

Mangrove Gastropod Research in Indonesia: A Scoping Review of Taxonomic Composition, Publication Trends, and Methodological Gaps (2015–2025)

Iwan Kuncoro^{1*}, Taufiq Ahmad Romdoni²

¹ Department of Marine Science, Faculty of Mathematics and Natural Sciences, Tanjungpura University, Pontianak, West Kalimantan, 78115, Indonesia

² Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, University of Borneo Tarakan, Tarakan, North Kalimantan, 77115, Indonesia

*Korespondensi : iwankuncoro@fmipa.untan.ac.id

Abstract

To our knowledge, based on the databases searched, no scoping review specifically mapping publication trends, reported taxonomic composition, methodological approaches, and research gaps in Indonesian mangrove gastropod studies has been identified. This study aimed to summarize the temporal and geographic distribution of publications, identify the most frequently reported gastropod families and species, evaluate sampling and data analysis approaches, and identify research gaps to guide future studies. This study adopted a scoping review approach guided by the Population–Concept–Context (PCC) framework and was reported using the PRISMA Extension for Scoping Reviews (PRISMA-ScR) guidelines. Literature searches were conducted in the Scopus and Sinta databases to identify articles published between 2015 and 2025. Of the 158 records identified, 122 studies met the inclusion criteria and were included in the scoping review. The available evidence was mapped and summarized using descriptive quantitative analysis and narrative synthesis. Publications increased substantially during 2022–2025, accounting for 63.9% of all included studies. Geographic disparities were evident, with Java accounting for 34.4% of studies that explicitly reported their research locations in the title or abstract, whereas Maluku and Papua accounted for only 6.3% of this subset. Furthermore, 47.5% of studies did not provide location information in the title or abstract. Purposive sampling was the most frequently reported station selection strategy (25.4%), while stratified random sampling was reported in only 1.6% of studies. Principal component analysis and cluster analysis were reported in 2.5% and 1.6% of the included studies, respectively. The most frequently reported gastropod families were Potamididae (59.0%), Littorinidae (45.1%), Neritidae (29.5%), and Ellobiidae (26.2%). The species with the highest reporting frequencies were *Littoraria scabra* (25 studies), *Telescopium telescopium* (24 studies), and *Pirenella cingulata* (20 studies). The Shannon–Wiener diversity index (H') was explicitly reported in only 31 of 122 studies (25.4%), with 61.3% categorized as having moderate diversity. Overall, research on Indonesian mangrove gastropods has increased rapidly in recent years; however, significant challenges remain regarding geographic representation, methodological transparency, and analytical approaches.

Keywords: Gastropods, Indonesia, Mangrove, Scoping Review, Research Gaps.

INTRODUCTION

Mangrove ecosystems are among the most productive tropical coastal ecosystems and possess substantial carbon storage capacity, particularly in below-ground biomass and sediments (Alongi, 2014; Donato *et al.*, 2011; McLeod *et al.*, 2011). Indonesia has the largest extent of mangroves globally, covering approximately 3.1–3.36 million hectares or about 20%–23% of the total global mangrove area, although estimates vary among sources and measurement years (Quevedo *et al.*, 2023; Fauziyah *et al.*, 2023; Mursyid *et al.*, 2021; Efriyeldi *et al.*, 2023). Indonesia's vast mangrove area is correlated with high mangrove biodiversity and associated fauna, including gastropods (Rahman *et al.*, 2024; Suhardi *et al.*, 2024). Within mangrove ecosystems, gastropods play crucial ecological roles as litter decomposers, detritivores, herbivores of epiphytic algae, predators, and trophic links to higher predators (Baiti *et al.*, 2025; Adamu *et al.*, 2024; Skilleter & Warren, 2000; Safitri *et al.*, 2025; Isoni *et al.*, 2023; Hadiyanto *et al.*, 2026). Because the

composition and abundance of mangrove gastropods are influenced by salinity, substrate, vegetation structure, and physicochemical habitat conditions, gastropods have been suggested as potential bioindicators of mangrove habitat conditions (Isroni *et al.*, 2023; Adamu *et al.*, 2024; Imamsyah *et al.*, 2020). Several mangrove gastropod species, including *Telescopium telescopium* and *Cerithidea spp.*, have been reported to be closely associated with Indo-West Pacific mangrove habitats, and their composition and abundance are influenced by habitat conditions and physicochemical environmental factors (Adamu *et al.*, 2024; Imamsyah *et al.*, 2020). Inventories of mangrove gastropods in Indonesia have also revealed that their communities comprise diverse mangrove taxa, including species commonly found in this ecosystem (Isroni *et al.*, 2023).

