

Obj 3 - To analyse Population ecology of Dominant species of marine Mollusca along South Saurashtra coast.

Introduction

The importance of assessing the density, abundance, and frequency of Mollusc populations cannot be overstated. Density and abundance measurements help determine the biomass and health of mollusc populations, indicating the productivity and carrying capacity of their habitats (Caddy & Defeo, 2003). Frequent monitoring of these metrics provides critical data for understanding population dynamics, reproductive success, and survival rates (Caddy & Defeo, 2003). High densities and abundances often correlate with healthy ecosystems, while declines may signal ecological imbalances (Leonardi et al., 2020). Frequent monitoring also aids in detecting seasonal and annual variations, providing insights into the long-term health and stability of marine environments (Chahouri et al., 2023).

In the population ecology study, key species were selected based on their abundance and year-round presence in the study area. Abundant species provide a larger sample size, enhancing the statistical power and reliability of the data, which allows for the detection of clear trends and patterns in population dynamics. Furthermore, two very prominent and dominant species (*Cerithium caeruleum* (CC), *Lunella coronatus* (LC)) were specifically chosen for studying the gonadal cycle. This decision was driven by their dominance and continuous presence, which allowed for a detailed analysis of their reproductive biology.

The detail methodology for this chapter has been described in materials and methods chapter.

Result and Discussion

The density, abundance and frequency of selected key species viz., *Cerithium caeruleum* (CC), *Lunella coronatus* (LC), *Peronia verruculatum* (PV) and *Trochus radiatus* (TR) was measured across different intertidal zones: Upper Intertidal Zone (UIZ), Middle Intertidal Zone (MIZ), and Lower Intertidal Zone (LIZ).

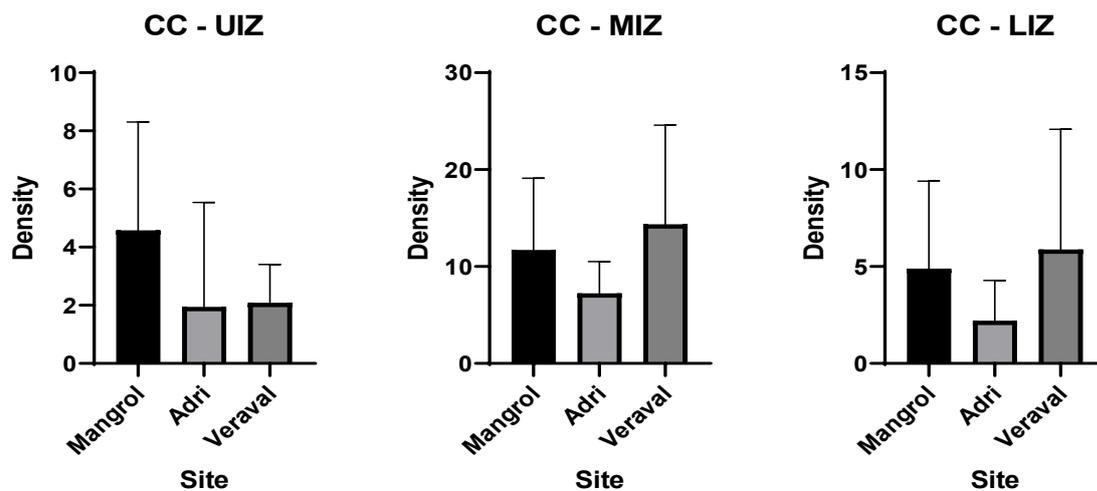


Fig – Density of *Cerithium caeruleum* along different study sites from different zones

The results showed statistically significant variation in density in both the UIZ and MIZ, with p-values of 0.0171 and 0.0500, respectively, indicating notable differences in habitat preferences across these zones. The significant p-value in the UIZ suggests that *Cerithium caeruleum* is influenced by factors such as exposure to air, sunlight, and desiccation stress, leading to varying densities at different sites within this zone. Similarly, the significant variation in the MIZ indicates sensitivity to moderate and stable conditions provided by regular tidal inundation, resulting in selective habitat preferences. Conversely, the LIZ showed a non-significant variation in density ($p=0.0670$), indicating a relatively uniform distribution in this zone. The lack of significant variation in the LIZ may be due to the stable submersion conditions, which create a consistent environment less influenced by factors that vary across different study sites.

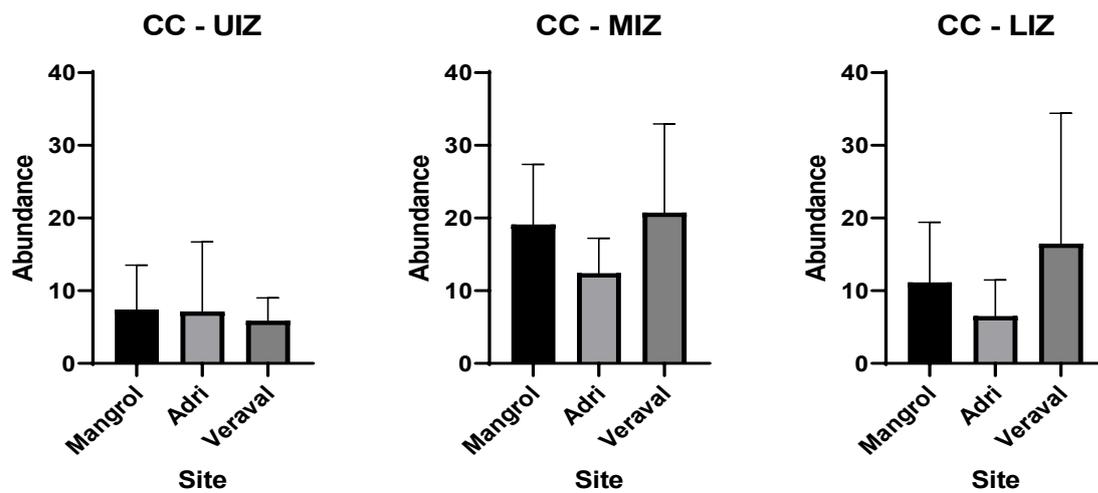


Fig – Abundance of *Cerithium caeruleum* along different study sites from different zones

The results showed statistically significant variation in abundance in the MIZ, with a p-value of 0.0455, indicating notable differences in habitat preferences across this zone. The significant p-value in the MIZ suggests that *Cerithium caeruleum* is sensitive to the moderate and stable conditions provided by regular tidal inundation, leading to varying abundances at different sites within this zone. Conversely, the UIZ and LIZ showed non-significant variations in abundance, with p-values of 0.3954 and 0.0874, respectively, indicating relatively uniform distributions in these zones. The lack of significant variation in the UIZ may be attributed to the broad tolerance of the species to varying environmental conditions such as exposure to air, sunlight, and desiccation stress. Similarly, the non-significant variation in the LIZ may be due to the stable submersion conditions, which create a consistent environment less influenced by factors that vary across different study sites.

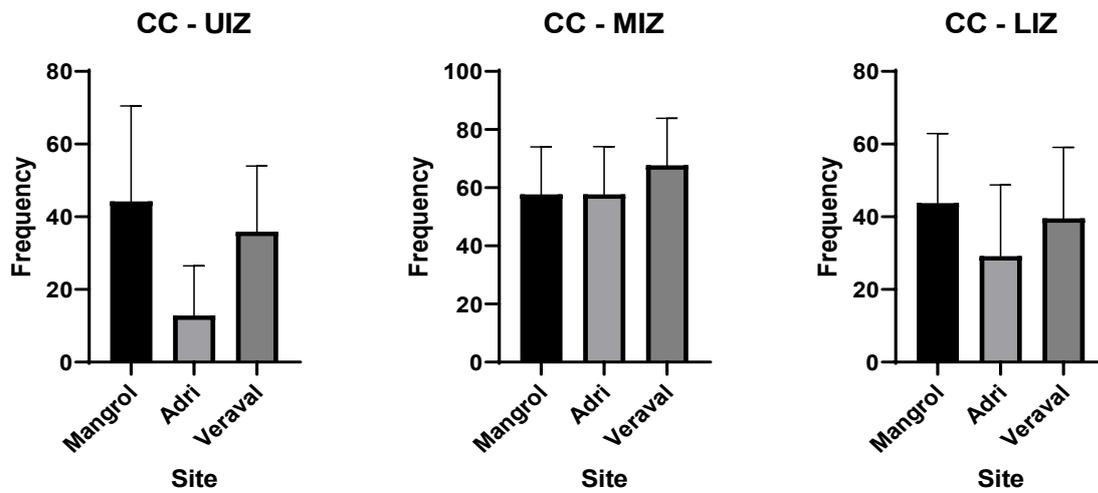


Fig – Frequency of *Cerithium caeruleum* along different study sites from different zones

The results showed statistically significant variation in frequency in the UIZ, with a p-value of 0.0018, indicating notable differences in habitat preferences across this zone. The significant p-value in the UIZ suggests that *Cerithium caeruleum* is influenced by factors such as exposure to air, sunlight, and desiccation stress, leading to varying frequencies at different sites within this zone. Conversely, the MIZ and LIZ showed non-significant variations in frequency, with p-values of 0.2763 and 0.2967, respectively, indicating relatively uniform distributions in these zones. The lack of significant variation in the MIZ and LIZ may be due to the species' broad tolerance to the moderate and stable conditions provided by regular tidal inundation and stable submersion conditions, which create consistent environments less influenced by factors that vary across different study sites.

