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Influence of lunar cycle on marine fish larvae

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Abstract:

The lunar cycle influence fish larvae distribution through processes such as spawning, migration and settlement however its effects remain unclear. This study investigated the impact of lunar phases on fish larvae abundance around Chumbe and Changuu Islands for six months in Zanzibar. Larvae were collected using plankton nets during evening hours (1900–2300 hrs) across different lunar phases while environmental parameters including temperature,pH and dissolved oxygen were recorded. A total of 682 larval specimens representing 22 coral reef families were identified with overall abundance being low (<10 individuals/100m³) likely due to the region's low productivity. Larval abundance was highest during the full moon followed by the new moon whereas the first and last quarter phases exhibited the lowest abundances. Statistical analysis using the Kruskal-Wallis test ($p < 0.05$) confirmed a significant association between lunar phases and larval abundance. This findings suggest that tidal dynamics driven by the lunar cycle play a key role in fish larval abundance with spring tides (full and new moons) enhancing larval transport and aggregation through stronger tidal currents while neap tides (first and last quarters) correspond with reduced abundance due to weaker currents.

Keywords: Fish larvae, abundance, lunar cycle, Chumbe and Changuu Islands, Zanzibar

1. Introduction

The lunar cycle plays a critical role in shaping the behavior, survival and distribution of marine fish larvae through its influence on environmental factors such as light intensity and tidal dynamic[1][2]. These factors vary across the lunar phases including new moon, first quarter, full moon and last quarter which creating distinct conditions that affect larval ecology[3][4]. The synchronization of biological processes with the lunar cycle is particularly evident in marine systems as many species have evolved to align their reproductive and dispersal strategies with these periodic changes [5]. Light intensity during the lunar phases directly influences the behavior and survival of marine fish larvae by altering their visibility to predators [6]. During full moons the bright nocturnal light increases the vulnerability of larvae to predation often leading to higher mortality [7]. Conversely the darkness during the new moon provides a natural shield, reducing predation risks and enhancing survival chances [8]. This variation in light intensity also affects larval behavior as larvae may adjust their vertical migration within the water column to avoid predators under varying moonlight conditions [9].

Also tidal patterns driven by the moon's gravitational pull further influence larval dynamics [10][7]. Spring tides which occur during the full and new moons produce strong currents that facilitate the dispersal of larvae to suitable nursery habitat [11]. These tides can improve larval access to nutrient-rich areas, promoting growth and survival. However the strong turbulence associated with spring tides can displace larvae into unsuitable environments or expose them to increased predation, illustrating the dual effects of tidal dynamics [12].The lunar cycle also plays a vital role in the reproductive strategies of marine fish [13] [14]. Many species synchronize their spawning events with specific lunar phases to ensure larvae hatch under favorable environmental conditions [15]. For instance, spawning during the new moon or darker phases often aligns with reduced predation risks and optimal tidal currents for dispersal, thereby enhancing larval survival [16]. This evolutionary adaptation ensures the continuity and success of species across generations. Despite the potential influence of the lunar cycle on fish larvae abundance, limited research has been conducted in the Western Indian Ocean to explore this relationship comprehensively [31].Understanding how lunar phases affect fish larvae abundance is crucial for gaining insights into fish community biology in coastal ecosystems and enhance our understanding of ecological processes influencing fish larvae dynamics which are essential for sustaining healthy marine ecosystems and supporting fisheries.

2. MATERIALS AND METHODS

2.1 The study area

The research was conducted in the coral reef ecosystems of Chumbe and Changuu Islands (Fig. 1) located in the Zanzibar Archipelago. Chumbe Island situated west of Unguja is a privately managed marine protected area known for its exceptional biodiversity. It features a fringing coral reef exposed to the open Indian Ocean which promotes continuous nutrient exchange, supporting habitats like coral reefs, seagrass beds and algal mats. These habitats along with moderate tidal fluctuations that enhance nutrient cycling, create favorable conditions for fish larvae by providing shelter, food and optimal growth environments [17] [18].Changuu Island approximately 5 km off the Zanzibar coast and also known as Prison Island, features shallow coral reefs that support diverse marine life including fish and mollusks. The relatively undisturbed environment of Changuu promotes larval development by offering nursery habitats and reduced anthropogenic pressures [19]. The distinct ecological features of both Islands provided contrasting settings for examining coral reef fish larvae under varying environmental conditions.

