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RESEARCH

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# Study of marine gastropod species in Balasore, Odisha, India, focusing shell morphometric distinctiveness through PCA analysis

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## Abstract

**Background** Data on the taxonomic variety of marine organisms is important for understanding the reasons of underpinning species diversification in locations with low physical barriers. Morphology is widely used for the organization of life. Morphometrics is one approach to investigating and characterizing the wide variety of animal shapes and sizes. During April 2022–April 2023, we randomly collected samples of nine important marine mollusc species from the Balramgadi, Bahabalpur, and Talapada coasts in the Balasore district of Odisha, India. In the morphometric analysis, the specimens were categorized into several groups based on their ratios of SL/SW, SL/AL, SL/AW, SL/SPL, and SL/BL.

**Result** In this research, we examined the distribution of nine mollusc species. Balramgadi shows a higher concentration of *Indothias lacerais* compared to Bahabalpur. Conversely, *Indothias lacerais* is also more prevalent in Bahabalpur than in Balramgadi. Additionally, while *Paratectonatica tigrina* and *Purpura bufo* are abundant in the both areas, however their distributions vary. Using the study area as a backdrop, principal component analysis (PCA) shows the significant connection between different kinds of organisms. This study demonstrates a favorable correlation between shell length and body size for the available species of Talapada (*T. duplicata* and *I. lacera*) and Balaramgadi (*C. magus*, L. *canarium*, and *P. bufo*). Whereas in Bahabalpur, *T. telescopium* and *V. cochlidium* are found, there is an inverse association between SL and other factors. Shell widths of *C. magus*, *P. tigrina*, and *L. canarium* are inversely correlated; nevertheless, there is a much more in common across the six species found in both Talapada and Bahabalpur. Body length is positively correlated with total weight in the species *P. bufo*, *T. duplicata*, *M. trapa*, *I. lacera*, *P. tigrina*, *Teliscopum teliscopium*, *L. canarium*, *C. magus*, and *V. cochlidium*, but negatively correlated with shell width, as shown by the Pearson correlation test.

**Conclusion** The article explores the use of morphometric analysis to differentiate nine mollusc species in significant coastal areas of Odisha, India. The study aims to identify variations in surroundings across sites and establish a benchmarks for future morphometric studies. Morphometric data can be used to quantify population diversity and investigate environmental factors' impact on shell development and trait selection of selected molluscs.


**Keywords** Morphology, Gastropod, Morphometric, Balasore, Principal component analysis

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## Background

Gastropoda, the largest and most diverse class in the phylum Mollusca, exhibits a broader range of in forms, habit and habitat (Kershaw, 1983). After the biggest phylum Arthorpoda, Mollusca has the second-largest phylum which has received an extensive adaptive variation where more than 62,000–80,000 species are present in living species and 13,000 are extant and fossil genera (Holthuis, 1995; Anderson, Diebel et al. 2005; Ponder, Lindberg et al. 2019; Wall-Palmer, Janssen et al. 2020). Although gastropods are generally amphibious in nature, it is represented as a biotic component of natural ecosystem, predominantly marine, but also widely represent in freshwater system (Presley & Willig, 2023). In India, gastropods are extensively distributed, especially in coastal regions (Kurhe, Rodríguez et al. 2014; Parveen, Chakraborty et al. 2020). Detailed study about the importance of these species for their possible use in aquaculture and medicinal industries are quite impactful (Valarmathi, 2016). They are considered as important biota of the water ecosystem and act as good bio-indicators for the pale environment as well as to know the pollution and clinical implications on the basis of their adaptive extremes condition (Orabi, El-Badry et al. 2018; Prasad, Dahal et al. 2019). Many mollusca has influenced their relative growth of various body proportions in their development stages due to the impact of both biotic and abiotic factors (Clark, Peck et al. 2020). Therefore, it can create selective pressure which can affect the shell morphology. Various important factors like predators, pollution, depth variation and climate change influence the shell morphology of molluscs (Márquez, González-José et al. 2011; Dmitrović, Savić et al. 2016). Morphometric studies based on morphological analysis of length and weight relationships provide paramount baseline data for broad investigation to quantify a trait of population index, the significance of habitat quality in biological managements and its significant use in fisheries industries (Saleky, Setyobudiandi et al. 2016; Gu, Husemann et al. 2019). However, the shell shape and size changes have given to basic information about on their evolutionary relationship, physiology, ontogeny and its exploitation within the aquatic system (Dominguez & Abdala, 2019). Researchers have statistically analyzed the species production to test hypotheses based on the significant objective of morphometric plasticity (Van Bocxlaer, Ortiz-Sepulveda et al. 2020). Identifying species based on morphology can be quite complex techniques. However, morphometric tools help to establish relationships by determining body plasticity across the habitats, shell sizes, shapes, apertures, spires and growth patterns (Yousif, 2012; Ullah, Gao et al. 2022). Further, these parameters are useful for taxonomic identification of new species and are crucial for every organism (Xu, Wu et al. 2019). The body length and weight relationship is also vital for determining growth pattern of an organism as well as its habitat condition (Jisr, Younes et al. 2018). In India, several gastropods have been reported from different geographical regions based on their morphological aspects (Kohn, 1978). Most of studies have been done on morphological, physiological, biological, and other crucial aspects of freshwater and marine gastropods. However, limited researcher studied on mollusca morphometric in coastal regions of India. Although many morphometrical approach-based studies were performed on fishes worldwide, very few numbers of literature were available on morphometric analysis on various mollusca at coastal regions. Panda, Falguni, et al. (2021) investigated different morphometric parameter with the shell length and width and subsequently correlated with five relative condition factors studied on *P. globosa* (Panda, Pati et al. 2021). Routh, S. S. et al. (2022) found the extended distribution of 17 cone snail species from the Andhra Pradesh coast based on morphometric analysis (Rout, Dash et al. 2022). Similarly, *Turritella maculata* and *Turritella fastigiata,* both turritellid gastropods, were investigated based on morphometric analysis for the first time from coastal region of Kerala, India (Sary & Pramod Kiran, 2018). Additionally, Kaviarasan, T., Ret al. (2020) investigated on egg capsule of *Rapana rapiformis* and *Hemifusus pugilinus* based on their structural and morphometric analysis with rheological properties from the southeast coast of India (Kaviarasan, Sivasankar et al. 2020). For the first time, researchers have confined six unusual marine gastropods from India's eastern and central Indo-Pacific ecoregions based on morphometric analysis and species distribution (Choudhury, Vizhi et al. 2022). Researchers have not yet studied the length–weight relationship, morphometric analysis, ecological factors, or the abundance of various gastropod species in the Balasore coastal region of India. Additionally, we have studied morphometric analysis from three different study areas of collected species along the Balasore coast. This present study provides the first baseline information regarding the marine habitat of mollusca species, including their sizes, length–weight relationships, and population density in Balasore district, Odisha, India. The consequences of present study will be definitely useful for comparison with future research to documented potential improvements or continued regression of ecological systems in the quality of aquatic ecosystems. Such phenomena not only support to the selected gastropod species, but it also signifies as promising to conservation and monitoring the best fisheries management practices.