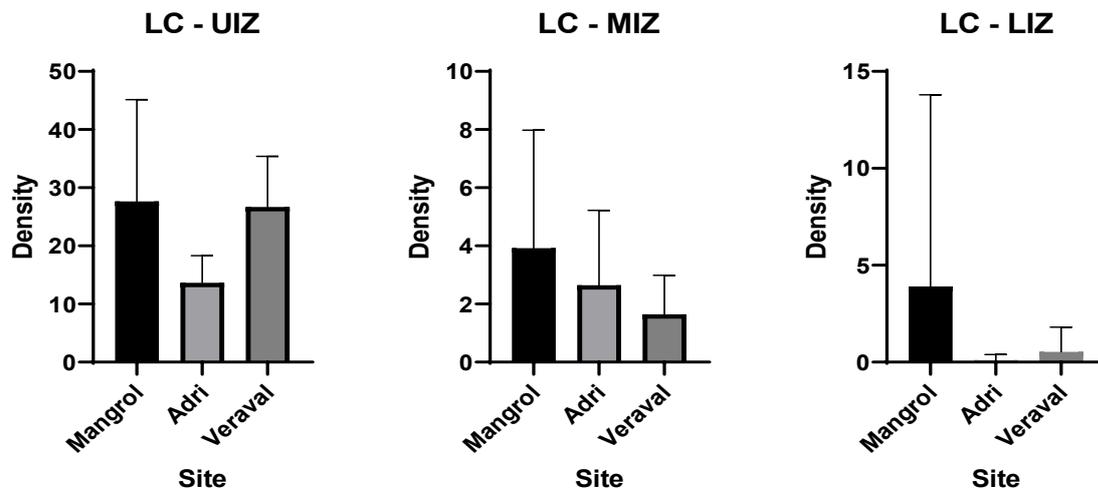


Fig – Density of *Lunella coronatus* along different study sites from different zones

In the UIZ, the density varied significantly across the study sites, with a p-value of 0.0014 indicating statistical significance. In the MIZ, density showed some variation but was not statistically significant ($p=0.2598$). The LIZ also exhibited significant variation in density, with a p-value of 0.0260. The significant variation in the UIZ suggests that *Lunella coronatus* is sensitive to conditions in this zone, which is characterized by greater exposure to air and sunlight, leading to higher temperatures and desiccation stress. In contrast, the non-significant variation in the MIZ implies a more uniform population density, likely due to the moderate and stable conditions provided by regular tidal inundation. The significant variation in the LIZ indicates influence by factors such as submersion, wave action, and predation.

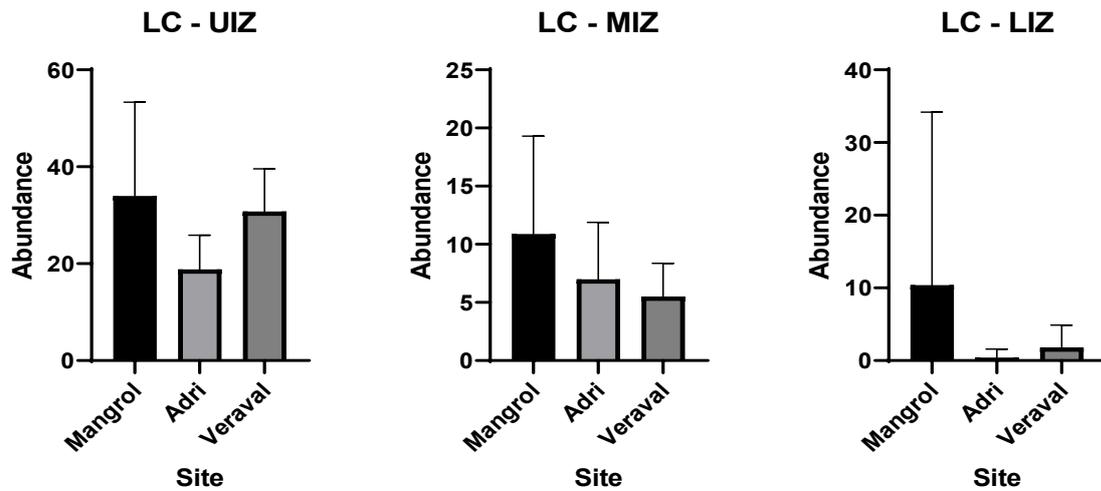


Fig – Abundance of *Lunella coronatus* along different study sites from different zones

The results showed significant variation in abundance in the UIZ and LIZ, with p-values of 0.0055 and 0.0234, respectively, indicating statistically significant differences across study sites. In the MIZ, the variation in abundance was not statistically significant, with a p-value of 0.1709. This suggests that *Lunella coronatus* is sensitive to environmental conditions in the UIZ, where greater exposure to air and sunlight leads to higher temperatures and desiccation stress, resulting in significant differences in abundance. In the LIZ, the significant variation is likely due to factors such as submersion, wave action, and predation, which affect habitat suitability. The lack of significant variation in the MIZ implies a more uniform abundance due to moderate and stable conditions provided by regular tidal inundation.

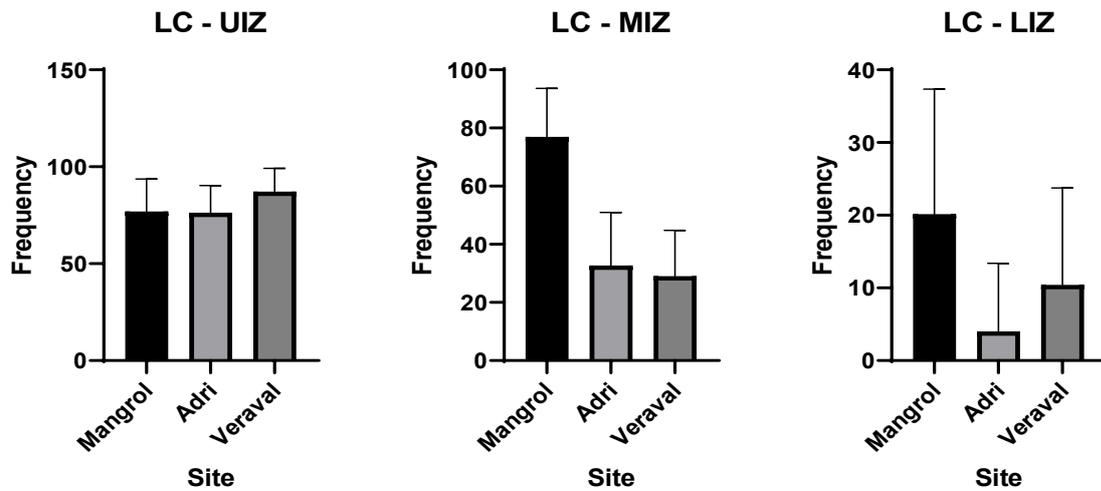


Fig - Frequency of *Lunella coronatus* along different study sites from different zones

The results showed that the variation in frequency in the UIZ was not statistically significant ($p=0.1071$), suggesting a relatively uniform distribution in this zone despite environmental stressors like higher temperatures and desiccation. In contrast, the MIZ exhibited highly significant variation in frequency ($p<0.0001$), indicating that *Lunella coronatus* is sensitive to the moderate and stable conditions provided by regular tidal inundation, leading to selective habitat preferences within this zone. Similarly, the LIZ showed significant variation in frequency ($p=0.0183$), which could be attributed to factors such as submersion, wave action, and predation that create varying habitat suitability.

