Marine molluscs diversity and ecological significance in Klang archipelago and Jeram-Kuala Selangor coastline, Peninsular Malaysia

[1,2]Nursalwa Baharuddin, [1]Iliya M. M. Riza, [1]Chai K. Ong, [3]Asamuddin A. Hasan, [4]Izarenah M. Repin, [1]Jen N. Lee

[1] Biodiversity Conservation and Management Programme, Faculty of Science and Marine Environment, University of Malaysia Terengganu, Kuala Nerus, Terengganu Malaysia; [2] Institute of Oceanography and Environment, University of Malaysia Terengganu, Kuala Nerus, Terengganu Malaysia; [3] Museum of Natural History, Faculty of Science and Technology, National University of Malaysia, Bangi, Selangor, Malaysia; [4] Division of Fisheries and Conservation and Protection, Department of Fisheries Malaysia, Putrajaya, Malaysia. Corresponding author: N. Baharuddin, nursalwa@umt.edu.my

Abstract. The Klang archipelago and Jeram-Kuala Selangor coastline along the Klang-Selangor corridor support extensive mangrove and intertidal habitats that underpin coastal productivity and fisheries resources. However, comprehensive baseline data on marine molluscan assemblages in this region remain scarce. This study assessed the diversity, distribution, and ecological significance of marine molluscs across 33 sampling site using visual encounter surveys. A total of 440 individuals representing 41 species and 21 families were recorded. Bivalves (subclass Autobranchia) dominated commercially important taxa, while gastropods, particularly Caenogastropoda, contributed substantially to overall species richness. Littorinidae was the most species-rich family, and *Littoraria articulata* was the most abundant species (123 individuals), highlighting the ecological importance of mangrove-associated grazers in nutrient cycling and energy transfer. Shannon-Wiener diversity values ranged from 0.7 to 1.9, indicating low to moderate diversity with generally high evenness among sites. Lower diversity values at more urbanized locations suggest potential environmental stress linked to anthropogenic activities. The prevalence of filter-feeding bivalves emphasizes their dual ecological role in sustaining local fisheries and serving as bioindicators of coastal water quality. Notably, most recorded species remained unevaluated under the IUCN Red List, underscoring existing conservation gaps. These findings provide essential baseline data to inform sustainable fisheries management, biodiversity conservation, and long-term ecological monitoring in this ecologically significant coastal system in Peninsular Malaysia.
Keywords: *Bivalvia*, *Caenogastropoda*, intertidal, mangrove, molluscs.

Introduction. The Klang archipelago and Jeram-Kuala Selangor, situated along the Klang–Selangor coastlines of Peninsular Malaysia, represent a complex of interconnected tropical habitats including mangroves, mudflats, and distinctive polychaete reefs. These ecosystems provide vital ecological and socioeconomic services, functioning as natural barriers against coastal erosion while serving as significant blue carbon sinks (Alongi 2014; Hamdan et al 2014). Furthermore, they support nutrient cycling and enhance fisheries productivity by providing critical nursery and foraging grounds for finfish and shellfish populations that underpin Selangor's artisanal fisheries (Sasekumar & Chong 1998; Chong 2007).

Despite these contributions, fisheries management in the Selangor coastal region faces challenges in effectiveness, particularly regarding the integration of habitat connectivity into conservation frameworks. The region is under increasing pressure from rapid coastal development, industrial activities, and aquaculture, which threaten the resilience of these ecosystems. In recognition of their biodiversity value, the study areas have been designated as Ecologically and Biologically Significant Marine Areas (EBSAs) under the Convention on Biological Diversity through Malaysia's Important Marine and Coastal Areas (MyIMCA) framework (WWF Malaysia 2024). This designation highlights the area's high species richness and the presence of distinctive biological communities that are increasingly vulnerable to anthropogenic stressors.

Marine molluscs, particularly gastropods, are integral components of these coastal environments. They play fundamental roles in grazing, detritus processing, and food-web dynamics, while also serving as sensitive bioindicators of environmental change (Ramesh et al 2025; Tan et al 2025). However, comprehensive knowledge of mollusk diversity along the Klang-Selangor coastline remains sparse, while existing literature is largely restricted to localised studies within the Kuala Selangor Nature Park (Singh & Jahid 2021).

There is an urgent need for updated biodiversity data to bridge the gap between habitat conservation and fisheries management. Therefore, this study aims to document the diversity and distribution of marine molluscs within the Klang–Selangor coastal system. By establishing this baseline, we seek to support national biodiversity records and provide the empirical foundation necessary to inform sustainable management and conservation strategies for these prioritised EBSAs.

Material and Method

Sampling sites. Field surveys were conducted in the Klang archipelago and Jeram-Kuala Selangor, Peninsular Malaysia during August and September 2022. A total of 33 sampling points were selected to represent the diverse coastal ecosystems of the region, including mangrove swamps, sandy beaches, mudflats, intertidal zones, lagoons, jetties, and polychaete reef ecosystems (Figure 1). These sites were chosen to capture the full gradient of environmental conditions and habitat types available to marine molluscs along the Selangor coastline.

