still learning about the complex behaviours that indicate the predator is about to be cleaned rather than attacked. Banded butterflyfish reproduce through broadcast spawning, in which a male releases sperm and a female releases egg simultaneously into the water column above the reef. Using this technique, there is a greater chance that fertilised eggs will be taken away by the currents and not consumed by egg predators on the reef's surface

Conclusions

Butterflyfkhes, which are obligate feeders on coral, are effective indicators of the ecological conditions of Pacific coral reefs. According to the indicator theory, butterflyfishes will alter their number, distribution, and behaviour in response to coral quality and quantity variations. When the long-term, gradual disturbance of the reef is causing changes, sensitive biotic indicators might be helpful. After appropriate indicator species are

found, the monitoring approach is low-cost and straightforward enough for non-specialists to understand. As a result, it is helpful in many coral reef regions around the globe when funding for management and protection may be limited. Definitive tests are being conducted to determine how and to what degree the indicator species react to reef disturbances. Before engaging in this spawning behaviour, the Banded butterflyfish, in contrast to several other reef fish species, establishes monogamous couples. Although they are primarily found in the Caribbean basin and surrounding areas (the Gulf of Mexico, Florida, Bermuda), banded butterflyfish may sometimes be found in New England and European waters. In those instances, experts think that strong, warm currents transported the observed people during very warm years. Scientists don't think they can procreate and establish stable, long-term populations in these areas. Although humans do not consume this species, it is caught and exhibited in public and private aquariums. Experts don't think the species is in danger of becoming extinct, and population numbers seem to remain steady. But it's crucial to monitor Banded butterflyfish populations so that any alterations brought about by adult capture or anticipated declines in coral reef health across its range may be promptly detected.

References

Afiq-Firdaus, A. M., Safuan, C. D. M., Shafie, S., Izhar, L. I., Awalludin, E. A., Ahmad, M. F., Johari, N. A. M., & Bachok, Z. (2023). Current Status of Coral Reef Fish Abundances at Pulau Bidong and Nearby Islands, South China Sea Using Stereo-Diver Operated Video System. *Ocean Science Journal*, *58*(2), 16.

Bellwood, D. R., & Pratchett, M. S. (2013). The origins and diversification of coral reef butterflyfishes. *Biology of butterflyfishes*, 1-18.

Brush, E. G. (2024). *Ecology of Fishes and Invertebrates Inhabiting the Coral Pocillopora grandis in Hawai'i* University of Hawai'i at Manoa].

Coker, D. J., DiBattista, J. D., Stat, M., Arrigoni, R., Reimer, J., Terraneo, T. I., Villalobos, R., Nowicki, J. P., Bunce, M., & Berumen, M. L. (2023). DNA metabarcoding confirms primary targets and breadth of diet for coral reef butterflyfishes. *Coral Reefs*, *42*(1), 1-15.

Ehrlich, P. R. (1975). The population biology of coral reef fishes. *Annual review of ecology and systematics*, 211-247.

Galbraith, G. F., Cresswell, B. J., McClure, E. C., & Hoey, A. S. (2024). Tropical seamounts as stepping-stones for coral reef fishes: range extensions and new regional distributions from mesophotic ecosystems in the Coral Sea, Australia. *Marine Biodiversity*, *54*(2), 17.

Graham, N., Wilson, S., Pratchett, M. S., Polunin, N. V., & Spalding, M. (2009). Coral mortality versus structural collapse as drivers of corallivorous butterflyfish decline. *Biodiversity and Conservation*, *18*, 3325-3336.

Grove, L. J. W., Blondeau, J., Cain, E., Edwards, K. F., Groves, S. H., Hile, S. D., Langwiser, C., Siceloff, L., Swanson, D. W., & Towle, E. K. (2023). National Coral Reef Monitoring Program, Biological Monitoring Summary–US Virgin Islands and Puerto Rico: 2021.

Huang, W.-C., Evacitas, F. C., Balisco, R. A., Nañola Jr, C. L., Chou, T.-K., Jhuang, W.-C., Chang, C.-W., Shen, K.-N., Shao, K.-T., & Liao, T.-Y. (2023). DNA barcoding of marine teleost fishes (Teleostei) in Cebu, the Philippines, a biodiversity hotspot of the coral triangle. *Scientific reports*, *13*(1), 14867.

Islands, S. (2024). *Fine-Scale Foraging and Movement Behaviour of Chaetodon Butterflyfish Along a Turbidity Gradient on a Coral Reef in the* Auckland University of Technology].

Karan, E. A. (2023). *Capturing the Diversity and Evolution of Color and Color Patterns Across Reef Fishes*. University of California, Los Angeles.

Keith, S., Hobbs, J. A., Boström-Einarsson, L., Hartley, I., & Sanders, N. (2023). Rapid resource depletion on coral reefs disrupts competitor recognition processes among butterflyfish species. *Proceedings of the Royal Society B*, *290*(1990), 20222158.

Krimou, S., Raick, X., Mery, E., Carlot, J., Carpentier, C., Sowinski, J., Sowinski, L., Minier, L., Roux, N., & Maueau, T. (2024). Restoring the reef: Coral restoration yields rapid impacts on certain fish assemblages. *Estuarine, Coastal and Shelf Science*, *302*, 108734.