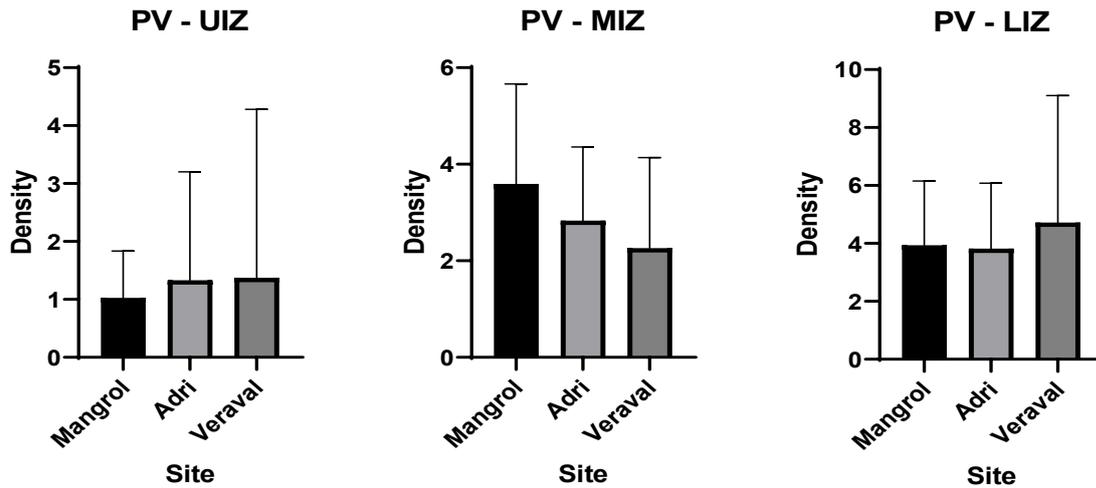


Fig – Density of *Peronia verruculata* along different study sites from different zones

The above graph indicates that the variation in density across study sites was not statistically significant in any of the zones. In the UIZ, the p-value was 0.6102, in the MIZ, the p-value was 0.2665, and in the LIZ, the p-value was 0.9597. These non-significant p-values suggest a relatively uniform density of *Peronia verruculata* across the different intertidal zones. The lack of significant variation may be attributed to the broad tolerance of the species to the varying environmental conditions present in the intertidal zones, such as changes in moisture, temperature, and wave action. This uniformity in density implies that *Peronia verruculata* can adapt well to the diverse microhabitats available within the intertidal regions, leading to a consistent distribution pattern across the study sites.

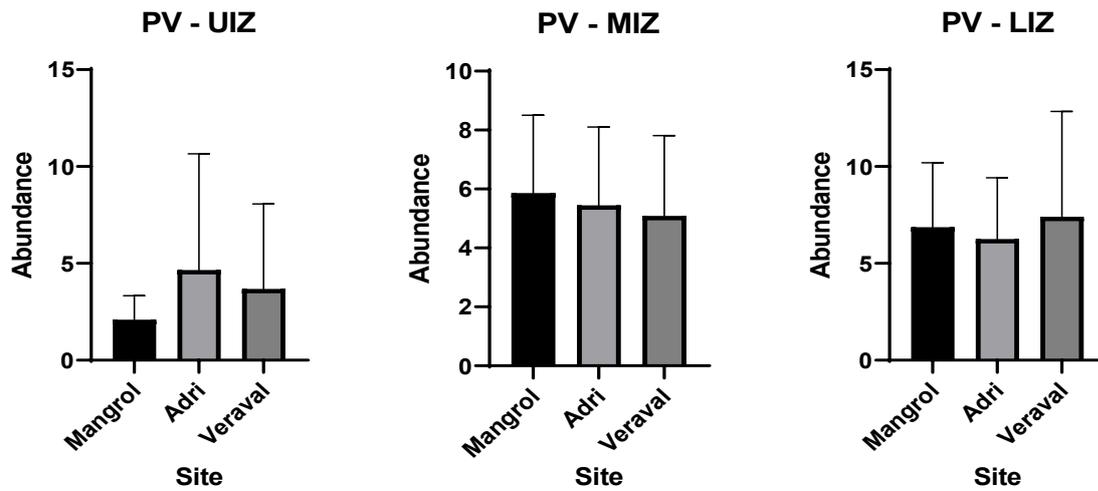


Fig – Abundance of *Peronia verruculata* along different study sites from different zones

The above graph indicates that the variation in abundance across study sites was not statistically significant in any of the zones. In the UIZ, the p-value was 0.7502, in the MIZ, the p-value was 0.8873, and in the LIZ, the p-value was 0.8819. These non-significant p-values suggest a relatively uniform distribution of *Peronia verruculata* across the different intertidal zones. The lack of significant variation may be attributed to the broad tolerance of the species to the varying environmental conditions present in the intertidal zones, such as changes in moisture, temperature, and wave action. This uniformity in abundance implies that *Peronia verruculata* can adapt well to the diverse microhabitats available within the intertidal regions, leading to a consistent distribution pattern across the study sites.

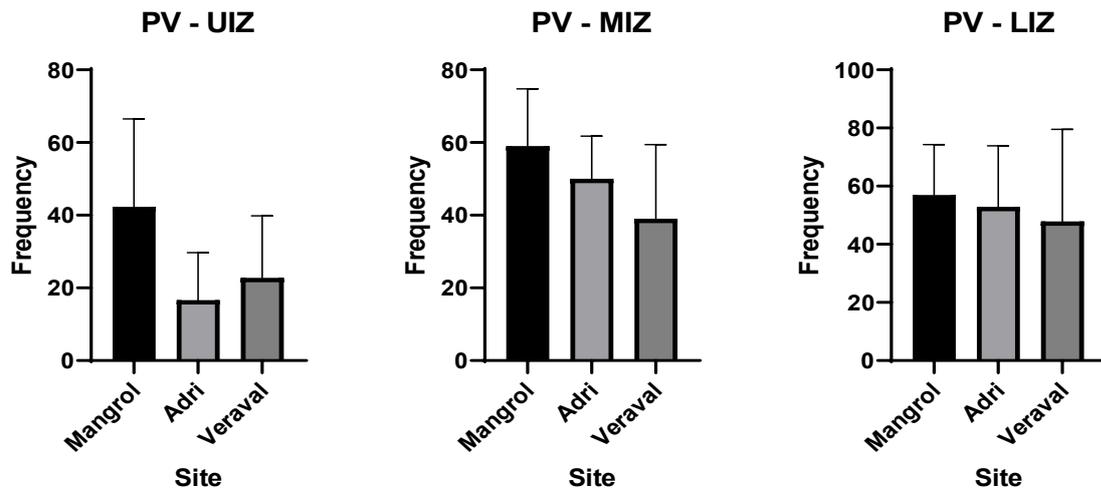


Fig – Frequency of *Peronia verruculata* along different study sites from different zones

The graphs indicate that the variation in frequency was statistically significant in the UIZ and MIZ, with p-values of 0.0234 and 0.0357, respectively, suggesting notable differences in habitat preferences across these zones. The significant p-value in the UIZ implies that *Peronia verruculata* may be influenced by factors such as exposure to air, sunlight, and desiccation stress, leading to varying frequencies at different sites within this zone. In the MIZ, the significant variation in frequency suggests that the species is sensitive to the moderate and stable conditions provided by regular tidal inundation, resulting in selective habitat preferences. Conversely, the LIZ showed a non-significant variation in frequency ($p=0.7520$), indicating a relatively uniform frequency in this zone. This may be due to the stable submersion conditions, which create a consistent environment less influenced by factors that vary across different study sites.