Over the past decade, publications on mangrove gastropods in Indonesia have expanded in topics and geographic coverage, spanning from Aceh to Papua, and have included diversity surveys, analyses of relationships with physicochemical parameters, and community studies in restored or degraded habitats (Baiti *et al.*, 2025; Safitri *et al.*, 2025; Isroni *et al.*, 2023; Ernawati *et al.*, 2024; Wintah *et al.*, 2021; Mawardi *et al.*, 2023; Setyadi *et al.*, 2021; Purnama *et al.*, 2024). Available bibliometric reviews also indicate an increase in Indonesian mangrove studies, especially after 2010, although not specifically on gastropods (Rudiastuti *et al.*, 2026). Nevertheless, existing studies have predominantly focused on individual research sites and descriptive ecological assessments, resulting in fragmented information on mangrove gastropod research at the national scale. In particular, limited synthesis is available concerning publication trends, geographic research coverage, reported taxonomic composition, and methodological approaches. These limitations highlight the need to map the existing literature systematically and identify areas requiring further investigation. A scoping review is appropriate for examining the extent and characteristics of available evidence and identifying knowledge gaps that may guide future research (Peters *et al.*, 2020).

Previous reviews of Indonesian mangrove ecosystems have mainly addressed broader themes, including ecosystem distribution, conservation status, biodiversity patterns, and management challenges (Rahman *et al.*, 2024; Kurniawansyah *et al.*, 2023). However, these reviews have generally not focused specifically on mangrove-associated gastropods or their community-level patterns. A scoping review focusing specifically on mangrove gastropod research in Indonesia is needed to map the available scientific literature, characterize the methodological approaches employed across studies, summarize reported taxonomic patterns, and identify research gaps that may inform future biodiversity assessments and conservation planning. This review provides a national-scale synthesis of gastropod research in Indonesian mangrove ecosystems, including publication trends, geographic representation, taxonomic composition, methodological practices, and diversity index reporting. Based on the databases searched, no scoping review specifically addressing publication trends, geographic research coverage, reported gastropod taxa, methodological characteristics, and research gaps in Indonesian mangrove ecosystems was identified.

This scoping review aimed to: (1) map temporal trends and geographic patterns in published research on mangrove gastropods in Indonesia; (2) summarize the most frequently reported gastropod families and species; (3) characterize sampling strategies, field sampling techniques, and analytical approaches employed in the reviewed studies; and (4) describe the reported diversity index patterns and identify methodological and geographic research gaps to guide future investigations. The results of this review are expected to provide not only a national-scale synthesis of mangrove gastropod diversity, but also serve as a reference for evidence-based conservation efforts and coastal ecosystem management policies adaptive to environmental change.

RESEARCH METHOD

Protocol and Research Questions

This study employed a scoping review approach to systematically map the existing literature on gastropod research in Indonesian mangrove ecosystems, characterize research trends and methodological approaches, and identify knowledge gaps. The methodological framework was

informed by the guidance of Peters et al. (2020), while the reporting of the review process was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018). The research question was structured using the Population–Concept–Context (PCC) framework, which provides a systematic approach to defining the scope, research questions, and eligibility criteria of evidence synthesis studies, particularly scoping reviews (Peters et al., 2020). In this study, the Population component referred to gastropod communities associated with Indonesian mangrove ecosystems. The Concept component encompassed taxonomic composition, biodiversity patterns, research trends, sampling strategies, and data analysis approaches.