## Methods

### Study sites

Balasore district is plain and coastal in the Indian state of Odisha and lies on the shores of the Bay of Bengal between 21°3′ and 21°59′ North latitude and 86°20′ and 87°29′ East latitude (Pramanik & Mohanty, 2016). This area has vast biological diversity because of India's coastal belt. Balaosre coast is stretch from between the Digha coast and the Bhadrak coastal belt (Sahoo & Bhaskaran, 2018). It covers four estuaries Subarnarekha, Panchupada, Budhabalanga, and Sona (Mishra, Chand et al. 2023). The total length of study area was around 32 km including Panchupada, Budhabalanga, and Sona delta. The area is placed between spring-tide and neap-tide levels and it is characterized by a shallow and swampy muddy environment. The study also continued around 5 km into the sea area due to unique pattern where the water recedes up to 5 km during the ebb tide. The area is a coastal alluvial tract with unconsolidated substrates, and this stretch of the coastline is geomorphologically dynamic, rich in habitat diversity, muddy and sandy beaches.

### Sampling and collection

Various mollusca were randomly collected from 3 zones of Balasore coastal lines from Bhabalpur, Balaramgadi, and Talapada. This study was conducted from the middle of April 2022 to the end of April 2023 in the morning and

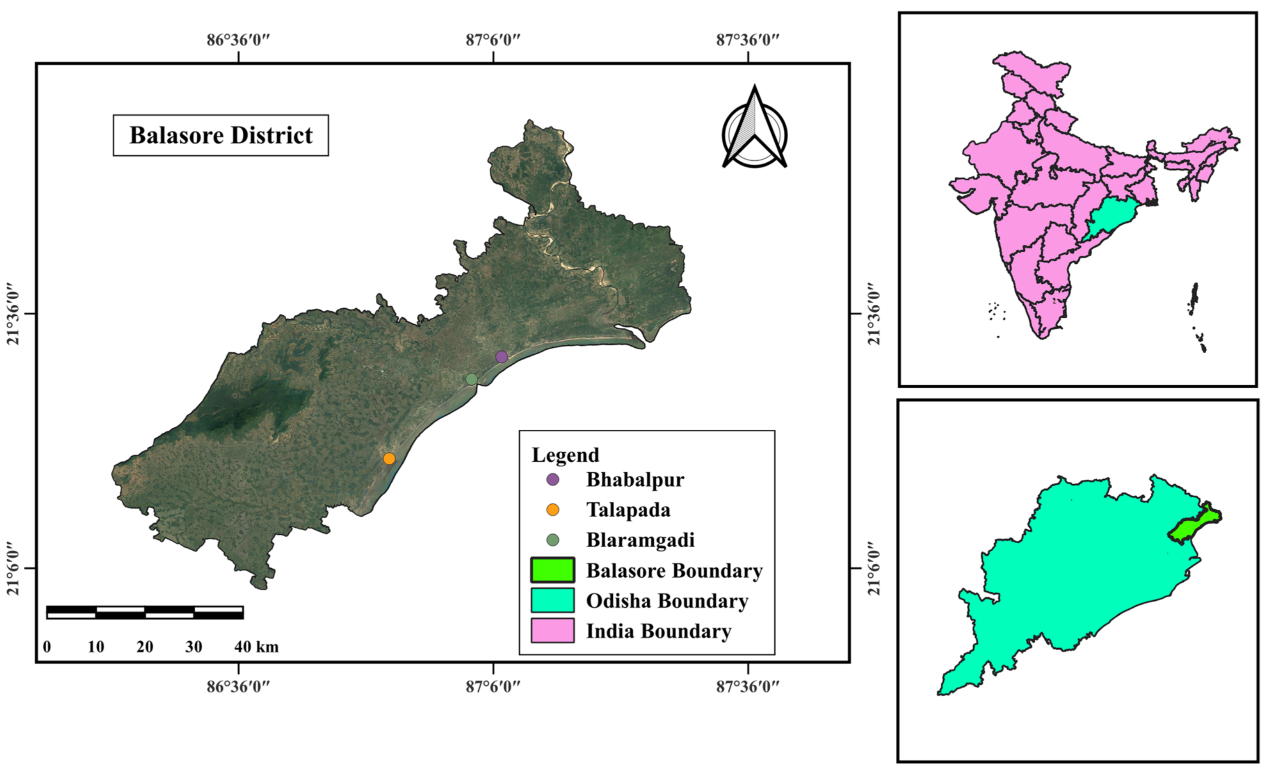


**Fig. 1** Study area of three sampling sites of coastal areas at Balasore district, Odisha, India

**Table 1** Bhabalpur, Balaramgadi, and Talapada are three coastal sample sites in the Balasore district of Odisha, India

| S.No | Site name | Latitude/longitude | Direction and distance from Balasore | Site characteristic |
|---|---|---|---|---|
| 1 | Bhabalpur | 21°30′54.96"N<br>87° 6′58.58"E | Northeast distance 23 km | Fishing with trawler and net |
| 2 | Balaramgadi | 21°28′16.98"N<br>87° 3′26.13"E | Northeast distance 22 km | Fishing with trawler and net |