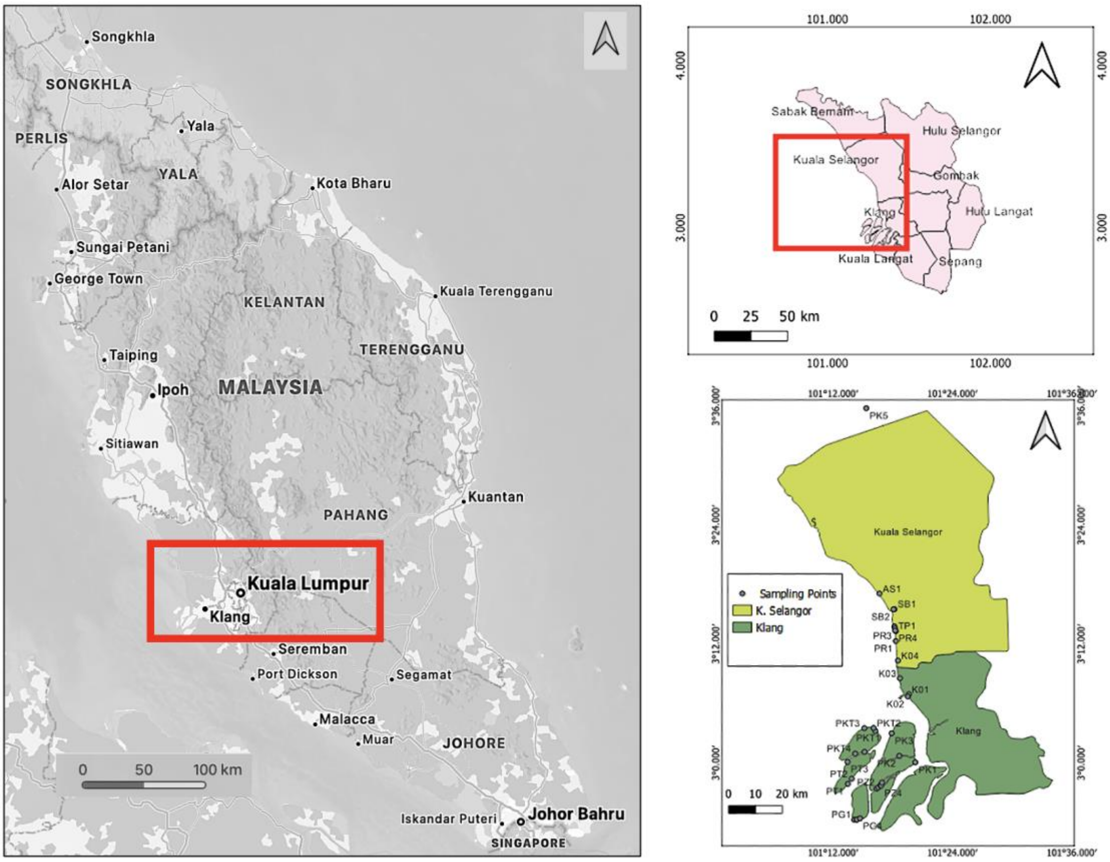

Figure 1. Location of sampling sites in the Klang archipelago and Jeram-Kuala Selangor, Peninsular Malaysia showing a total of 33 sampling points.

Sampling methods and microhabitats. Specimens were collected using the visual encounter survey method (Scott et al 1994) with a standardised sampling effort of one hour per site by two collectors. Surveys targeted diverse microhabitats to ensure a comprehensive biodiversity assessment, including mangrove roots, branches, and leaves as well as muddy and sandy substrata. Additional observations were conducted in rocky intertidal crevices and on fallen logs (Figure 2A-F). All collected samples were stored in labelled zip-lock bags and maintained in a chiller (±4°C) prior to laboratory processing.

Species identification and taxonomic verification. In the laboratory, specimens were cleaned and identified based on diagnostic morphological characteristics such as shell shape, color, size, and specific shell features of bivalves and gastropods. Taxonomic identification was performed using established keys (Dance & Abbott 1990; Abbott 1991; Swennen et al 2001; Coleman 2003; Long & Ramli 2010). Species nomenclature and taxonomic hierarchy were verified using the World Register of Marine Species (WoRMS) database. Furthermore, the conservation status of each recorded species was checked against The International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Photographic documentation was performed using a Canon DSLR camera.