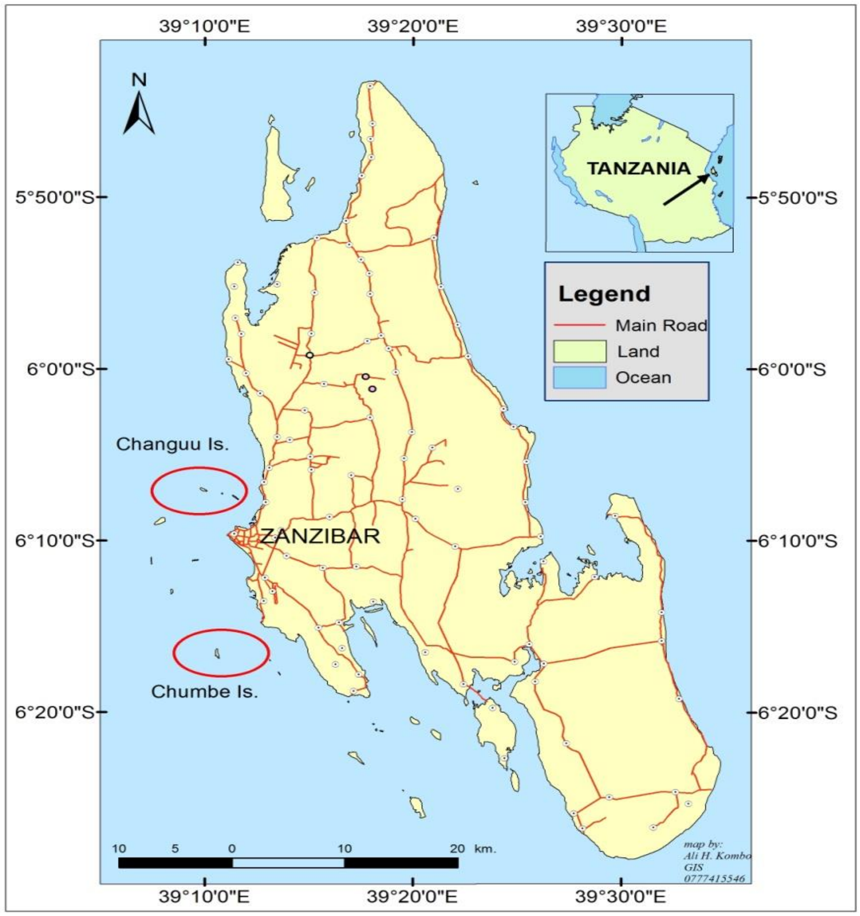

Fig. 1: A Map of Unguja Island showing the location of study areas.

2.2 Sampling procedures

Sampling was conducted over six months with four sampling sessions each month, during the early evening (7:00–11:00 PM) at Chumbe and Changuu Islands corresponding to the new moon, first quarter, last quarter and full moon. Fish larvae were collected using planktonic net with a removable cod end (mesh size 50 µm), a mouth diameter of 20 cm and a length of 50 cm. The net was equipped with an oceanic flow meter in the mouth frame to estimate the volume of water filtered. Sea surface tows were carried out by towing the net for 15 minutes at the boat's minimum speed using a 10-meter-long rope. At Chumbe Island sampling took place outside the marine protected area due to no-take restrictions while at Changuu Island sampling occurred within its boundaries. Four replicates were performed at each site: two near coral reefs and two away from coral reefs. Larvae were preserved in a solution of 70% ethanol mixed with seawater immediately after collection. Environmental parameters were measured on-site using a multi-parameter device

(HATCH HQ 40D).In the laboratory fish larvae were transferred to 70% ethanol for long-term storage. Larvae were sorted under a stereomicroscope and identified to the family level using taxonomic guides [20]. Developmental stages were categorized as pre-flexion, flexion and post-flexion. Distorted fish larvae without intact morphological features or that could not be identified were grouped as unidentified.