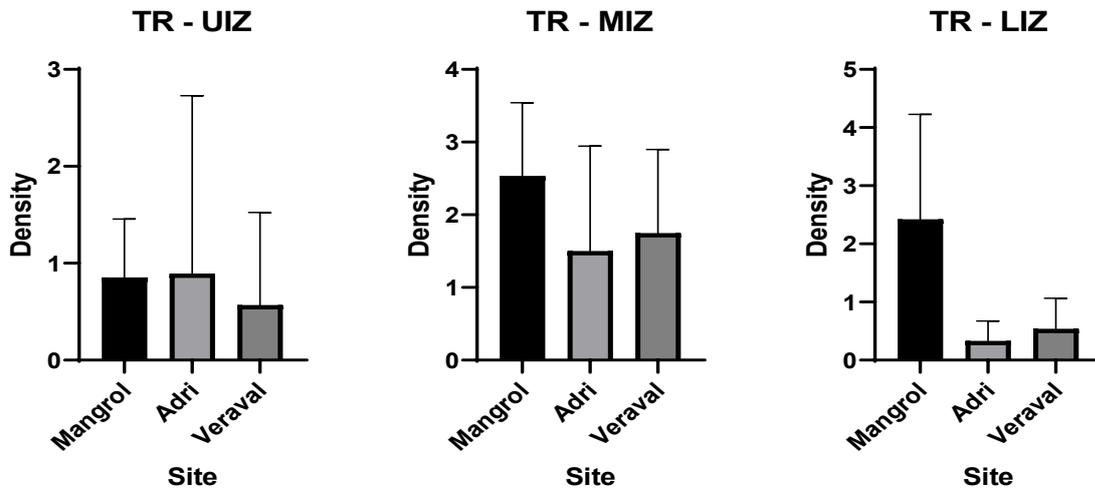


Fig – Density of *Trochus radiatus* along different study sites from different zones

The results showed statistically significant variation in density in the UIZ and LIZ, with p-values of 0.0496 and 0.0005, respectively, indicating notable differences in habitat preferences across these zones. The significant p-value in the UIZ suggests that *Trochus radiatus* is influenced by factors such as exposure to air, sunlight, and desiccation stress, leading to varying densities at different sites within this zone. In the LIZ, the highly significant variation in density indicates that the species is sensitive to the stable submersion conditions, wave action, and potential predation, resulting in selective habitat preferences. Conversely, the MIZ showed a non-significant variation in density ($p=0.8873$), indicating a relatively uniform distribution in this zone. This may be due to the moderate and stable conditions provided by regular tidal inundation, which create a consistent environment less influenced by factors that vary across different study sites.

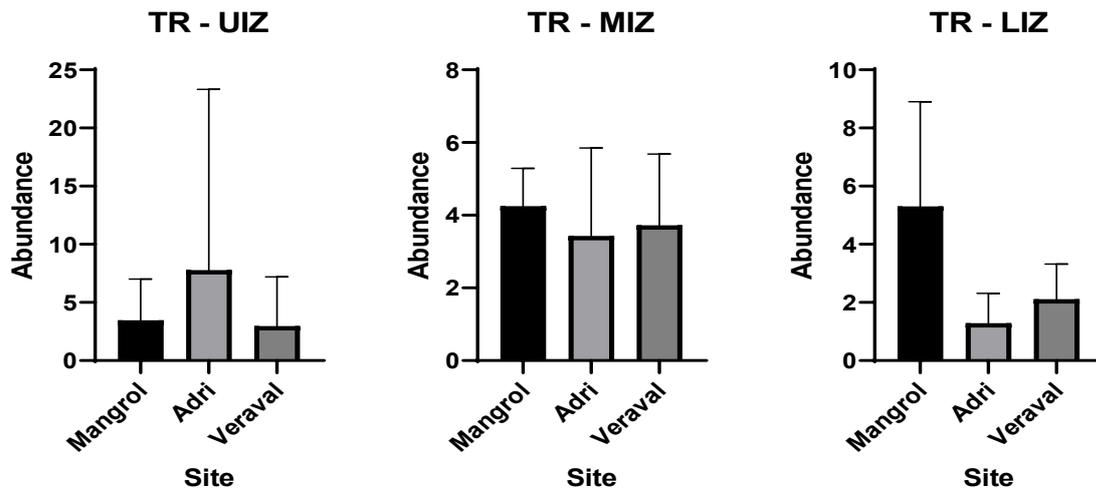


Fig – Abundance of *Trochus radiatus* along different study sites from different zones

The results showed that the variation in abundance was statistically significant in the LIZ with a p-value of 0.0011, indicating notable differences in habitat preferences across this zone. The significant p-value in the LIZ suggests that *Trochus radiatus* is sensitive to the stable submersion conditions, wave action, and potential predation, resulting in selective habitat preferences. Conversely, the variation in abundance in the UIZ ($p=0.2183$) and MIZ ($p=0.1567$) was not statistically significant, indicating a relatively uniform distribution in these zones. The lack of significant variation in the UIZ and MIZ may be attributed to the broad tolerance of the species to varying environmental conditions such as changes in moisture, temperature, and tidal inundation.

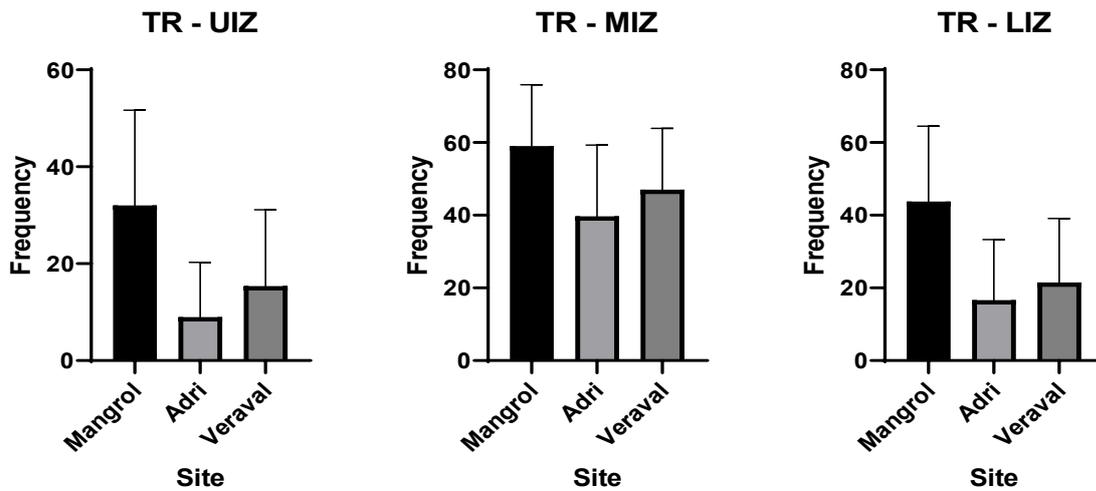


Fig – Frequency of *Trochus radiatus* along different study sites from different zones

The results showed statistically significant variation in frequency in both the UIZ and LIZ, with p-values of 0.0062 for both zones, indicating notable differences in habitat preferences. The significant p-value in the UIZ suggests that *Trochus radiatus* is influenced by factors such as exposure to air, sunlight, and desiccation stress, leading to varying frequencies at different sites within this zone. Similarly, the significant variation in the LIZ indicates that the species is sensitive to stable submersion conditions, wave action, and potential predation, resulting in selective habitat preferences. Conversely, the MIZ showed a non-significant variation in frequency ($p=0.0659$), indicating a relatively uniform distribution in this zone. The lack of significant variation in the MIZ may be due to the moderate and stable conditions provided by regular tidal inundation, which create a consistent environment less influenced by factors that vary across different study sites.