| 3 | Talapada | 21°18′55.01"N<br>86°53′44.05"E | Southeast distance 20 km | Fishing with hand net |

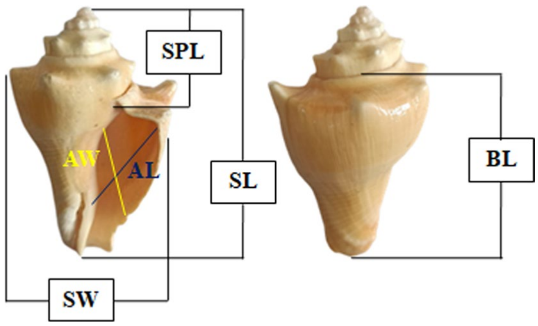


**Fig. 2** Schematic representation of the species *V. cochlidium* with measurements used in the morphometric ranges of shell length (SL), shell spire length (SPL), shell width (SW), aperture width (AW), aperture length (AL), and basal length (BL)

evening times from 3 collecting zones (Fig. 1) (Table 1). The author visited the marshy area of the shoreline, which was suitable for sample collection, especially the intertidal zones of the beach area. A total of 1088 specimens were collected during this tenure with the help of small hand net, plastic bags, and picking methods; these are labeled with the site name, date, time and the record was maintained every month. We clean the collecting specimen by oxalic acid through brush and preserve these samples for identification and future study.

### Sample identification with laboratory procedure

The collected specimens were identified through the keys and online database (https://www.molluscabase.org/) (https://www.discoverlife.org/20/q?guide=Molluscs). The taxonomic status, diversity assessment and its conservation status were adopted from WoRMS and IUCN guidelines (https://www.marinespecies.org/) (https://www.iucnredlist.org/). Further morphometric measurement were carried out at P.G. Department of Zoology, Fakir Mohan University, Odisha, India. Shell morphometric analysis includes shell length (SL) and shell width (SW), aperture length (AL) and aperture width (AW), spire length (SPL), basal length (BL) in cm and total body weight measured in gm (Fig. 2) (Matos, Matthews-Cascon et al. 2020). Each specimen's size and width were measure by Vernier slide caliper, but weights measurement was carried out with the help of a weighing machine.