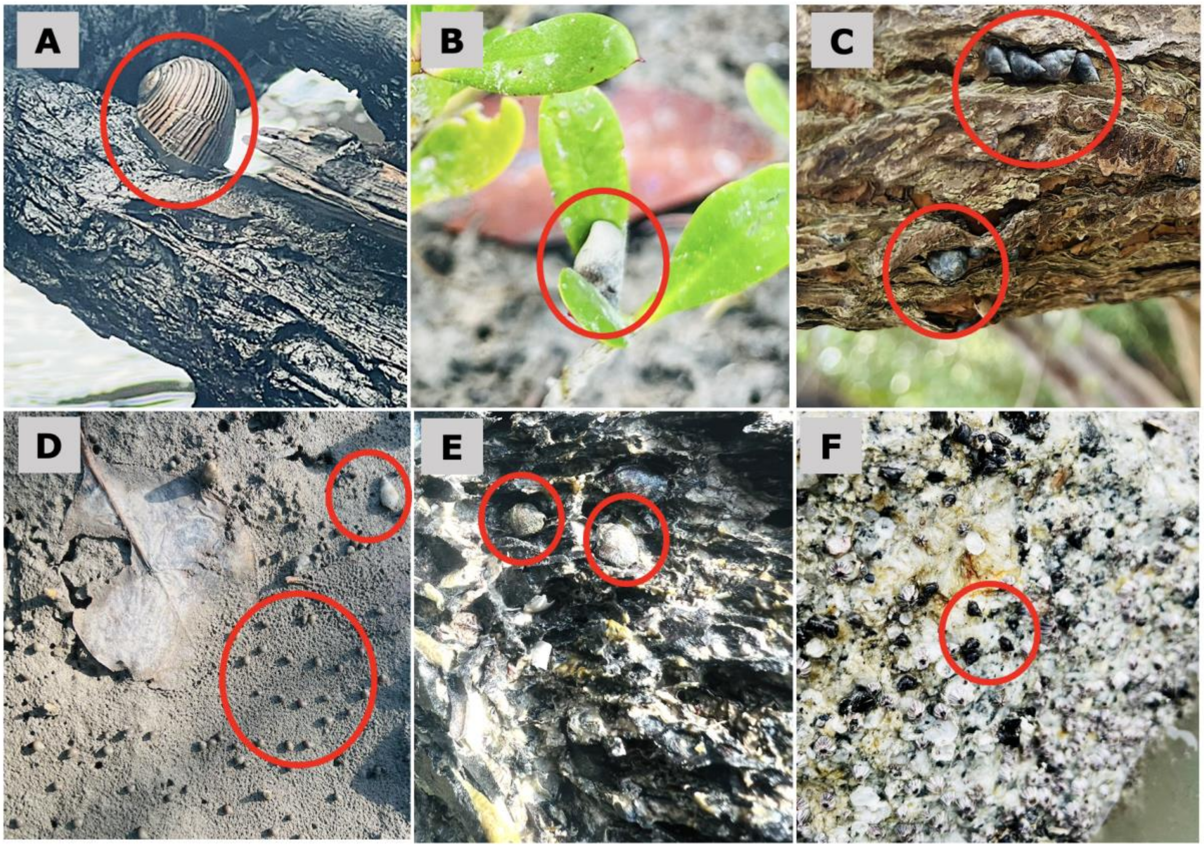

Figure 2. Microhabitats where marine molluscs (indicated by red circles) were collected: (A) on mangrove roots, (B) mangrove leaves, (C) mangrove trunks, (D) muddy-sandy substrata, (E) fallen logs, and (F) rocky intertidal zones.

Ecological indices and statistical analysis. Alpha diversity was assessed using PAST software (version 4.11). The indices used to evaluate diversity, richness, and evenness are summarised in Table 1.

Table 1
Summary of ecological indices used to assess species diversity, richness, and evenness of marine molluscs

Index	*Formula*	*Interpretation*
Shannon-Wiener (H')	$H' = -\sum (pi \ln pi)$	Diversity: Measures species uncertainty. Low: < 2; Mod: 2–4; High: > 4 (Odum & Barret 2004).
Simpson's (1-D)	$D = 1 - \sum (pi)^2$	Diversity: Probability individuals belong to different species. Values near 1 = high diversity.
Margalef Richness (Ma)	$Ma = (S - 1) / \ln N$	Richness: Species count adjusted by natural log of individuals. Higher values = greater richness.
Menhinick Richness (Me)	$Me = S / \sqrt{N}$	Richness: Species count per square root of total individuals. Higher values = greater richness.
Pielou's Evenness (J')	$J' = H' / \ln S$	Evenness (Equitability): Quantifies numerical equality of species. Values near 1 = even distribution.

Note: S = Total number of species in the sample; N = Total number of individuals in the sample; pi = Proportion of individuals belonging to the i^{th} species (n_i/N); ln = Natural logarithm; Σ = Summation of all species.

Results

Species composition and abundance. The sampling effort yielded a total of 440 individuals across 21 families and 41 species (Table 2). The taxonomic composition was heavily skewed toward two subclasses: Autobranchia (47%) and Caenogastropoda (43%), which together accounted for the vast majority of the assemblage. In contrast, Heterobranchia and Neritimorpha were poorly represented, each contributing only 5% of the total composition (Figure 3). Species richness was slightly higher at Jeram-Kuala Selangor (30 species) than at the Klang archipelago (24 species), although total abundance remained comparable between the two regions. The family Littorinidae exhibited the highest species richness, followed by Muricidae, Nassariidae and Potamididae (Table 2). At the species level, dominance was particularly pronounced in *Littoraria articulata* and *Nassarius livescens*, which were the most abundant species recorded across both study areas. Conversely, at the family level, Neritidae was the most abundant family overall, primarily driven by the prevalence of *Neripteron violaceum* and *Nerita balteata* in the intertidal zones (Figure 4-7).