Gonadal Cycle Analysis of Selected dominant Species

Lunella coronatus

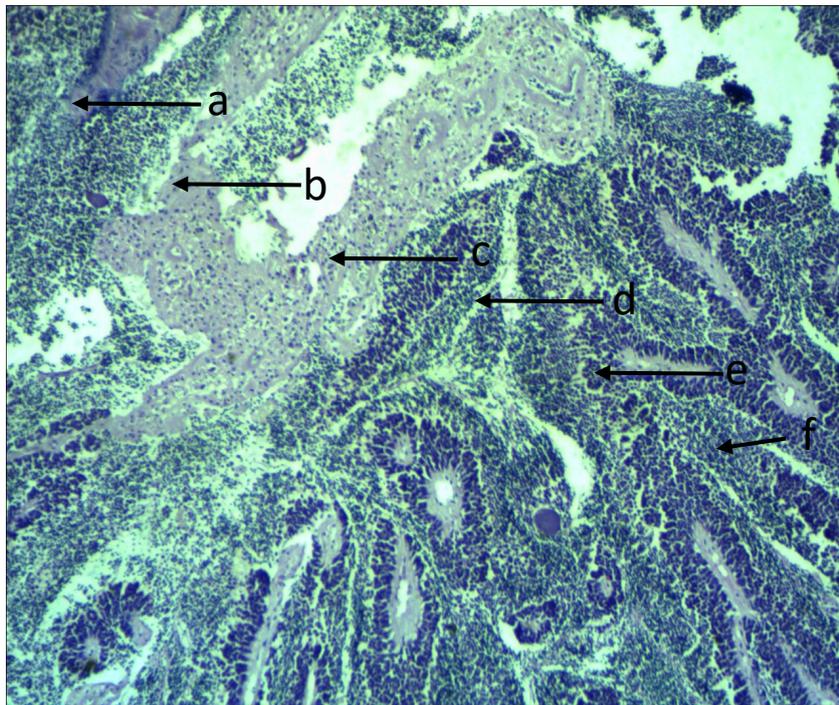


Fig - Histological slide of the male gonad of *Lunella coronatus* from **March (Summer)**
a) Mature spermatozoa b) Spermatocytes c) Spermatids d) Sertoli Cells e) Leydig Cells f)
Blood Vessels

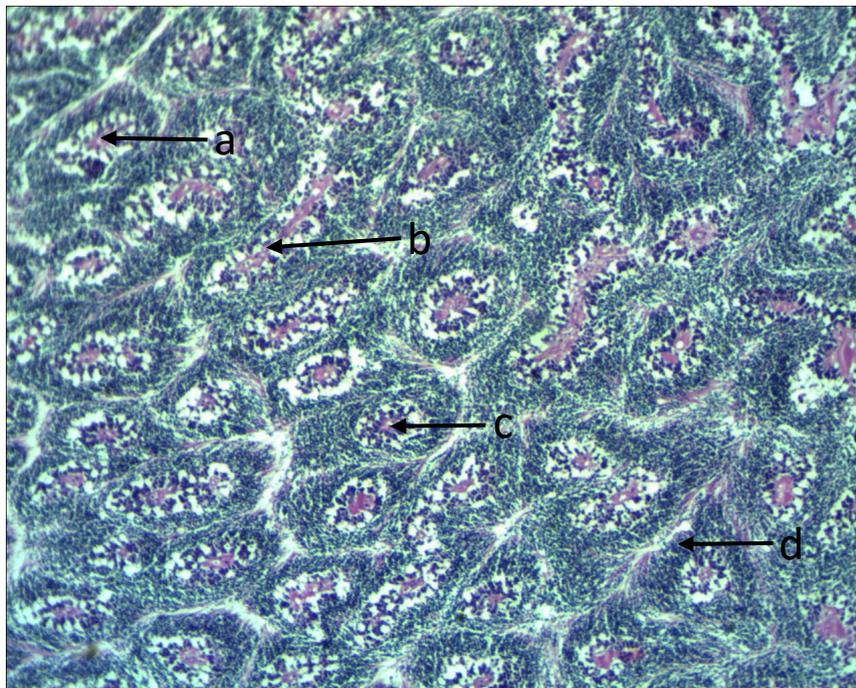


Fig - Histological slide of the male gonad of *Lunella coronatus* from **January (Winter)**
a) Spermatogonia b) Spermatocyst c) Leydig cells d) Blood vessels

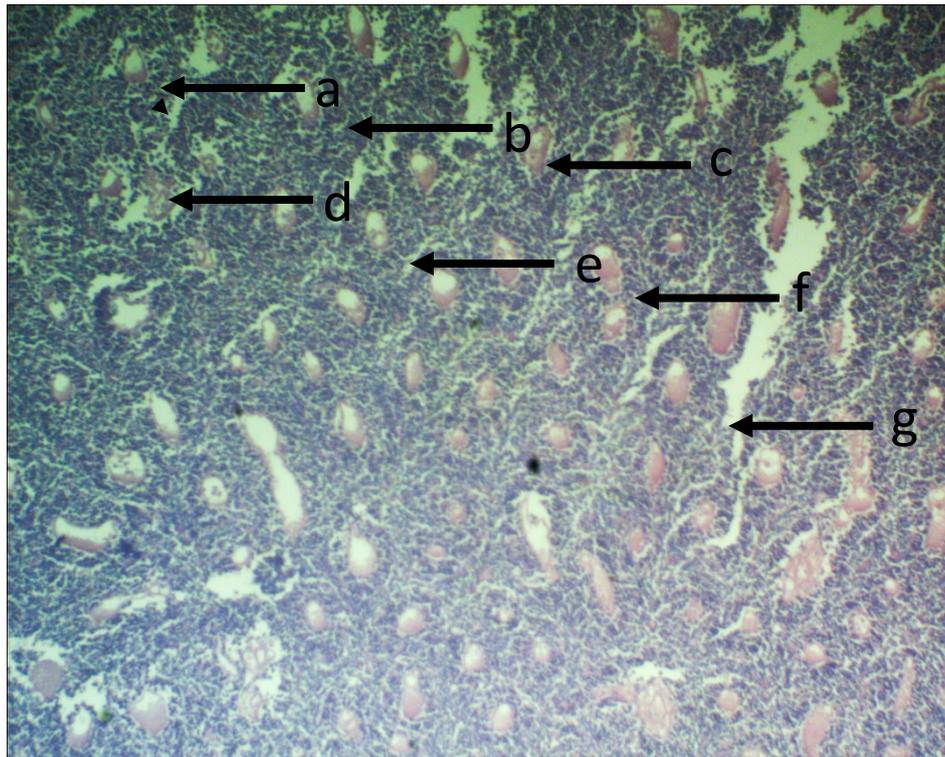


Fig – Histological slide of the male gonad of *Lunella coronatus* from August (Monsoon) a) Spermatogonia b) Spermatids c) Sertoli cells d) Spermatocytes e) Mature Spermatozoa f) Leydig cells g) Blood vessels

The histological examination of **male gonads** of *Lunella coronatus*, across summer, winter, and monsoon seasons reveals distinct variations in spermatogenesis and gonadal activity. During the summer, the gonads exhibit peak reproductive activity with densely packed mature spermatozoa, significant numbers of spermatocytes and spermatids, active Sertoli cells providing support, and Leydig cells producing testosterone, supported by prominent vascularization. In contrast, the winter season shows reduced activity, with predominant spermatogonia indicating the initiation of spermatogenesis, fewer primary spermatocytes, less active Sertoli and Leydig cells, and less prominent blood vessels, reflecting a resting stage. The monsoon season represents a transitional phase, where gonads exhibit characteristics of both resting and active stages, including various stages of sperm development, some mature spermatozoa, and adequately active Sertoli and Leydig cells, preparing for the next reproductive cycle. These seasonal variations highlight the influence of environmental factors on the reproductive cycle of *Lunella coronatus*, providing insights into their reproductive strategies and ecological adaptations.

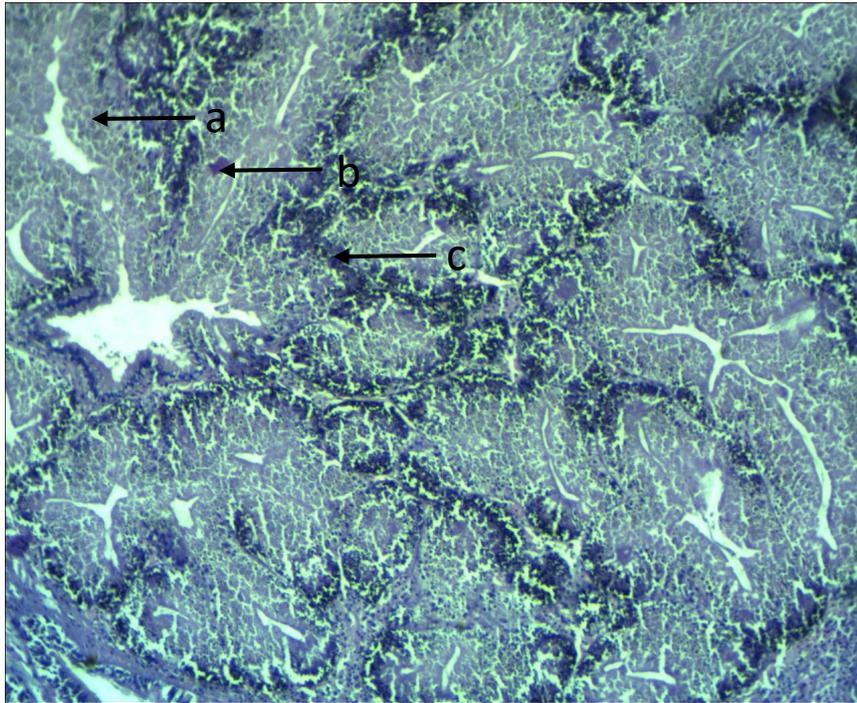


Fig - Histological slide of the female gonad of *Lunella coronatus* from **March (Summer)** a) Mature oocytes b) Follicular Cells c) Stroma