**Fig. 3** Nine distinct gastropod species were collected from three sampling sites in Balasore district having considered the most prominent coastal areas

**Table 2** Nine different species of gastropods, each with their common name, range, IUCN status, and potential hazard to humans that were collected from three different sampling sites in the Balasore coastal area, Odisha, India

| Scientific name | Common name | IUCN status | Distribution | Threat to human |
|---|---|---|---|---|
| *Purpura bufo* (Lamarck, 1822) | Toad Purpura | Not evaluated | Western & eastern, Indian ocean northwest & West central, Pacific | Harmless |
| *Turritella duplicata* (Linnaeus, 1758) | Duplicate turret | Not evaluated | Eastern & Western, Indian ocean Western central, Pacific | Harmless |
| *Murex trapa* (Röding, 1798) | Rare-spined Murex | Not evaluated | Eastern & Western, Indian ocean northwest & West central, Pacific | Harmless |
| *Indothais lacera* (Born, 1778) | Carinate rock snail | Not evaluated | Eastern & Western, Indian ocean northwest & West central, Pacific | Harmless |
| *Paratectonatica tigrina* (Röding, 1798) | Tiger moon snail | Not evaluated | Eastern, Indian ocean Northwest, Pacific Eastern central & Southeast, Atlantic | Harmless |
| *Telecopium telescopium* (Linnaeus, 1758) | Telescope snail | Least Concern (LC) 2010 | Eastern & Western, Indian ocean northwest & West central, Pacific | Harmless |
| *Laevistrombus canarium* (Linnaeus, 1758) | Dog conch | Not evaluated | Eastern & Western, Indian ocean northwest & West central, Pacific | Harmless |
| *Conus magus* (Linnaeus, 1758) | Magicians cone | Least Concern (LC) 2011 | Eastern & Western, Indian ocean West central, Pacific | Harmless |
| *Volegalea cochlidium* (Linnaeus, 1758) | Spiral melongena | Not evaluated | Eastern & Western, Indian ocean northwest & West central, Pacific | Harmless |

### Data analysis

The species density and morphometric analysis data were obtained by PAST software version 4.10 and R version 4.2, respectively (Hammer, Harper et al. 2001). The relationships of linear regression analysis were established considering the above morphometric parameters, and shell length intake as a basic index was established by among the parameters. Statistical analysis (correlation and regression) was calculated by PAST software version 4.10 (Hammer, Harper et al. 2001; Bewick, Cheek et al. 2003). The shell length, weight, height and width of spire, width, aperture length and width relationship was established by principal components analysis (PCA) in different habitats of our study sites (Vitt, Caldwell et al. 1997).

## Results

Nine different significant species of gastropod were collected from three major coastal area of the Balasore district of Odisha, India, through random sampling (Fig. 3) (Table 2). The result of our study is mainly divided into three different direction, collected specimen from the study sites, a matrix plot has been generated concerning the relative density data (Fig. 4). Furthermore, multivariate principal component analysis (PCA) plots for the species from all three locations, Balaramgadi, Bahabalpur, and Talapada was performed on the basis of specific parameters to know the group similarity and dissimilarity. Then, linear Pearson's correlation of each species was carried out to obtain the linear relationship between the variables.

The relative densities of nine different species of snails across 3 distinct regions of Balasore, Odisha, namely Balramgadi, Bahabalpur, and Talapada, are displayed clearly with the help of matrix plot. The matrix

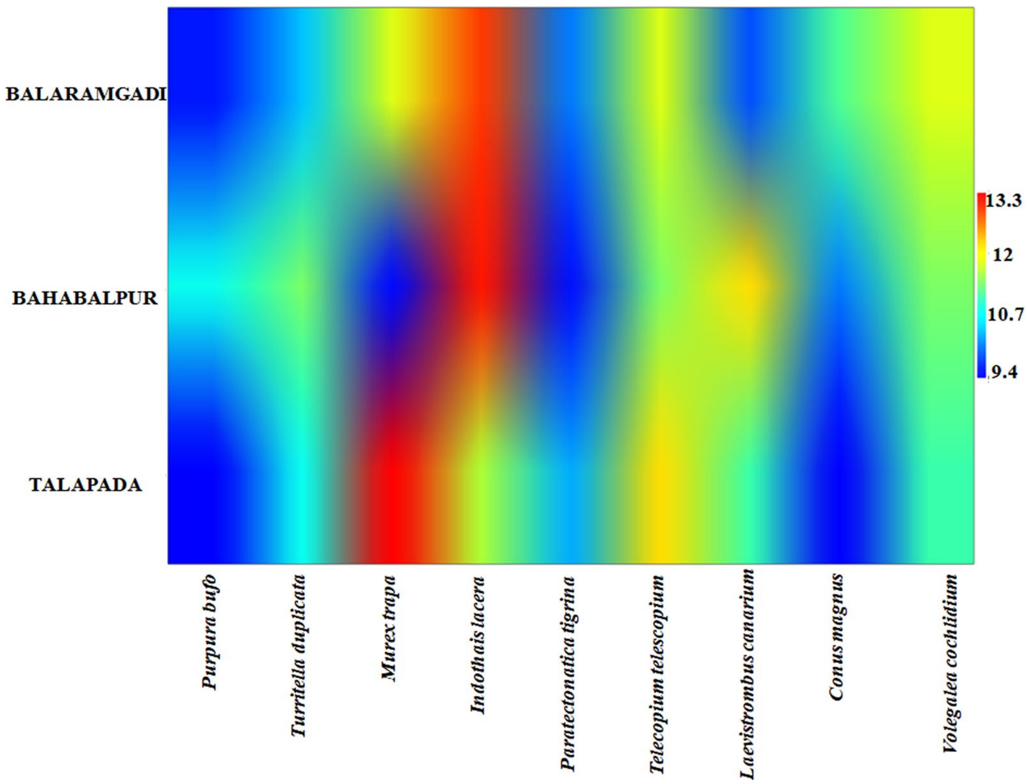


**Fig. 4** Matrix plot represents species density on the basis of a number of collected species of gastropods from the sampling sites