Conservation status and commercial significance. A significant portion of the recorded malacofauna currently lacks formal conservation assessment, with the majority of species classified as Not Evaluated (NE) under the IUCN Red List. Only *Telescopium telescopium* was identified as Least Concern (LC). From a socioeconomic perspective, there was a clear distinction between the two primary classes. Within Bivalvia, 12 of the 13 recorded species were identified as commercially important, reflecting their high value in local fisheries and trade. Conversely, only five out of the 28 Gastropoda species held commercial status (Table 2, Figures 4-7). This disparity underscores the different role that these groups play in both ecosystem function and local coastal economies.

Table 2

List of marine mollusc species recorded at the sampling sites, with abundance, IUCN status, and commercial importance

Subclass/family/class	*Species*	*Klang Archipelago (ind.)*	*Jeram-Kuala Selangor (ind.)*	*IUCN status*	*C/NC*
Autobranchia Bivalvia					
Arcidae	*Tegillarca granosa* (Linnaeus, 1758)	4	0	NE	C
	Tegillarca nodifer (E. von Martens, 1860)	0	1	NE	C
Cyrenidae	*Geloina expansa* (Mousson, 1849)	1	2	NE	C
Donacidae	*Latona faba* (Gmelin, 1791)	0	10	NE	C
Mesodesmatidae	*Coecella horsfieldii* J. E. Gray, 1853	0	1	NE	C
Mytilidae	*Lithopaga teres* (R. A. Philippi, 1846)	0	5	NE	NC
	Perna viridis (Linnaeus, 1758)	1	0	NE	C
Pectinidae	*Minnivola pyxidata* (Born, 1778)	1	0	NE	C
Pholadidae	*Pholas orientalis* Gmelin, 1791	0	7	NE	C
Solenidae	*Solen vagina* Linnaeus, 1758	1	0	NE	C
Unionidae	*Pseudodon vondembuschianus* (I. Lea, 1840)	0	17	NE	C
Veneridae	*Meretrix lyrata* (G. B. Sowerby II, 1851)	3	3	NE	C
	Paratepes textile (Gmelin, 1791)	3	0	NE	C
Caenogastropoda Gastropoda					
Assiminidae	*Optediceros breviculum* (L. Pfeiffer, 1855)	14	10	NE	NC
Clavatulidae	*Turrritula javana* K. Martin, 1883	3	0	NE	NC
Littorinidae	*Littoraria lutea* (R. A. Philippi, 1847)	0	2	NE	NC
	Littoraria articulata (R. A. Philippi, 1846)	49	74	NE	NC
	Littoraria melanostoma (J. E. Gray, 1839)	10	6	NE	NC
	Littoraria pallescens (R. A. Philippi, 1846)	0	1	NE	NC
	Littoraria undulata (J. E. Gray, 1839)	0	1	NE	NC
	Littoraria vespacea D. Reid, 1986	2	0	NE	NC
	Littoraria scabra (Linnaeus, 1758)	1	6	NE	NC
Marginellidae	*Cyptospira ventricosa* (J. Hall, 1852)	2	0	NE	NC
Melongenidae	*Volegalea cochlidium* (Linnaeus, 1758)	0	1	NE	C
Muricidae	*Chicoreus capucinus* (Lamarck, 1822)	3	0	NE	NC
	Indothais gradata (Jonas, 1846)	3	17	NE	NC
	Indothais malayanensis (K. S. Tan & Sigurdsson, 1996)	0	3	NE	NC
	Indothais rufonticta (K. S. Tan & Sigurdson, 1996)	4	3	NE	NC

	Murex trapa Röding, 1798	1	0	NE	C
Nassariidae	*Illyanasa obsoleta* (Say, 1822)	0	2	NE	NC
	Nassarius jacksonianus (Quoy & Gaimard, 1833)	8	2	NE	NC
	Nassarius livescens (R. A. Philippi, 1849)	59	0	NE	NC
	Nassarius olivaceus (Bruguière, 1789)	0	2	NE	NC
Naticidae	*Paratectonatica tigrina (*Röding, 1798)	0	1	NE	NC
Potamididae	*Cerithidea quoyii* (Humbron & Jacquinot, 1848)	0	2	NE	C
	Cerithidea obtusa (Lamarck, 1822)	10	2	NE	C
	Pirenella cingulata (Gmelin, 1791)	4	23	NE	NC
	Telescopium telescopium (Linnaeus, 1758)	2	6	LC	NC
Heterobranchia Gastropoda					
Ellobiidae	*Ellobium aurisjudae* (Linnaeus, 1758)	0	4	NE	NC
Neritimorpha Gastropoda					
Neritidae	*Neripteron violaceum* (Gmelin, 1791)	0	4	NE	NC
	Nerita balteata Reeve, 1855	24	9	NE	C
Total family	21				
Total species	41				
Total individual		213	227		

Note: NE = Not evaluated; LC = Least concern; C = Commercial; NC = Non-commercial.