2.3 Data analysis

The field data collected was organized in an Excel spreadsheet and analyzed using SPSS version 26. The abundance of larval fish was expressed as the number of individuals per 100 m^3. Descriptive statistics were used to assess the relative abundance of different larval taxa and their growth stages (pre-flexion flexion and post-flexion). The relationship between fish larvae abundance and the lunar cycle was examined using Kruskal-Wallis test since the data did not meet the assumptions for parametric testing.

2. RESULTS

3.1 Fish larvae growth stage composition

The study recorded 682 fish species across 22 families with Mullidae (42.4%) as the dominant family followed by Clupeidae (14.4%), Tripterygiidae (9.8%), Atherinidae (5.3%) and Sillaginidae (4.8%). Other families included Engraulidae (2.3%), Carangidae (1.9%), Balistidae (1.3%), Hemirhamphidae (1.2%), Gobiesocidae (0.9%), Siganidae (0.9%), Lutjanidae (0.9%), Pseudochromidae (0.8%), Microdesminae (0.7%), Labridae (0.7%), Synodontidae (0.7%), Scaridae (0.5%), Blenniidae (0.5%), Monocanthidae (0.3%), Lethrinidae (0.1%), Gerreidae (0.1%), and Gobiidae (0.1%). Fish larvae were predominantly in the preflexion stage (77.7%) followed by postflexion (6.9%) and flexion (5.6%). Unidentified larvae constituted 3.1% of the total while 6.3% of the samples contained no larvae as illustrated in (Fig. 2). The species distribution highlighted the dominance of onshore marine families such as Mullidae, Clupeidae, Atherinidae and Sillaginidae while offshore families like Carangidae, Balistidae and Lutjanidae were less abundant. Transitional families such as Tripterygiidae and Labridae were observed inhabiting both onshore and offshore environments.