plot has the lowest range, i.e., 9.4, which is shown in the deep blue color and the highest range of 13.3, displayed with the deep red color (Fig. 4). In the Balramgadi region, *Indothias lacera* is relatively higher than other species, whereas on the other hand species like *Paratectonatica tigrina*, *Purpura bufo* and *Laevistrombus canarium* are less abundant in the Balramgadi region. Likewise, in the region of Bahabalpur, *Indothias lacera* availability is relatively higher than *Turritella duplicata, Volegalea cochlidium, Telescopium telescopium*, *Laevistrombus canarium* and the plot shows notable observations about the *Paratectonatica tigrina*, *Purpura bufo,* as these two species are relatively low in both Balramgadi and Bahabalpur regions (Fig. 4). But in the Talapada region of Balasore, the *Paratectonatica tigrina* is relatively moderate leaving behind the *Purpura bufo,* which is still found low as compared to other species density in these three regions. The data also show a bright red spot upon the *Murex trapa*, which signifies the higher density of the mentioned species in Talapada region, which is less abundant in the Bahabalpur region. A few numbers of species such as *Volegalea cochlidium, Conus magus, Telescopium telescopium, Turritella duplicata* are almost moderately abundant in almost all the three regions of studied areas (Fig. 4). However, investigating the morphometric and radular traits of *Thais lacera*, *T. blanfordi*, *T. tissoti*, *T. rudolphi*, *T. bufo*, and *T. subnodulosa* may help researchers resolve the taxonomic ambiguities associated with Thais species. The first denticle on the outer base of the lateral cusp in *T. rudolphi* was smaller than the other five denticles, whereas in *T. blanfordi*, all of the denticles were the same size from the Maharashtra coast of India (Kumar, Jaiswar et al. 2017). Similarly, with a relative abundance of 28.84, *Pirenella cingulata* was the species with the highest abundance. The other major species on Sonadia Island, Bangladesh, were *Turritella duplicate*, *Cerithium columna*, *Umbonium vestiarium*, and *Paratectonatica tigrina* with their respective relative abundances were 27.64, 15.81, 3.46, and 2.48 (Antu, Islam et al. 2023). Subsequently, *Nassarious* species of a few millimeters in length and *Telescopium* species with lengths of 10 cm or more make up the gastropod population of the outer channel region. The sea grass bed included species of *Bullia vittata*, *Neritina smithii*, *Indothais lacera*, and *Natica tigrina* among others (Mahapatro, Panigrahy et al. 2015). Further comparing Indian turritella e species' Drilling Frequency (DF) to average worldwide data values reveals that it is low. The