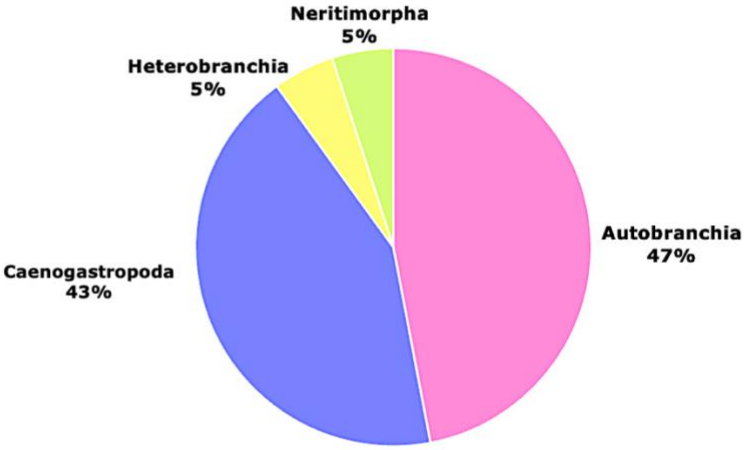

Figure 3. Percentage composition of marine molluscs subclasses recorded in Klang archipelago and the Jeram-Kuala Selangor coastline.

Diversity indices. The diversity indices revealed notable spatial variation among the sampling sites (Table 3). While the Shannon-Wiener (H') and Simpson's (D) indices indicated moderate levels of diversity across most locations, species richness (assessed via Margalef and Menhinick indices) showed more localised peaks, particularly within the Jeram-Kuala Selangor coastline. Despite these variations in richness, Pielou's evenness (J') and equitability (Ep) remained consistently high across both regions. This suggests that individuals are relatively evenly distributed among the species present, with few sites being entirely dominated by a single taxon to the exclusion of others.

Table 3

Comparison of ecological diversity, richness, and evenness indices for marine molluscs among sampling sites in Klang Archipelago (KA) and Jeram-Kuala Selangor (JK)

Ecological indices (Sites)	*KJ*	*PG*	*PZ*	*PT*	*PK1*	*PK2*	*CO*	*KP*	*R1*	*TK*	*SB*	*AJ*	*R2*	*SM*
Simpson	1.6	0.8	1.3	1.6	1.8	1.9	1.4	1.8	1.8	1.6	0.7	1.2	1.8	1.9
Margalef	0.8	0.5	0.6	0.7	0.8	0.8	0.7	0.8	0.8	0.8	0.5	0.6	0.8	0.8
Menhinick	1.6	0.5	1.6	1.4	2.4	2.5	1.2	2.6	2.1	2.1	0.4	0.9	2.1	2.4
Pielou's	1.4	0.5	1.0	0.8	2.0	1.8	0.9	1.7	1.2	1.9	0.5	0.7	1.7	1.5
Evenness	0.9	0.8	0.5	0.7	0.8	0.7	0.8	0.6	0.6	0.9	1.0	0.8	0.9	0.8

Note: Sites: KJ = Ketam-Jetty; PG = Pulau Pintu Gedong; PZ = Pulau Che Mat Zin; PT = Pulau Tengah; PK1 = Pulau Klang 1; PK2 = Pulau Klang 2; CO = Coastal; KP = Kapar; R1 = Pantai Remis; TK = Tanjung Keramat; SB = Sungai Buloh; AJ = Assam Jawa; R2 = Pantai Remis 2; SM = Sky-Mirror.

Quantitatively, the highest community complexities were observed at Pulau Klang 2 (PK2) and Sky-Mirror (SM), which both exhibited peak Shannon-Wiener values of H' = 1.9, identifying them as major biodiversity hotspots within the study area. This trend was supported by elevated species richness metrics, with the absolute maximum Margalef richness recorded at Kapar (KP = 2.6), followed closely by PK2 (2.5). Conversely, Sungai Buloh (SB) and Pulau Pintu Gedong (PG) demonstrated pronounced ecological constraints. Station SB registered the lowest diversity (H' = 0.7, D = 0.5) and the lowest overall richness metrics (Margalef = 0.5, Menhinick = 0.4) across the dataset. Interestingly, despite this severe depletion in species numbers, station SB exhibited perfect equitability with a Pielou's evenness score of J' = 1.0, denoting that the few surviving taxa were distributed with uniform abundance. In contrast, the lowest community evenness was observed at Pulau Che Mat Zin (Ep = 0.5), signifying localized dominance by a restricted number of mollusc species (Table 3).