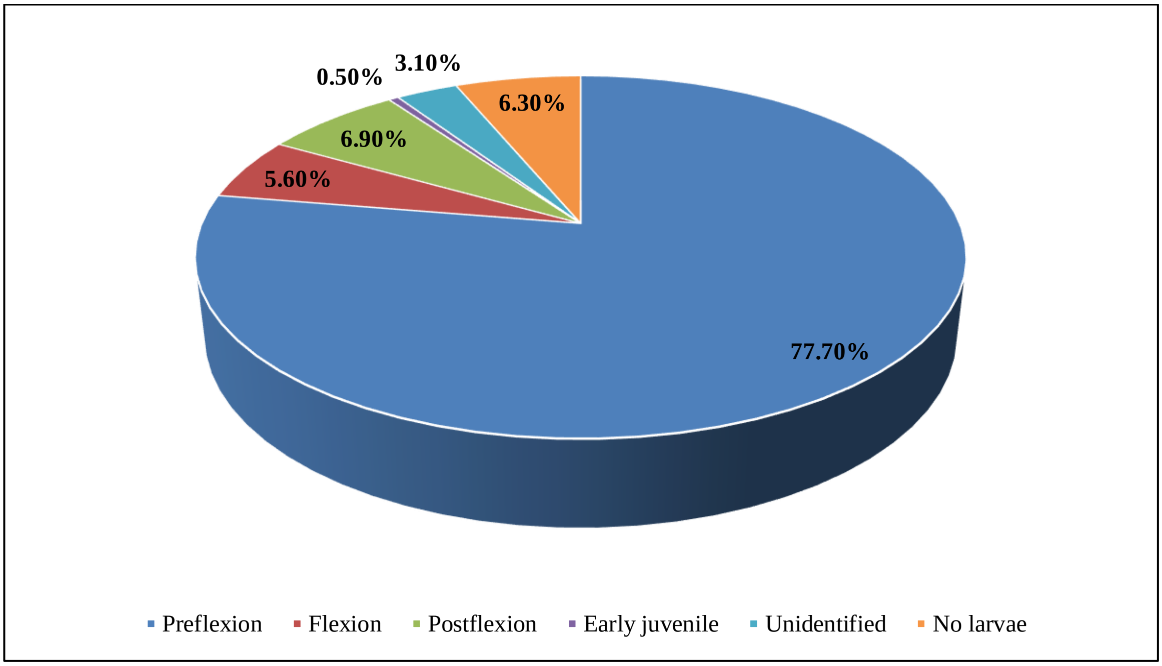

Fig. 2: Growth stage of fish larvae

3.2 Fish Larvae Abundance Across Families and Lunar Phases

The abundance of fish larvae across various families during different lunar phases are differs as shown in (Fig. 3). The Mullidae family exhibits the highest abundance, particularly during the full moon and first quarter phases suggesting a significant lunar influence. The Clupeidae family ranks second in abundance also peaking during the first quarter and full moon. Transitional families like Tripterygiidae show relatively consistent abundance across all lunar phases. In contrast, families such as Lethrinidae, Gobiesocidae, and Monacanthidae display minimal or negligible abundance. Overall the data reveals that certain families especially Mullidae and Clupeidae are strongly influenced by lunar cycles with peak abundances observed during the full moon and first quarter phases.