The Context component referred to mangrove ecosystems located within Indonesia. Based on these components, the primary review question was formulated as follows: What is the scope and distribution of published research on mangrove gastropods in Indonesia between 2015 and 2025, particularly in relation to publication trends, geographic representation, reported taxonomic composition, sampling methods, analytical approaches, and research gaps? This framework was used to organize the research objectives and guide the formulation of eligibility criteria, literature searches, data extraction, and descriptive evidence synthesis.

Search Strategy

A structured literature search was conducted using Scopus and the Science and Technology Index (Sinta) to identify relevant publications on mangrove gastropod research in Indonesia. These sources were selected to capture literature indexed in international and nationally accredited journals within the defined review scope. The search was conducted in May 2026 using predefined keywords covering three main domains: (1) taxonomic group: ("gastropod" OR "gastropoda" OR "snail" OR "keong"); (2) ecosystem group: ("mangrove" OR "mangrove ecosystem" OR "hutan mangrove"); and (3) geographic group: ("Indonesia" OR "Sumatra" OR "Kalimantan" OR "Java" OR "Sulawesi" OR "Papua" OR "Maluku" OR "Nusa Tenggara"). In Scopus, the search strategy was applied to the title, abstract, and keyword fields using Boolean operators, with AND used to combine the three main domains and OR used within each domain. The Scopus search string was: TITLE-ABS-KEY ((gastropod OR gastropoda OR snail OR keong) AND (mangrove OR "mangrove ecosystem" OR "hutan mangrove") AND (Indonesia OR Sumatra OR Kalimantan OR Java OR Sulawesi OR Papua OR Maluku OR "Nusa Tenggara")). For nationally accredited publications, searches were conducted through Sinta and the relevant journal platforms using predefined keywords related to gastropods, mangrove ecosystems, and Indonesia. The literature records were compiled from Scopus and Sinta-indexed journal sources and organized into a combined dataset for subsequent screening and descriptive analysis. The available documentation identified the publication sources and the total number of retrieved records; however, detailed search histories and platform-specific retrieval procedures were not available in the combined dataset. The search was limited to original research articles published between January 2015 and December 2025 and written in English or Indonesian. The publication period was selected to capture recent developments in mangrove gastropod research in Indonesia while providing sufficient temporal coverage to identify publication trends. The initial search identified 26 records from Scopus and 132 records from Sinta, resulting in a total of 158 records before duplicate removal. After duplicate removal, selection was summarized using the classification labels documented in the combined literature spreadsheet. Detailed records of full-text retrieval and eligibility assessment were not available in this dataset.

Eligibility Criteria and Study Selection

The eligibility criteria for this scoping review were structured according to the Population–Concept–Context (PCC) framework to ensure consistency between the review objectives, research questions, and selection of relevant evidence (Peters et al., 2020). A study was included if it met all the following conditions: (1) it was an original research article (not a review, opinion, or technical report) reporting gastropod data from mangrove habitats within the territory of the Republic of Indonesia; (2) it was published in a Scopus-indexed journal or a nationally accredited journal (rank

1–6) between 2015 and 2025; (3) it reported gastropod taxa at least at the family or species level and provided sufficient information on field sampling techniques; (4) it was written in Indonesian or English; and (5) it was available in full text. Conversely, we excluded proceedings without a clear peer-review process, studies reporting only bivalves or cephalopods without gastropod data, studies conducted outside Indonesia, and duplicate articles appearing in more than one database or in two different language versions from the same authors and location. The study selection process was documented using the classifications recorded in the combined literature dataset. Records were organized according to their original database sources and selection labels. The final dataset was established by retaining the 26 Scopus records and 96 Sinta records labelled "Include", resulting in 122 selected records for descriptive evidence mapping. Duplicate identification was performed carefully by checking the similarity of author combinations, publication year, research location, and reported data, considering the possibility that the same article might have been published in two language versions (Indonesian and English) in different journals. The study selection process is presented in Figure 1, using a PRISMA-style flow diagram adapted for this scoping review.