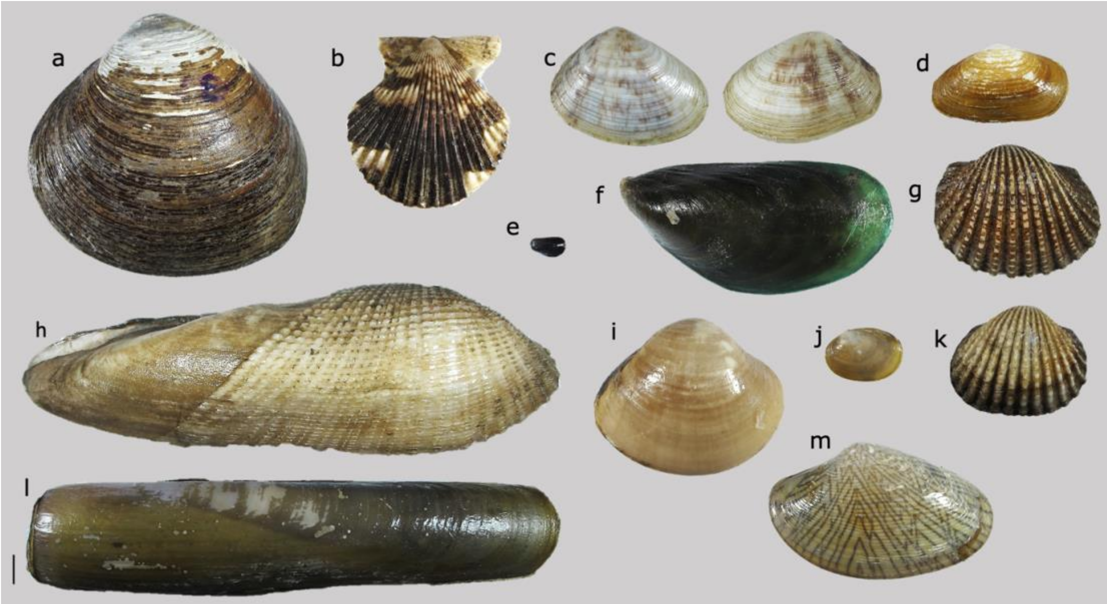

Figure 4. Marine molluscs species from the subclass Autobranchia recorded at the Klang archipelago and the Jeram-Kuala Selangor coastline: (a) *Geloina expansa*; (b) *Minnivola pyxidata*; (c) *Latona faba*; (d) *Coecella horsfieldii*; (e) *Lithophaga teres*; (f) *Perna viridis*; (g) *Tegillarca granosa*; (h) *Pholas orientalis*; (i) *Meretrix lyrata*; (j) *Pseudodon vondembuschianus*; (k) *Tegillarca nodifera*; (l) *Solen vagina*; and (m) *Paratapes textilis*. Scale bar = 1.0 cm

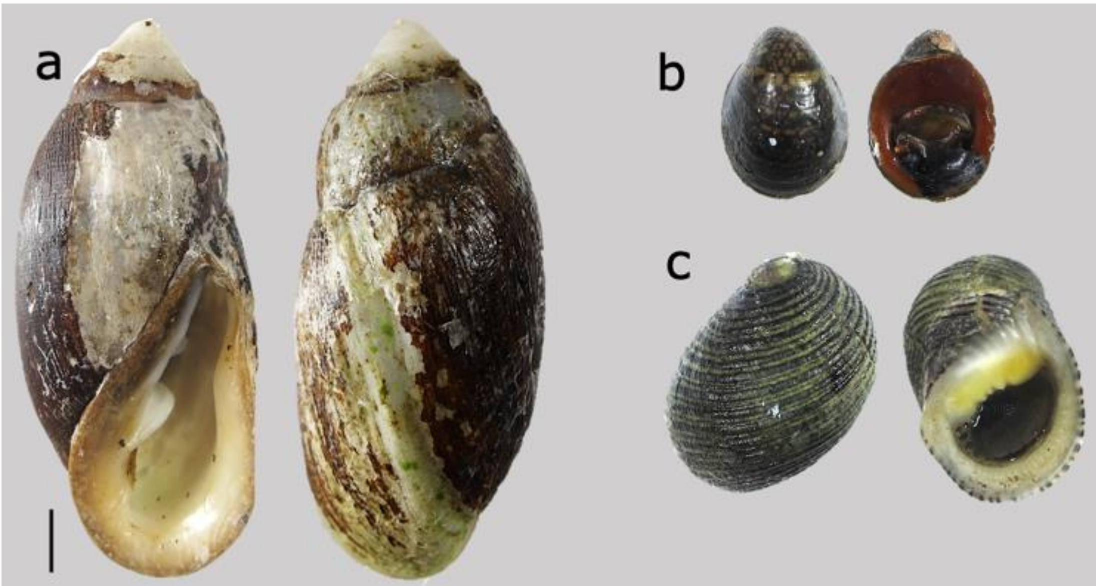

Figure 5. Marine molluscs species from the subclasses Heterobranchia and Neritimorpha recorded at Klang archipelago and Jeram-Kuala Selangor coastline: (a) *Ellobium aurisjudae*; (b) *Neripteron violaceum*; and (c) *Nerita balteata*. Scale bar = 1.0 cm.