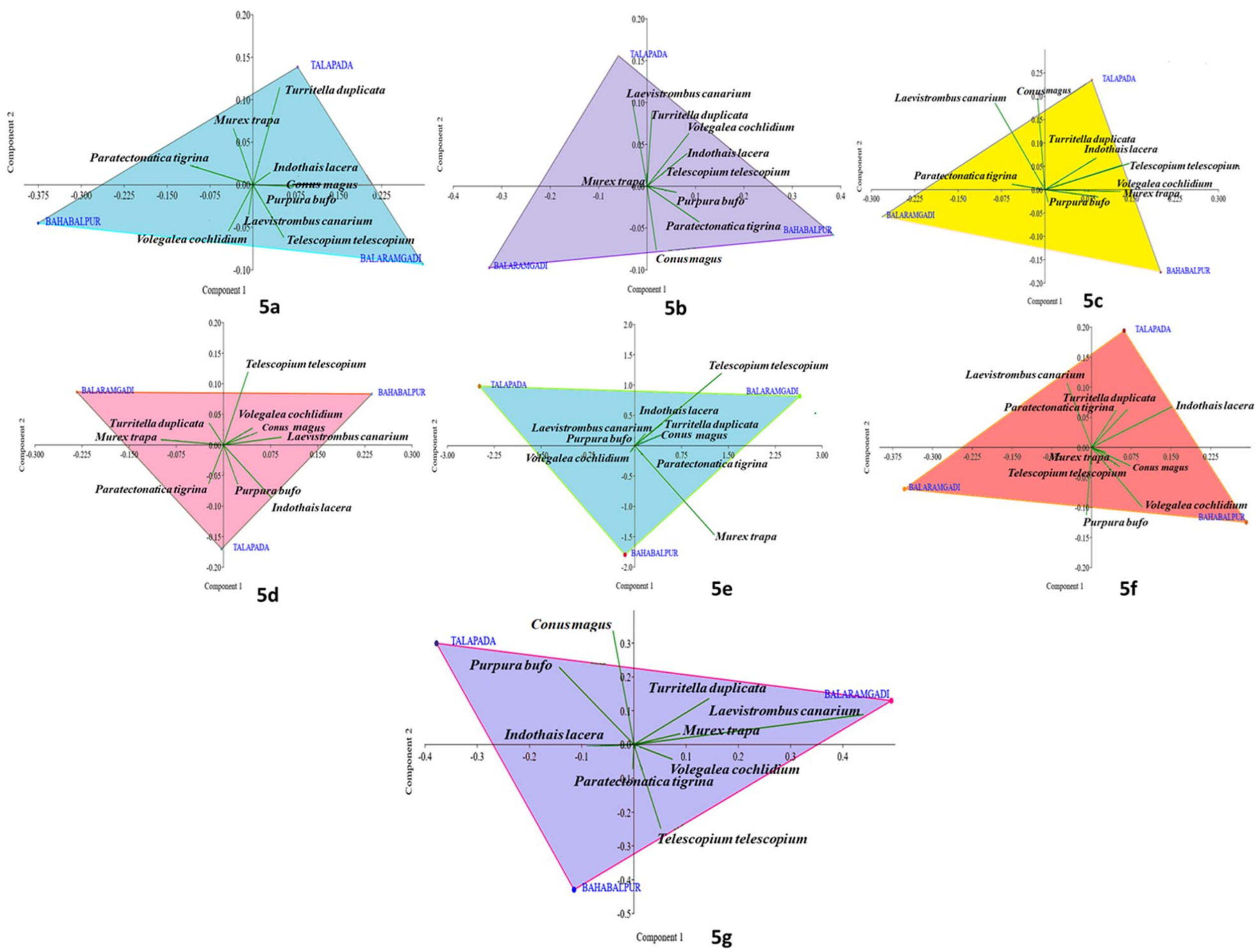


**Fig. 5** Principal component analysis (PCA) of diverse morphometric ranges of different gastropod species: **a** The PCA analysis indicates that shell length of *T. duplicata*; *I. lacera* species from Talapada and *C. magus*, L. *canarium*, *P. bufo* from Balaramgadi is positively correlated. **b** The PCA analysis indicates that spiral length of *M. trapa* at Balaramgadi is adversely related. **c** The shell width of *C. magus*, *P. tigrina*, *and L. canarium* of Talapada is negatively corresponding where all other six species from both the Talapada and Bahabalpur are much similar found in PCA analysis. **d** Aperture lengths of maximum species are correlated positively in all three-study site except *P. tigrina* in Talapada coast found in PCA analysis. **e** The PCA analysis found the basal lengths of *V. cochlidium*, *P. tigrina* of Bahabalpur and *P. bufo,* L. *canarium* of Talapada are negatively allied. **f** Aperture widths of these specimens from Bahabalpur and Talapada are quite analogous, whereas *P. bufo, T. telescopium* of Balaramgadi beach are unfavorably linked. **g** The PCA analysis concluded the total weight of *C. magus, P.bufo, T. duplicata, M. trapa, L. canarium,* and *P. tigrina* from all three-study areas is positively interrelated

majority of species found in India are bigger (>4 cm) than those found elsewhere (Paul, Das et al. 2013).

## Discussion

PCA of each parameter shows the correlation between the different species of the study area in reference. The shell length data of the above study found *T. duplicata; I. lacera* species from Talapada and *C. magus, L. canarium, P. bufo* from Balaramgadi are positively correlated (Fig. 5a). The SL of *T. telescopium* and *V. cochlidium* are negatively correlated with others at Bahabalpur. In case of spiral length only, *M. trapa* of Balaramgadi is adversely related, but all other species from Bahabalpur and Talapada have direct relation (Fig. 5b). Further shell width of *C. magus*, *P. tigrina*, *and L. canarium* of Talapada is negatively corresponding where all other six species from both Talapada and Bahabalpur are much similar (Fig. 5c). Additionally, aperture lengths of maximum taken species are correlated positively in all three-study site except *P. tigrina* in Talapada coast (Fig. 5d). Basal lengths of *V. cochlidium, P. tigrina* of Bahabalpur and *P. bufo, L. canarium* of Talapada are negatively allied (Fig. 5e). Again the aperture widths of major gastropod specimen from Bahabalpur and Talapada are quite analogous, whereas *P. bufo, T. telescopium* of Balaramgadi beach are unfavorably linked (Fig. 5f). Lastly total weight