Data Charting and Taxonomic Verification

Relevant information from each included study was systematically charted using a structured data extraction worksheet developed for this review. The charted variables included bibliographic characteristics (authors, publication year, article title, and journal), geographic information (island, province, and geographic coordinates, where available), methodological characteristics (station selection strategy, sampling units, field sampling techniques, and analytical approaches), mangrove vegetation characteristics, reported gastropod taxa, and abundance data when provided. To improve taxonomic consistency, each species name listed in the original article was checked against the World Register of Marine Species (www.marinespecies.org). Taxonomic synonyms were standardized to currently accepted scientific names, where applicable, to ensure consistency across the reviewed studies. In the context of mangrove gastropods, species such as *T. telescopium* and *Cerithidea* spp. have been reported to be associated with Indo-West Pacific mangrove habitats, while their distribution and abundance are influenced by physicochemical environmental conditions (Adamu *et al.*, 2024; Imamsyah *et al.*, 2020). Ecological indices, including the Shannon–Wiener diversity index (H'), evenness, and dominance indices, were also charted when explicitly reported in the original studies.

Data Mapping, Synthesis, and Categorization

The charted evidence was summarized using descriptive quantitative analysis and narrative synthesis to characterize publication trends, geographic reporting, taxonomic composition, methodological approaches, and research gaps. Taxonomic reporting frequency was defined as the number of included studies documenting a particular gastropod family or species rather than the abundance of individuals. Publication trends were summarized according to publication year, whereas geographic reporting was assessed based on whether research locations were explicitly identified in article titles or abstracts. Studies without such information were classified as "location not specified in the title or abstract." This classification did not necessarily indicate that geographic information was absent from the full text. Reported Shannon–Wiener diversity index (H') values were grouped into three operational categories: low ($H' < 1.5$), moderate ($1.5 \leq H' \leq 3.0$), and high ($H' > 3.0$). These categories were used for descriptive evidence mapping and were not treated as universal ecological thresholds. The synthesis focused on describing the characteristics of the available literature and identifying methodological and geographic research gaps. No pooled estimate of gastropod diversity or ecological effect size was calculated.

RESULTS AND DISCUSSION

Search Results and Study Selection

The compiled literature dataset contained 158 records, comprising 26 records from Scopus and 132 records from Sinta. After the removal of one duplicate record, 157 records remained. Based on the selection classifications documented in the combined dataset, 35 additional records

were not retained. The final evidence-mapping dataset comprised 122 selected records, consisting of 26 Scopus records and 96 Sinta records labelled "Include". The record identification and selection process is summarized in Figure 1.

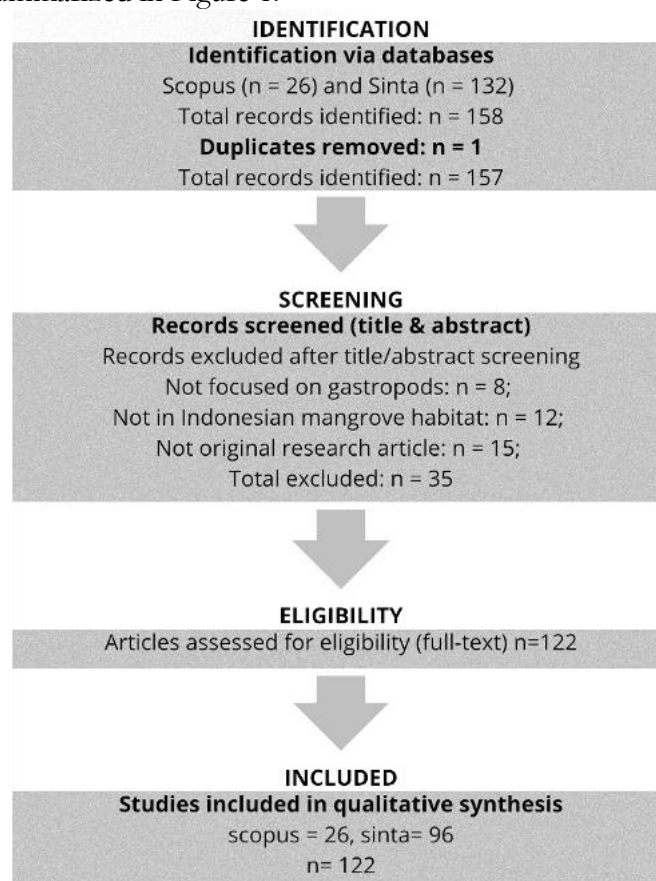


Figure 1. Flow diagram of literature record identification and selection based on the documented classifications.