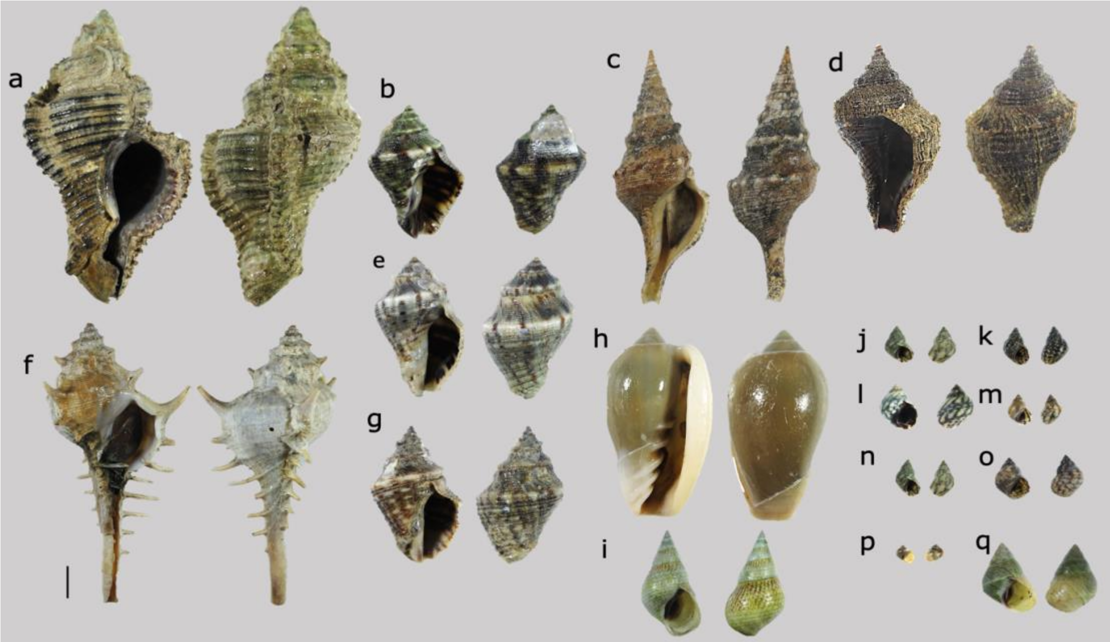

Figure 6. Marine molluscs species from the subclass Caenogastropoda recorded at the Klang archipelago and Jeram-Kuala Selangor coastline: (a) *Chicoreus capucinus*; (b) *Indothais rufotincta*; (c) *Turricula javana*; (d) *Volegalea cochlidium*; (e) *Indothais gradata*; (f) *Murex trapa*; (g) *Indothais malayensis*; (h) *Cryptospira ventricosa*; (i) *Littoraria melanostoma*; (j) *Littoraria pallescens*; (k) *Littoraria vespacea*; (l) *Littoraria undulata*; (m) *Littoraria articulata*; (n) *Littoraria scabra*; (o) *Littoraria lutea*; (p) *Optediceros breviculum*; and (q) *Ilyanassa obsoleta*. Scale bar = 1.0 cm.

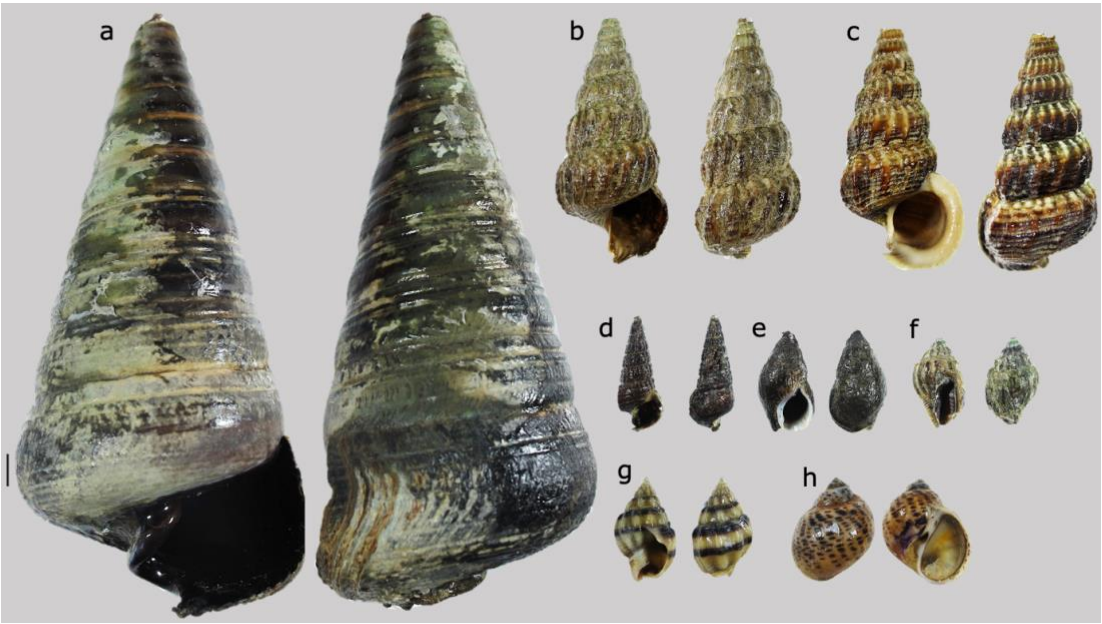

Figure 7. Marine mollusc species from the subclass Caenogastropoda recorded at the Klang archipelago and the Jeram-Kuala Selangor coastline: (a) *Telescopium telescopium*; (b) *Cerithidea quoyii*; (c) *Cerithidea obtusa*; (d) *Pirenella cingulata*; (e) *Nassarius olivaceus*; (f) *Nassarius livescens*; (g) *Nassarius jacksonianus*; and (h) *Paratectonatica tigrina*. Scale bar = 1.0 cm.

Discussion

Commercial significance and public health implications. In the present study, the subclass Autobranchia (Class Bivalvia) accounted for approximately 98% of the commercially valuable species recorded. Taxa such as *Geloina expansa*, *Pholas orientalis*, *Pseudodon vondembuschianus*, *Tegillarca granosa* and *Paratepes textilis* are staples in local markets and restaurants, reflecting their significance socioeconomic value. However, the prevalence of these filter feeders raises critical management concerns regarding food safety. Bivalves are well-documented bioindicators that readily accumulate heavy metals and pollutants (Waykar & Deshmukh 2012; Martinez et al 2019; Vidyalakshmi et al 2024).