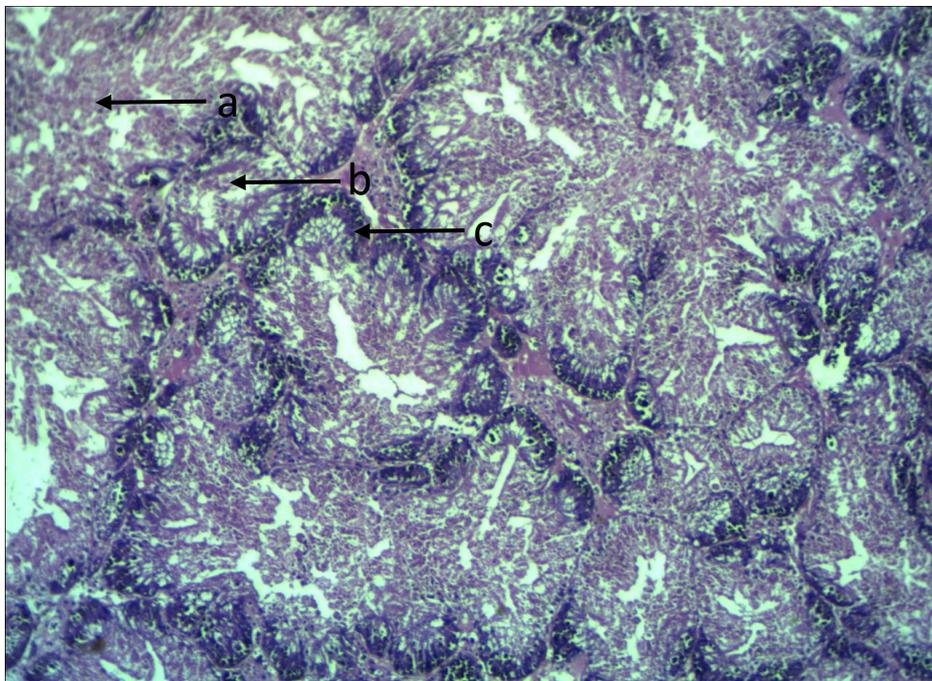


Fig - Histological slide of the male gonad of *Lunella coronatus* from **January (Winter)** a) Oocytes b) Follicular Cells c) Stroma

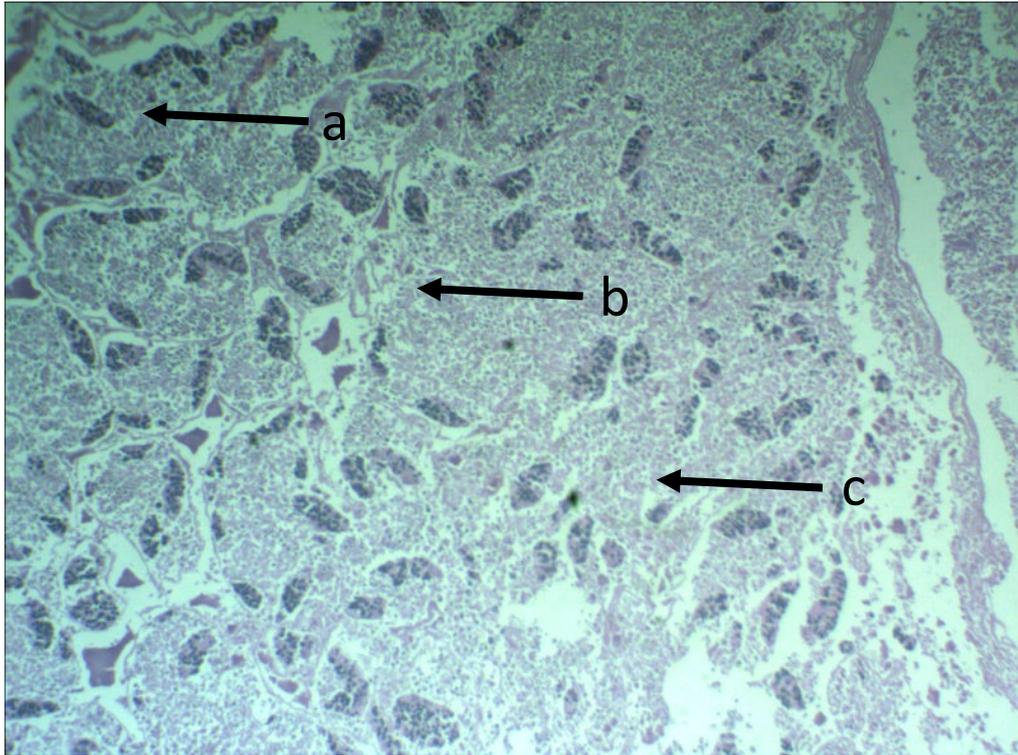


Fig – Histological slide of the female gonad of *Lunella coronatus* from August (Monsoon) a) Oocytes b) Follicular cells c) Stroma

The histological examination of **female gonads** of *Lunella coronatus* across summer, winter, and monsoon seasons reveals distinct variations in oogenesis and gonadal activity. During the summer, the gonads exhibit peak reproductive activity with numerous mature oocytes, well-developed follicular cells, and organized stroma, indicating readiness for spawning. In contrast, the winter season shows reduced activity, with fewer and less developed oocytes, prominent follicular cells, and stroma tissue, reflecting a resting stage. The monsoon season represents a transitional phase, where gonads exhibit characteristics of both resting and active stages, including various stages of oocyte development and adequately active follicular and stroma cells, preparing for the next reproductive cycle. These seasonal variations highlight the influence of environmental factors on the reproductive cycle of *Lunella coronatus*, providing insights into their reproductive strategies and ecological adaptations.

Cerithium Caeruleum

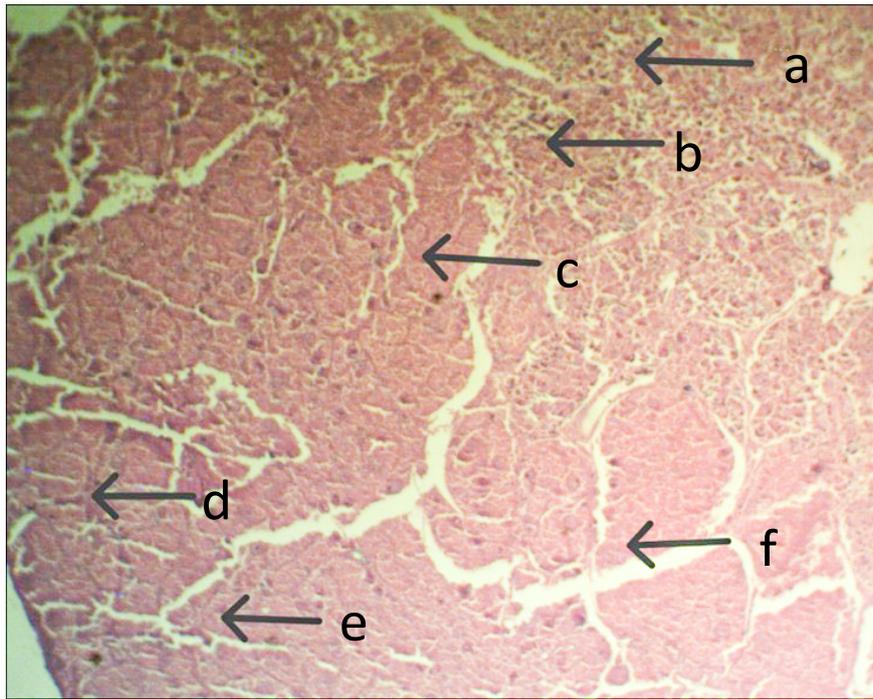


Fig - Histological slide of the male gonad of *Cerithium Caeruleum* from **August (Monsoon)** a) Spermatozoa b) Spermatids c) Secondary Spermatocytes d) Spermatogonia e) Seminiferous tubule f) Interstitial cells