This scoping review mapped 122 articles published between 2015 and 2025 and identified important patterns in the development of mangrove gastropod research in Indonesia. The findings revealed a substantial concentration of publications during 2022–2025, alongside persistent disparities in geographic research coverage, methodological reporting, and analytical approaches. This pattern indicates an expansion in the focus and geographic scope of studies; however, from the available evidence, it cannot be concluded that this surge is directly a response to specific national policies or journal accreditation (Rahman *et al.*, 2024). Despite the increasing number of publications, several important challenges remain regarding geographic research coverage, methodological transparency, and the application of analytical approaches.

General Characteristics of Studies

Most of the 122 included studies employed field-based research approaches, with cross-sectional sampling designs commonly reported in studies assessing gastropod community structure. The distribution of publication years showed a marked concentration of studies during 2022–2025, with 78 articles (63.9% of the total) published within this four-year period. Detailed information is presented in Table 1.

A pronounced geographic disparity was identified in this review. Of the 122 studies, only 64 (52.5%) specified the research location in the title or abstract. Among the studies with a clear location (n=64), Java accounted for the largest proportion (22 studies; 34.4%), followed by Sumatra, Bali-Nusa Tenggara, and Kalimantan (11 studies each; 17.2%). In contrast, Maluku-Papua was represented by only four studies (6.3%) and Sulawesi by five studies (7.8%). Table 2 presents the complete geographical distribution.

Table 1. Distribution of publication years of the included studies (n = 122).

Publication year	Number of articles	Percentage (%)
2015	2	1.6
2016	1	0.8
2017	4	3.3
2018	6	4.9
2019	9	7.4
2020	13	10.7
2021	9	7.4
2022	17	13.9
2023	14	11.5
2024	24	19.7
2025	23	18.9
Total	122	100.0

Table 2. Geographic distribution of the studies.

Region/Island	Number of Studies	Percentage (%) of studies with clear location (n = 64)	Percentage (%) of all studies (n = 122)
Java	22	34.4	18.0
Sumatra	11	17.2	9.0
Bali–Nusa Tenggara	11	17.2	9.0
Kalimantan	11	17.2	9.0
Sulawesi	5	7.8	4.1
Maluku–Papua	4	6.3	3.3
Location not specified in title or abstract	58	-	47.5
Total	122	100.0	100.0

Geographic disparity emerged as one of the principal knowledge gaps identified through this scoping review. Java accounted for the largest proportion of studies with explicitly reported locations (22 studies; 34.4%), whereas Maluku and Papua were represented by only four studies (6.3%). The uneven geographic distribution of studies may partly reflect differences in research infrastructure, institutional accessibility, and logistical constraints among Indonesian regions. More importantly, nearly half of the studies (47.5%) did not specify the location in the title or abstract. Incomplete reporting of research locations in article titles and abstracts may hinder the identification and mapping of geographically relevant studies. Nevertheless, geographic information may still be available in the full texts. More consistent reporting of study sites and geographic coordinates would facilitate future spatial evidence synthesis and biodiversity assessments. If geographic research disparities persist, future national-scale assessments may continue to underrepresent mangrove gastropod research from eastern Indonesia. Increasing research coverage in these regions is therefore important for developing a more geographically balanced evidence base.

Three station selection strategies were reported in the included studies. Purposive sampling was the most frequently used approach (31 studies; 25.4%), followed by random sampling (11 studies; 9.0%), and stratified random sampling (2 studies; 1.6%). A total of 78 studies (63.9%) did not explicitly mention their station selection strategy. Regarding field sampling units, quadrats measuring 1 m × 1 m were the most frequently reported sampling units, occurring in 73 studies (59.8%). Other plot sizes reported varied from 0.5 m × 0.5 m to 5 m × 5 m. Line transects were used in seven studies (5.7%) and belt transects in five studies (4.1%). A summary is presented in Table 3.