The degradation of water quality notably at aquaculture sites near the Sungai Buloh River where levels of ammoniacal nitrogen and copper exceed National Water Quality Standards suggest a high risk of contamination (Sani et al 2025). Applying the US National Shellfish Sanitation Program (NSPP) framework, these areas would likely be categorised as 'restricted', necessitating post-harvest depuration or relaying before human consumption (Norhana et al 2016). For sustainable fisheries management in Selangor, establishing a rigorous shellfish sanitary monitoring program is essential to mitigate public health risks while supporting the local bivalve industry.

Ecological dominance and adaptive strategies. The subclass Caenogastropoda constituted 43% of the total species composition, dominated largely by the family Littorinidae. The prevalence of *Littoraria articulata* which accounted for a quarter of all individuals underscores the success of herbivorous grazers in these mangrove and intertidal systems. This dominance is likely facilitated by a reproductive strategy involving planktotrophic veliger larvae, which enhances dispersal and colonization across fragmented coastal habitats (Sanpanich et al 2008). Similarly, the widespread distribution of Neritidae across nearly all sampling sites indicates high ecological resilience. Their robust shell morphology and ability to adhere firmly to hard substrates allow them to thrive in high-energy hydrodynamic conditions (Sahidin et al 2019). These gastropod groups serve as vital components of the food web, regulating algal and bacterial biofilms, and their population stability is a key indicator of the functional integrity of the intertidal zone.

Conservation priorities and rare species. The record of *Murex trapa* as a single individual highlights its rarity within the Klang-Selangor corridor. As a carnivorous mesopredator, its low abundance may indicate either specialised habitat requirements of sensitivity to environmental shifts. Given its 'Vulnerable' status in regional red lists (e.g., Singapore), its presence in Selangor warrants targeted monitoring to prevent local extirpation. Furthermore, the discovery of the 'Critically Endangered' mangrove *Bruguiera hainesii* (Abd Razak & Juliana 2020) near PG reinforces the status of the Klang archipelago as a critical biodiversity refuge. These isolated islands maintain higher Shannon-Wiener diversity index (H' = 1.3-1.9) compared to mainland sites, likely due to the absence of permanent human settlement and the presence of mature, functioning mangrove structures that provide essential nursery grounds.

Anthropogenic pressures and management recommendations. Spatial variation in diversity reflects the varying degrees of anthropogenic pressure along the coastline. The high diversity at SM suggests a stable environment, yet its popularity as a tourism destination requires regulated visitor management to maintain ecological integrity. Conversely, the low diversity at SB (H' = 0.7) coincides with rapid urbanization and industrial runoff.

Conclusions. This study establishes a critical biodiversity baseline for the Klang archipelago and Jeram-Kuala Selangor coastline, documenting 41 species across 21 families. The findings highlight the ecological dominance of gastropods, particularly *Littoraria articulata*, and the significant socioeconomic value of the subclass

Autobranchia, while underscoring the conservation priority of anthropogenically stressed regions like as SB. To sustain the ecological integrity of the EBSAs, it is essential to integrate these biodiversity records into the MyIMCA framework and implement targeted environmental mitigation. Furthermore, future research must prioritise toxicological assessments of heavy metal contamination bioaccumulation in commercial shellfish to ensure food safety and support evidence-based coastal management.

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Authors Contributions. Conceptualization: NB, JNL; Methodology: NB, IMMR, IMR; Formal analysis: NB, IMMR; Investigation: NB, CKO, AAH; Data curation: NB, IMMR; Writing – original draft: NB, IMMR; Writing – review & editing: NB, IMMR, CKO, AAH, IMR, JNL; Supervision: JNL.

Conflict of Interest. The authors declare that there is no conflict of interest.

Data Availability. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Authors:
Nursalwa Baharuddin (NB), Biodiversity Conservation and Management Programme, Faculty of Science and Marine Environment, University of Malaysia Terengganu, 21030 Kuala Nerus Terengganu, Malaysia, e-mail: nursalwa@umt.edu.my
Illiya Maisarah Mohamad Riza (IMMR), Faculty of Science and Marine Environment, University of Malaysia Terengganu, 21030 Kuala Nerus Terengganu, Malaysia, e-mail: illiyamaisarahriza@gmail.com
Chai Kee Ong (CKO), Faculty of Science and Marine Environment, University of Malaysia Terengganu, 21030 Kuala Nerus Terengganu, Malaysia, e-mail: ongchaikee@gmail.com
Asamuddin Abu Hasan (AAH), Museum of Natural History, Faculty of Science and Technology, National University of Malaysia, 43600 Bangi Selangor Malaysia, email: asamuddin@ukm.edu.my
Izarenah Md Repin (IMR), Division of Fisheries and Conservation and Protection, Department of Fisheries Malaysia, 62628 Putrajaya, Malaysia, e-mail: izarenah@dof.gov.my
Jen Nie Lee (JNL), Faculty of Science and Marine Environment, University of Malaysia Terengganu, 21030 Kuala Nerus Terengganu, Malaysia, email: jennie@umt.edu.my

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