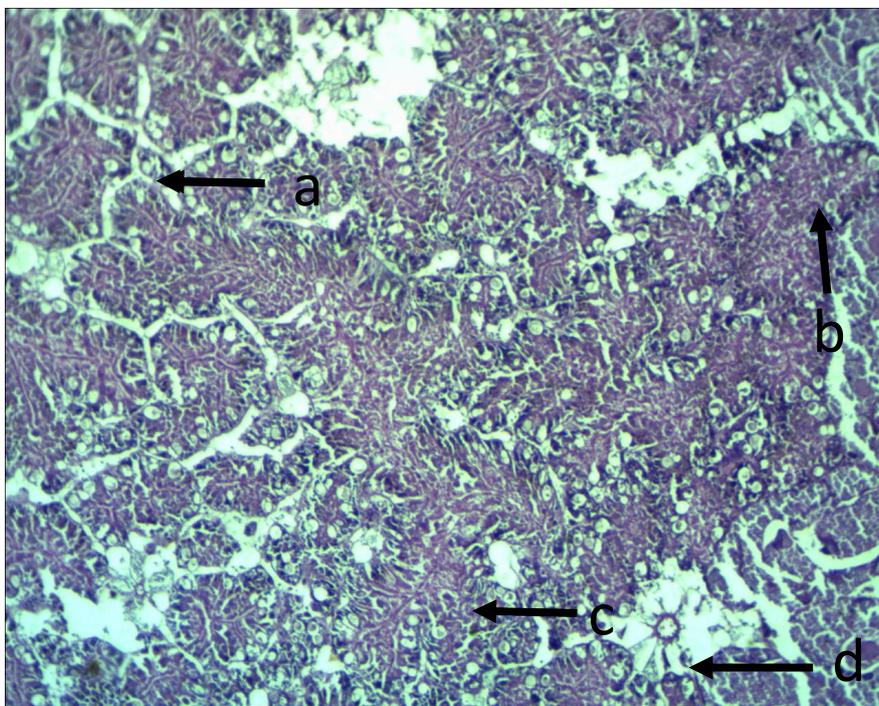


Fig - Histological slide of the male gonad of *Cerithium Caeruleum* from **January (Winter)** a) Spermatogonia b) Spermatozoa c) Spermatocytes d) Spermatid

The histological examination of the male gonad of *Cerithium Caeruleum* across different seasons August (Monsoon), January (Winter), and March (Summer)—revealed significant variations in spermatogenic activity. During the monsoon, the gonads exhibited the highest level of activity with abundant spermatogonia, spermatocytes, spermatids, and mature spermatozoa, supported by active interstitial cells producing testosterone. In winter, there was a marked reduction in spermatogenic activity, with fewer spermatogonia, spermatocytes, and spermatids, suggesting a seasonal downregulation of reproductive processes due to lower temperatures. In summer, a resurgence in spermatogenic activity was observed, with increased numbers of spermatogonia and spermatocytes and significant quantities of mature spermatozoa, indicating preparatory phases for enhanced reproductive activity. These seasonal variations underscore the influence of environmental factors on the reproductive physiology of *Cerithium Caeruleum*, providing insights into its reproductive ecology and informing conservation strategies amidst changing environmental conditions.

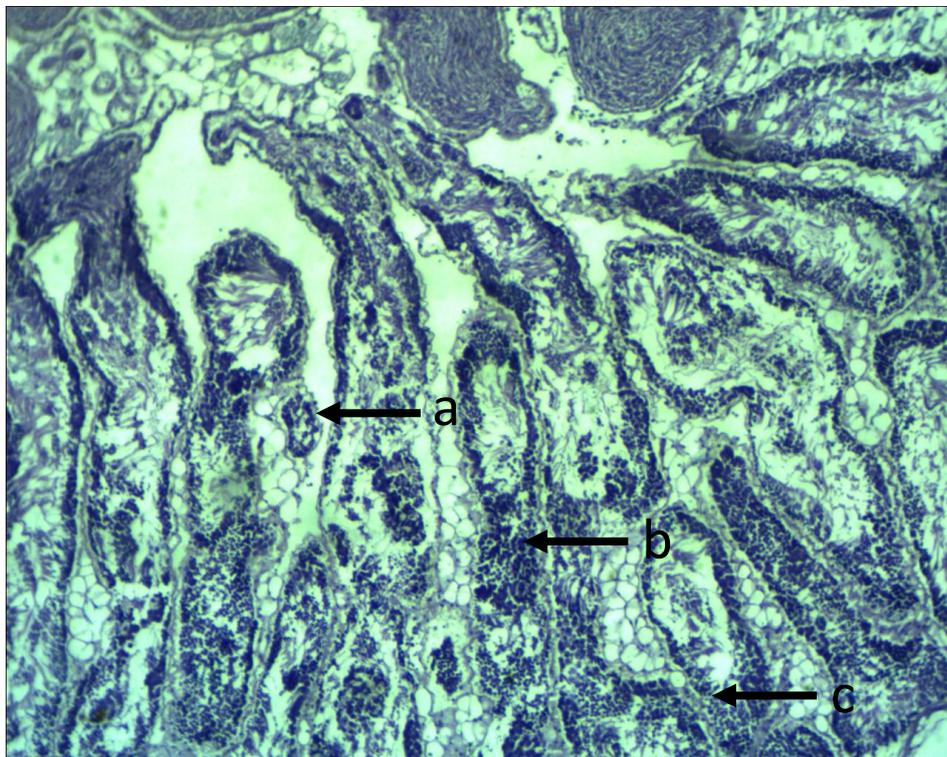


Fig - Histological slide of the male gonad of *Cerithium Caeruleum* from March (Summer) a) Spermatogonia b) Spermatozoa c) Spermatocytes

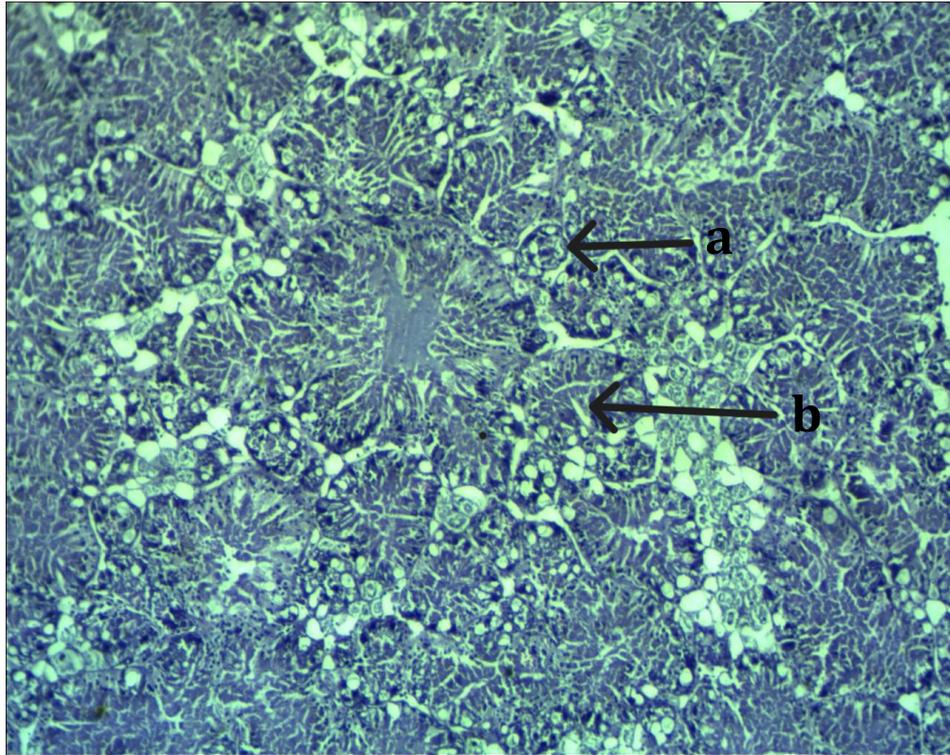


Fig - Histological slide of the female gonad of *Cerithium Caeruleum* from March (Summer) a) Oocytes b) Follicular cells