Table 3. Frequency of sampling method usage in the included studies (a study may use combinations of station selection strategies and field sampling units; percentages calculated from $n = 122$).

Methodological aspect	Method	Frequency	Percentage (%)
Station selection strategy	Purposive sampling	31	25.4
	Random sampling	11	9.0
	Stratified random sampling	2	1.6
	Not explicitly reported	78	63.9
Field sampling unit/technique	1 m $\times$ 1 m quadrat/plot	73	59.8
	Line transect	7	5.7
	Belt transect	5	4.1

The use of multivariate analysis was limited. Principal component analysis (PCA) was reported by three studies (2.5%) and cluster analysis by two studies (1.6%). No studies used Non-metric Multidimensional Scaling (NMDS), Permutational Multivariate Analysis of Variance (PERMANOVA), or Canonical Correspondence Analysis (CCA) (Table 4).

Table 4. Frequency of multivariate analysis in the included studies ($n=122$).

Multivariate analysis approach	Frequency	Percentage (%)
Principal Component Analysis (PCA)	3	2.5
Cluster Analysis	2	1.6

From a methodological perspective, purposive sampling was the most frequently reported station selection strategy (25.4% of studies), while stratified random sampling, which can better accommodate habitat heterogeneity in ecological studies (Roux *et al.*, 2013; Smith *et al.*, 2011; Henderson *et al.*, 2007; Michalcová *et al.*, 2011; Hédl, 2007), was reported in only 1.6% of the studies. Purposive sampling, although practical and cost-effective, may introduce limitations when the objective is to generalize ecological patterns across heterogeneous mangrove habitats because site selection depends on predefined criteria and researcher judgment (Michalcová *et al.*, 2011; Hédl, 2007). In mangrove ecosystems, which are naturally structured into different zones (seaward, mid-, and landward) with varying salinity gradients and substrate characteristics, the absence of stratified approaches may reduce the ability to capture variation among habitat zones. Consequently, differences in reported diversity indices should be interpreted cautiously because they may partly reflect variations in sampling designs and methodological approaches among studies. The evidence mapping identified limited reporting of multivariate analytical approaches, with principal component analysis (PCA) documented in three studies (2.5%) and cluster analysis in two studies (1.6%). These findings indicate opportunities for broader application of analytical approaches to investigate ecological community patterns in future research. Different multivariate techniques address different ecological questions. PCA and cluster analysis can be useful for exploring patterns in environmental or community data, whereas NMDS can support the visualization of community dissimilarities, PERMANOVA can test differences in multivariate community composition, and CCA can examine associations between species composition and environmental gradients when its assumptions are met (Anderson *et al.*, 2008; Legendre & Legendre, 2012).

The limited reporting of multivariate analyses suggests that many of the reviewed studies emphasized descriptive community assessments. Future studies could benefit from analytical approaches selected according to clearly formulated ecological questions and appropriate data structures. This gap may reflect differences in research capacity, analytical resources, and methodological preferences among institutions. Nevertheless, in terms of taxonomic composition, the findings of this review reveal consistent patterns in the reporting frequencies of several gastropod families. The scoping review identified Potamididae (59.0%), Littorinidae (45.1%),

Neritidae (29.5%), and Ellobiidae (26.2%) as the most frequently reported gastropod families in the reviewed literature. These reporting frequencies reflect patterns in the available research rather than direct estimates of ecological dominance or relative abundance. Previous studies have also highlighted the ecological importance of molluscs and other invertebrates in mangrove ecosystems (Nagelkerken *et al.*, 2008; Cannicci *et al.*, 2021). The frequent reporting of *Littoraria scabra* (25 studies) and *Telescopium telescopium* (24 studies) highlights their representation in the reviewed literature and suggests their potential relevance for future mangrove monitoring research. However, their suitability as ecological indicators requires further validation using standardized measurements of environmental gradients, habitat disturbance, and population responses.