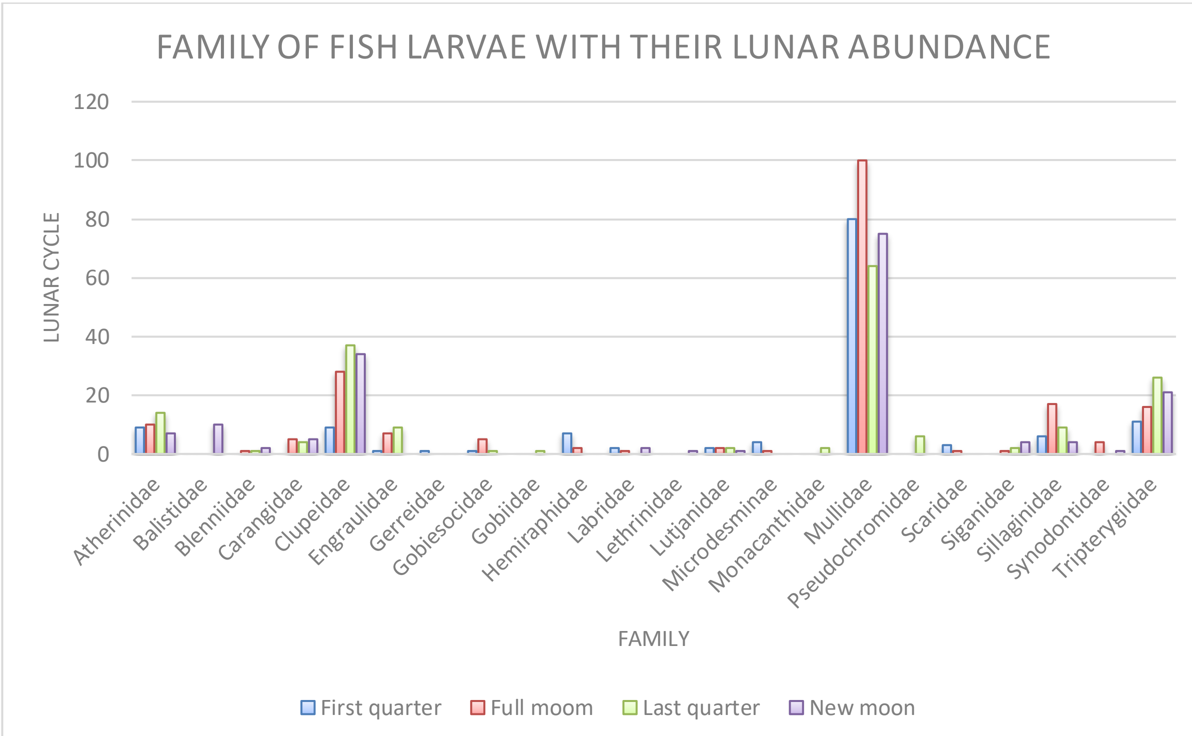

Fig. 3: Families of fish larvae with their phases of lunar cycle

3.3 Influence of lunar cycle on fish larvae abundance

The box plot shows significant differences in population density among the lunar phases. Full moon exhibits the highest population density with a larger interquartile range .First quarter and last quarter phases show much lower population densities with small interquartile ranges**.** New Moon has intermediate population density as shown in (Fig. 4).The observed cyclical pattern in fish larval abundance with peaks during the full moon and lower numbers during the first quarter suggests a potential lunar influence. However independent Kruskal-Walls test (H = 79.9, df = 3 p = 0.000) reveals statistically significant relationship between lunar phases and larval abundance.

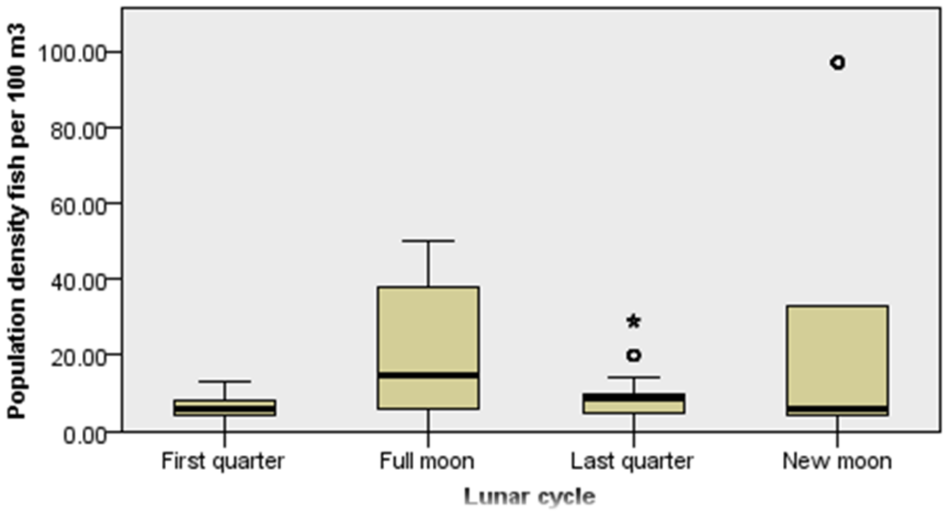

Fig 4: Larval abundance with relation to lunar cycle

4.DISCUSSION

The study shows that Mullidae and Clupeidae dominate coastal habitats while transitional families like Tripterygiidae are adaptable to both coastal and offshore environments due to the sampling methods employed. The observed pattern of higher larval abundances during full and new moons and lower abundances during the first and last quarters of the moon is likely influenced by tidal dynamics rather than predation or synchronized larval release [22][23]. Full and new moons coincide with spring tides characterized by larger tidal variations due to the alignment of the sun and moon's gravitational forces [24][25]. These stronger currents enhance the transport of larvae from reef nursery grounds to offshore sites contributing to higher observed abundances [26]. Conversely the weaker tidal forces during the first and last quarter moons result in neap tides with reduced current strength, limiting larval dispersal and leading to lower observed abundances during these periods [11] [27].The study found a statistically significant association between lunar cycles and larval abundance aligning with research by [31] which noted that lunar cycles influence spawning and larval release in specific species and [32] who observed that coral reef fish larvae recruitment is synchronized with lunar cycles. However other studies [28][29][30] suggest that local environmental factors such as water temperature, food availability and the monsoon season may have a greater influence than lunar phases in determining larval abundance.

5. CONCLUSION AND RECOMMANDATION

The study reveals that fish larval abundance is significantly influenced by lunar phases with higher densities observed during the full moon. Species distributions are closely associated with habitat types with coastal families such as Mullidae and Clupeidae dominating in onshore environments while transitional families like Tripterygiidae exhibit adaptability across both coastal and offshore habitats. These findings underscore the crucial role of lunar cycles in shaping ecological patterns and influencing fish populations. It is recommended that conservation efforts focus on protecting reef nursery habitats during the full and new moons when larval transport is most pronounced to ensure the successful dispersal and recruitment of key fish species.

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