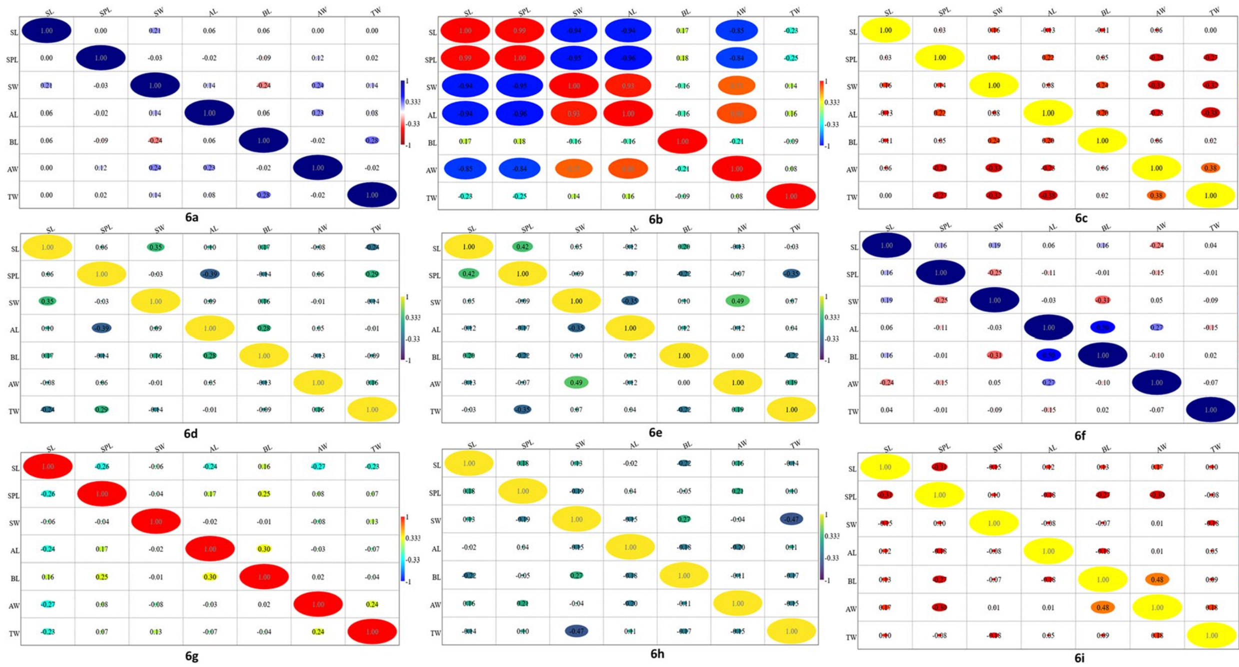

**Fig. 6** Linear Pearson's correlation of diverse morphometric ranges of different gastropod species: **a** linear Pearson's correlation in *P. bufo* the body length and total weight is highly correlated, 0.28, whereas body length and shell width are less similar, –0.24. **b** Linear Pearson's correlation of spiral length of *T. duplicata* is related maximally to shell length and minimally to aperture length. **c** Linear Pearson's correlation of the total weight of *M. trapa* is mostly correlated with aperture weight. **d** Linear Pearson's correlation of *I. lacera* shell width and shell length is most comprehensive with the positive value being 0.35. **e** Linear Pearson's correlation of *P. tigrina* aperture width and shell width is more related ranging 0.49. **f** Linear Pearson's correlation of *Teliscopum teliscopium* body length is firmly correlated with aperture length by 0.50. **g** Linear Pearson's correlation of *L. canarium*, the body length, and aperture length has a strong correlation of 0.30. **h** Linear Pearson's correlation of the body length and total width of *C. magus* is also maximally and minimally linked to shell width. **i** Linear Pearson's correlation of *V. cochlidium* shows a strong association between body length and aperture weight of 0.48

of *C. magus, P. bufo, T. duplicata, M. trapa, L. canarium,* and *P. tigrina* from all three-study areas are positively interrelated (Fig. 5g). Even so *I. lacera* from Talapada and *V. cochlidia, T. teliscopium* from Balaramgadi have negative TW value. Some researchers found that the PCA reduced the variation by 82.383%, with three groups created: one that included *Nerita fulgurans* and *N. peloronta*, one that included *Nerita tessellata* only, and one that included *Nerita versicolor* (Altomari, Alves et al. 2021). Further the average SL and SW for *S. canarium, S. urceus, S. marginatus*, and *S. vittatus* at various locations in Taiwan were found to be 55.24 ± 0.32 mm and 35.13 ± 0.19 mm, 56.62 ± 0.60 mm and 24.53 ± 0.37 mm, 48.44 ± 1.32 mm and 24.66 ± 0.43 mm, and 83.74 ± 5.6 mm and 25.53 ± 3.38 mm, respectively (Chiu, Chen et al. 2002). Similarly the average shell length (SL) of *N. albicilla* measured 24.74 mm ± 3.40 and its average aperture length (AL) 11.09 mm ± 2.69 in the rocky intertidal zone of Oma Village, Central Moluccas, Eastern Indonesia (Haumahu & Uneputty, 2018).