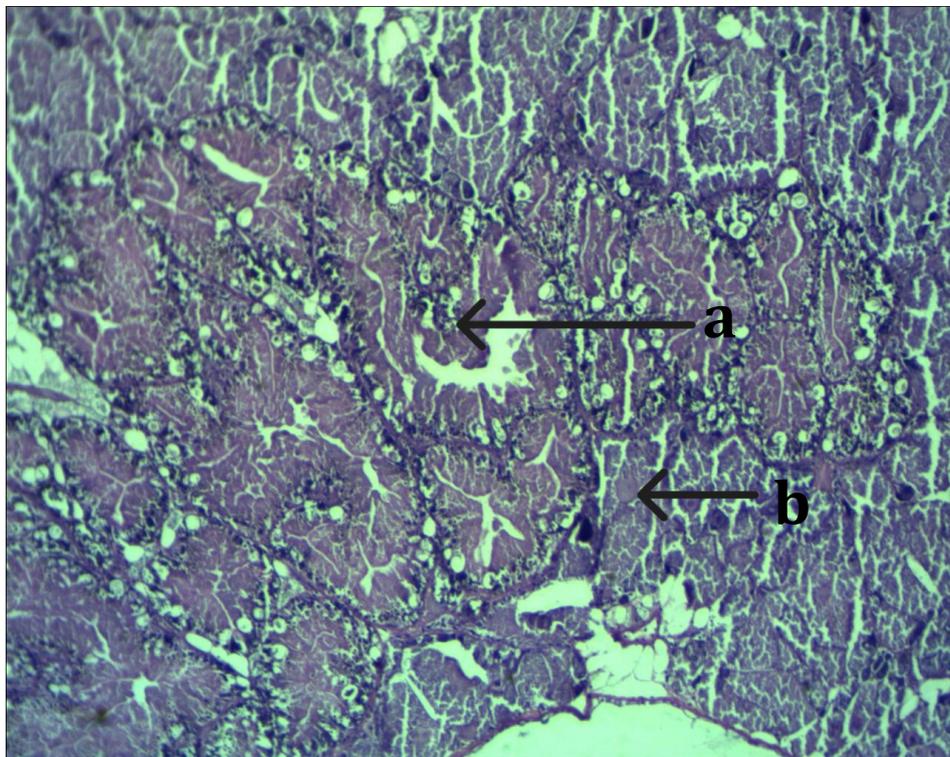


Fig - Histological slide of the female gonad of *Cerithium Caeruleum* from January (Winter) a) Oocytes b) Follicular cells

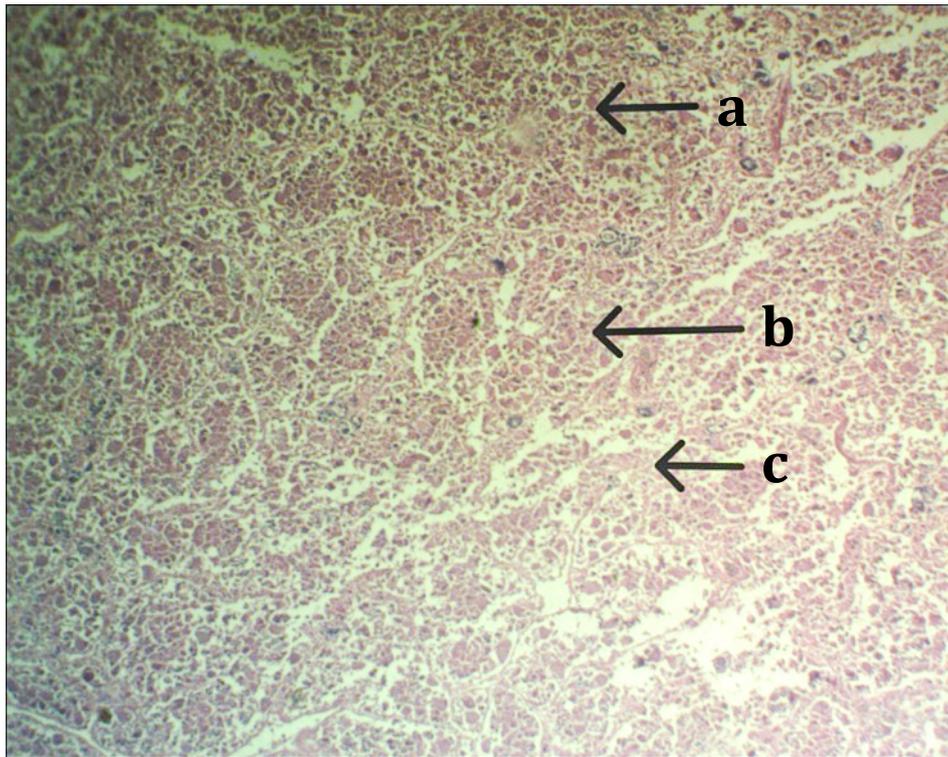


Fig - Histological slide of the female gonad of *Cerithium Caeruleum* from **August (Monsoon)** a- Oocytes b- Follicular cells c- Stroma

The histological examination of the **female gonad** of *Cerithium caeruleum* across different seasons reveals significant variations in reproductive activity, reflecting the species' adaptive reproductive strategies. In March (summer), the gonads display well-developed oocytes (Fig. a) surrounded by organized follicular cells (Fig. b), indicating active gametogenesis and preparation for spawning. This high level of reproductive activity is typical of the summer season, where environmental conditions are conducive to gamete maturation and spawning. In contrast, the gonads from January (winter) show less developed oocytes (Fig. a) and reduced density and arrangement of follicular cells (Fig. b), indicating lower reproductive activity. This reduction suggests reproductive dormancy due to less favourable conditions, likely an adaptive strategy to conserve energy and resources during the winter months.

The histological slide from August (monsoon) presents a unique pattern, with oocytes (Fig. a) in various stages of development and a pronounced stroma (Fig. c), in

addition to visible follicular cells (Fig. b). This suggests ongoing and possibly opportunistic reproductive activity influenced by the abundant food supply and favourable environmental conditions typical of the monsoon season. The presence of well-developed stroma along with varying stages of oocyte development points to a dynamic and flexible reproductive period compared to the distinct peaks seen in summer. These seasonal differences in the histological structure of the female gonad of *Cerithium caeruleum* provide valuable insights into the reproductive biology of this species, highlighting how it maximizes reproductive success in response to changing environmental cues.

The population ecology study of dominant marine molluscs along the South Saurashtra coast revealed significant insights into the density, abundance, and frequency of species such as *Cerithium caeruleum*, *Lunella coronatus*, *Peronia verruculata*, and *Trochus radiatus* across different intertidal zones. *Cerithium caeruleum* showed significant density variations in the Upper Intertidal Zone (UIZ) and Middle Intertidal Zone (MIZ), influenced by air exposure and tidal conditions, while its abundance varied significantly in the MIZ, highlighting the impact of environmental factors such as air and sunlight exposure (Vaghela, 2010). *Trochus radiatus* exhibited significant density and abundance variations in the UIZ and Lower Intertidal Zone (LIZ), reflecting sensitivity to environmental stressors and stable submersion conditions, respectively, demonstrating the species' responsiveness to habitat stability and stress (Vaghela, 2010). *Peronia verruculata* displayed uniform density and abundance across all zones, suggesting broad environmental tolerance, yet showed frequency variations in the UIZ and MIZ, indicating some degree of habitat selectivity despite its overall adaptability (Vakani et al., 2017). *Lunella coronatus* showed significant density and abundance variations in the UIZ and LIZ, indicating sensitivity to air exposure, wave action, and predation, thus highlighting the complex interplay between biotic and abiotic factors in shaping mollusc distribution (Joshi, 2010). The gonadal cycle analysis of *Cerithium caeruleum* and *Lunella coronatus* revealed seasonal variations in reproductive activity, with peak activity during summer, reduced activity in winter, and transitional phases during monsoon, underscoring the influence of environmental factors on reproductive strategies (Joshi, 2010). These findings align with previous studies that emphasize the importance of habitat conditions on mollusc distribution and reproductive strategies, ultimately enhancing our

understanding of the ecological adaptations and population dynamics of these species for effective conservation and management efforts in the region (Society, 2016).