Taxonomic Composition of Gastropods

Mapping the reported taxonomic composition across the 122 included studies revealed that the most frequently documented gastropod families were Potamididae (72 studies; 59.0%), Littorinidae (55 studies; 45.1%), Neritidae (36 studies; 29.5%), and Ellobiidae (32 studies; 26.2%). Other families, such as Cerithiidae, Muricidae, and Assimineidae, were each reported in fewer than 10% of studies. Table 5 presents the complete frequencies along with the commonly reported genera.

Table 5. Reporting frequencies of selected gastropod families and their commonly reported genera in the included studies.

Family	Number of papers	Percentage (%)	Commonly reported genera
Potamididae	72	59.0	<i>Telescopium</i> , <i>Terebralia</i> , <i>Cerithidea</i> , <i>Pirenella</i>
Littorinidae	55	45.1	<i>Littoraria</i> , <i>Littorina</i>
Neritidae	36	29.5	<i>Nerita</i> , <i>Neritina</i> , <i>Neripteron</i>
Ellobiidae	32	26.2	<i>Ellobium</i> , <i>Cassidula</i> , <i>Pythia</i> , <i>Melampus</i>
Cerithiidae	9	7.4	<i>Cerithium</i> , <i>Chpeomorus</i>
Muricidae	5	4.1	<i>Chicoreus</i> , <i>Murex</i> , <i>Thais</i>
Assimineidae	3	2.5	<i>Assimineia</i>

Note: Reporting frequencies indicate the number of studies documenting each family. Because individual studies could report multiple families, percentages are not expected to sum to 100%.

After standardizing taxonomic names according to WoRMS, 15 species were ranked highest in reporting frequency. The most frequently reported species were *Littoraria scabra* (25 studies), *Telescopium telescopium* (24 studies), *Pirenella cingulata* (20 studies), *Terebralia sulcata* (17 studies), and *Cerithidea obtusa* (12 studies). The name *Cerithidea cingulata* was treated as a synonym of *Pirenella cingulata* based on the taxonomic standardization adopted in this review. Table 6 presents a complete list of the top 15 species.

An important taxonomic issue concerns the use of *Cerithidea cingulata* and *Pirenella cingulata*, which represent synonymous scientific names under the taxonomic classification adopted in this review, following Reid *et al.* (2008) and the World Register of Marine Species (WoRMS). In this review, we merged the two entries, making *P. cingulata* the third most frequently reported species (20 studies). This taxonomic inconsistency highlights an important challenge in biodiversity research. We recommend that every manuscript submitted to international journals include verification of names through WoRMS and provide taxonomic authority at the first mention of each species. The scoping review found that the Shannon–Wiener diversity index (H') was explicitly reported in 31 of the 122 included studies (25.4%). Based on the operational categories adopted in this review, 61.3% of these studies were classified as having moderate diversity, 22.6% as low diversity, and 16.1% as high diversity. These findings describe the distribution of reported diversity categories rather than providing a pooled estimate of gastropod diversity across Indonesian mangrove ecosystems.

Table 6. The most frequently reported gastropod species in Indonesian mangrove ecosystems. Note: Synonymous scientific names were consolidated according to the accepted taxonomic nomenclature in the World Register of Marine Species (WoRMS).

Species	Number of papers	Family
<i>Littoraria scabra</i>	25	Littorinidae
<i>Telescopium telescopium</i>	24	Potamididae
<i>Pirenella cingulata</i> (syn. <i>Cerithidea cingulata</i>)	20	Potamididae
<i>Terebralia sulcata</i>	17	Potamididae
<i>Cerithidea obtusa</i>	12	Potamididae
<i>Cassidula aurisfelis</i>	10	Ellobiidae
<i>Cassidula nucleus</i>	8	Ellobiidae
<i>Ellobium aurisjudae</i>	8	Ellobiidae
<i>Terebralia palustris</i>	8	Potamididae
<i>Nerita planospira</i>	5	Neritidae
<i>Nerita lineata</i>	4	Neritidae
<i>Chicoreus capucinus</i>	4	Muricidae
<i>Faunus ater</i>	3	Pachychilidae
<i>Littoraria melanostoma</i>	3	Littorinidae
<i>Nerita undata</i>	3	Neritidae

Diversity Index

The Shannon-Wiener index (H') was explicitly reported in only 31 of 122 studies (25.4%). Of these, 19 studies (61.3%) fell into the moderate category ($1.5 \leq H' \leq 3.0$), 7 studies (22.6%) into the low category ($H' < 1.5$), and 5 studies (16.1%) into the high category ($H' > 3.0$). These results are summarized in Table 7.