The Pearson correlation assesses how strongly two variables are correlated linearly. Its range of values is from −1 to 1, with −1 denoting a completely inverse linear correlation, 0 denoting no correlation, and 1 denoting a completely inverse positive correlation. In *P. bufo*, the body length and total weight are highly correlated, 0.28, whereas body length and shell width are less similar value, −0.24 (Fig. 6a). Similarly, the spiral length of *T. duplicata*is related maximally to shell length and minimally to aperture length having values 0.99 and −0.96, respectively (Fig. 6b). Weight of *M. trapa* is mostly correlated with aperture weight, i.e., 0.38, and adversely with aperture length, i.e., −0.38 (Fig. 6c). In *I. lacera*, the shell width and shell length are most comprehensive with the positive value being 0.35 (Fig. 6d). The relationship between aperture length and spiral length is relatively weak, with a correlation coefficient of -0.39. In contrast, in *P. tigrina*, the aperture width and shell width show a stronger positive correlation of 0.49. However, a negative correlation exists between aperture length and total weight (–0.35) when compared to shell width, spiral length and shell width (Fig. 6e). In *Teliscopum teliscopium*, body length is firmly correlated with aperture length by 0.50 and has an inverse correlation with shell width by −0.31 (Fig. 6f). In *L. canarium*, the body length and aperture length have a strong correlation of 0.30, however aperture width and shell length have a weaker correlation of −0.24 (Fig. 6g). The body length and total width of *C. magus* are also maximally and minimally linked to shell width with values of 0.27 and −0.47 correspondingly (Fig. 6h). Lastly in *V. cochlidium* it shows a strong association between body length and aperture weight of 0.48 and an inverse correlation between shell length and spiral length is −0.31 (Fig. 6i). Similarly, *Volegalea cochlidium* morphometric measures were 2.9 cm in shell length, 1.8 cm in shell width, 1.8 cm in aperture length, and 1.2 cm in aperture width from Coastal Waters of Bangladesh (Sultana, Brishti et al. 2021). Further, *T. telescopium* shells length, diameter, and weight morphometric measurements ranged from 3.58 to 9.51 cm, 1.5 to 1.43 cm, and 3–69 g, respectively. The morphometric parameters of *T. telescopium* range from 3 to 87 g in total weight, 3.58 to 9.97 cm in length, and 1.51 to 5.01 cm in diameter in the Mangunharjo Mangrove Forest, Semarang City, at Indonesia (Rizaldi, Redjeki et al. 2022). Some researchers found that on the Southeast coast of India, the average SL of *Turbinella pyrum* at adult age was measured to be 10.148 ± 0.222 cm and average SW was 5.476 ± 0.118 cm (Arularasan, Viswanathan et al. 2016).

## Conclusions

This article investigates whether the nine species analyzed may be distinguished using the morphometric ratios of their shells. Among the species examined, the ratios SL/SW, SL/AL, SL/AW, SL/SPL, and SL/BL are significantly different (Panda, Pati et al. 2021). The primary goal of this research was to conduct a morphometric examination of randomly collected specimens from the three most prominent coastal regions of the Balasore district (Balramgadi, Bahabalpur, and Talapada) of Odisha, India. The present investigation shows that environments may differ significantly across the locations. The current investigation provides valuable reference points for future morphometric research. Researchers can identify correlations and support various concepts by combining ecological, molecular, and environmental data with the morphometric data. However, due to specimen collection restrictions genetic diversity studies cannot utilize molecular data. Instated, morphometric data gathered through carefully taken photography can be used to measure population diversity and study the influence of environmental variables shell growth or trait selection. The study confines the morphological differences among various species, suggesting that these differences are adaptive responses to environmental factors such as ecological, substrate type, and the weave motion. The abundance study shows that species distribution patterns can influence seasonal fluctuations, human impacts, and habitat preferences. This phenomenon highlights the importance of preserving biodiversity in coastal areas, as some species demonstrate the ecological resistance. Overall, this study depends on our understanding of gastropod species and lays the groundwork for future studies on the environmental influences affecting marine molluscs and their morphological adaptations. It also encourages the integration of ecological modeling and genetic analysis to explore species interaction and evolutionary trends.

### Abbreviations

| | |
|---|---|
| PCA | Principal Component Analysis |
| SL | Shell Length |
| SW | Shell Width |
| AL | Aperture Length |
| AW | Aperture Width |
| SPL | Spire Length |
| BL | Basal Length |
| Km | Kilometer |
| IUCN | International Union for Conservation of Nature |
| cm | Centimeter |
| DF | Drilling Frequency |
| Fig | Figure |

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### Author contributions

SKD involved in writing the original manuscript draft and editing, conceptualization, data curation, methodology; JKB, PM, and AKJ took part in data collection, photography, maps creating, conceptualization, formal data analysis, methodology, writing—review & editing. MB is a supervisor and involved in review & editing. BB is a co-supervisor and involved in writing—review & editing.

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### Availability of data and materials

All data generated or analyzed during this study are included in this published article.

## Declarations

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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