Leitão, M., Hackradt, C. W., Silva, Í. L. e., Ciancio, J. E., & Félix-Hackradt, F. C. (2023). Effect of human impact on coral reef herbivorous fish niche. *Marine Biology*, *170*(5), 59.

Li, Y., Zhang, J., Chen, Z., Dai, X., Xiong, P., & Yu, W. (2023). Taxonomic diversity of fishes from two coral-reef waters

of the South China Sea. *Marine and Freshwater Research*, *74*(17), 1455-1464.

Liedke, A. M., Pinheiro, H. T., Floeter, S. R., & Bernardi, G. (2020). Phylogeography of the banded butterflyfish, Chaetodon striatus, indicates high connectivity between biogeographic provinces and ecosystems in the western Atlantic. *Neotropical Ichthyology*, *18*(1), e190054.

McClanahan, T., Friedlander, A. M., Chabanet, P., Bruggemann, J., Wickel, J., & Azali, M. (2024). Modeling the spatial distribution of numbers of coral reef fish species and community types in the Western Indian Ocean faunal province. *Marine Ecology Progress Series*, *730*, 59-78.

Mehrotra, R., McGrath, T., McCabe, T., Chankong, A., Sangsawang, L., Desmolles, M., Monchanin, C., Jualaong, S., & Putchakarn, S. (2023). A cup half full: the first assessment on the distribution, ecology and need for conservation of the threatened Neptune's cup sponge, Cliona patera, in the Gulf of Thailand. *Environmental Monitoring and Assessment*, *195*(12), 1475.

Meira, C. L. S., Daroz, B. G., Xavier, T. B., Moraes, J. d. C., Pereira, Y. d. S., Ferreira, D. P., Cunha Júnior, C. A. C. d., & Pontes, H. A. R. (2022). Sialolithiasis of the submandibular gland associated with stafne bone defect: case report. *Jornal Brasileiro de Patologia e Medicina Laboratorial*, *58*, e4292022.

Molina, W. F., Khensuwan, S., de Moraes, R. L. R., Sassi, F. d. M. C., da Costa, G. W. W. F., Miguel, D. Z., Supiwong, W., Jantarat, S., Phintong, K., & Seetapan, K. (2024). Karyotypic stasis and its implications for extensive hybridization events in corallivores species of butterflyfishes (Chaetodontidae). *Heliyon*, *10*(6).

Morejón-Arrojo, R. D., & Rodríguez-Viera, L. (2024). Opportunistic predation on hydromedusae by the foureye butterflyfish and associated crustaceans. *Discover Oceans*, *1*(1), 19.

Motta, P. J. (2012). *The butterflyfishes: success on the coral reef* (Vol. 9). Springer Science & Business Media.

Nanami, A. (2024). Nocturnal substrate association of four coral reef fish groups (parrotfishes, surgeonfishes, groupers and butterflyfishes) in relation to substrate architectural characteristics. *PeerJ*, *12*, e17772.

Ng, C. S. L., Sam, S. Q., Kikuzawa, Y. P., Toh, T. C., & Chou, L. M. (2024). Coral Reef Ecosystem Enhancement in Singapore's Highly Urbanized Port. In *Reclaiming Eden* (pp. 251-278). Jenny Stanford Publishing.

Nowicki, J. P., d Adam, K. D., & Stefan, P. (2013). Butterflyfishes as a model group for reef fish ecology: important and emerging research topics. *Biology of butterflyfishes*, 310.

Pratchett, M. S., Chong-Seng, K. M., Feary, D. A., Hoey, A. S., Fulton, C. J., Nowicki, J. P., Dewan, A. K., Walker, S. P., & Berumen, M. L. (2013). Butterflyfishes as a model group for reef fish ecology: Important and emerging research topics.

Ramírez-Ruiz, C. I., Schmitter-Soto, J. J., & Díaz-Osorio, A. C. (2023). Interactions of coral reef cleaner species in the Mexican Caribbean. *Environmental Biology of Fishes*, *106*(9), 1831-1850.

Reinhart, S., & Christopher, R. (2023). Consumer Perspectives on Data Privacy and Transparency for Blockchain-Based Systems in the US Biotechnology Industry. *Journal of Commercial Biotechnology*, *28*(5).

Russ, G. R., & Leahy, S. M. (2017). Rapid decline and decadal-scale recovery of corals and Chaetodon butterflyfish on Philippine coral reefs. *Marine Biology*, *164*, 1-18.

Samoilys, M., Alvarez-Filip, L., Myers, R., & Chabanet, P. (2022). Diversity of coral reef fishes in the western Indian Ocean: Implications for Conservation. *Diversity*, *14*(2), 102.

Sun, L., & Choi, E. (2023). Substrate Transport in Cylindrical Multi-Capillary Beds with Axial Diffusion. *Letters in Biomathematics*, *10*(1), 63-74.

Tréhin, J. R. (2023). Citizen science and mobile apps engaging the public in fish taxonomy. *FishTaxa-Journal of Fish Taxonomy*, *30*.

Zhang, S., Song, Y., Liu, M., Yuan, Z., Zhang, M., Zhang, H., Seim, I., Fan, G., Liu, S., & Liu, X. (2023). Chromosome-level genome of butterflyfish unveils genomic features of unique colour patterns and morphological traits. *DNA Research*, *30*(5), dsad018.