Table 7. Distribution of Shannon-Wiener index (H') categories in studies that explicitly reported it ($n = 31$).

Category	Criteria	Number of Studies	Percentage (%)
Low	$H' < 1.5$	7	22.6
Moderate	$1.5 \leq H' \leq 3.0$	19	61.3
High	$H' > 3.0$	5	16.1

Differences in reported Shannon diversity categories may reflect variations in habitat characteristics, environmental conditions, anthropogenic disturbance, and sampling methodologies. However, these relationships were not quantitatively examined in the present scoping review; therefore, causal interpretations should be avoided. Furthermore, the limited availability of consistently reported Shannon diversity indices may constrain quantitative comparisons of gastropod diversity among Indonesian mangrove ecosystems. This scoping review has several limitations that should be considered when interpreting the mapped evidence. First, the use of only two databases (Scopus and Sinta), although justified to reach international and accredited national publications, means that articles indexed only in the Web of Science, Google Scholar, or local journals not indexed by Sinta were not included, potentially introducing source coverage and selection bias toward publications in internationally indexed and nationally accredited journals. Second, the geographic mapping was based on the 64 studies that explicitly identified their research locations in their titles or abstracts. Consequently, the geographic patterns presented in this review reflect the reporting characteristics of this subset rather than the complete geographic distribution of all 122 studies. Future evidence mapping should extract study locations from full-text articles whenever available. Third, differences in sampling strategies, analytical methods, and the availability of comparable quantitative data limited direct comparisons among studies.

Accordingly, this scoping review focused on descriptive evidence mapping and narrative synthesis rather than statistical pooling or estimation of combined ecological effects, consistent with its objectives (Peters *et al.*, 2020).

Based on the mapped evidence, three recommendations are proposed for future research and mangrove biodiversity monitoring. First, *Littoraria scabra* and *Telescopium telescopium* may warrant further investigation as potential indicator taxa for mangrove monitoring programs because they are frequently reported in Indonesian mangrove habitats and may be suitable for standardized field observations. Second, future research initiatives should prioritize underrepresented regions, particularly eastern Indonesia, to improve the geographic coverage of biodiversity assessments and provide a stronger scientific basis for mangrove conservation planning. Third, capacity-building initiatives in ecological statistics and multivariate analysis could strengthen future research. Such initiatives may include training in R-based analytical tools and collaborative research programs involving institutions across Indonesia. Addressing these methodological and geographic research gaps could strengthen Indonesia's contribution to broader ecological research and evidence-based coastal ecosystem management.

CONCLUSIONS AND RECOMENDATION

This scoping review mapped 122 articles published between 2015 and 2025 to characterize the development of mangrove gastropod research in Indonesia. A substantial proportion of the included publications (63.9%) appeared during 2022–2025, indicating increased research activity in recent years. Geographic reporting was uneven, with Java accounting for 34.4% of the 64 studies that explicitly identified their research locations in titles or abstracts, whereas Maluku and Papua accounted for 6.3% of this subset. Furthermore, 47.5% of all included studies did not specify research locations in their titles or abstracts, highlighting limitations in the accessibility of geographic information during literature screening. Potamididae (59.0%), Littorinidae (45.1%), Neritidae (29.5%), and Ellobiidae (26.2%) were the most frequently reported gastropod families. At the species level, *Littoraria scabra*, *Telescopium telescopium*, and *Pirenella cingulata* showed the highest reporting frequencies. These findings reflect their occurrence in the reviewed literature rather than direct estimates of ecological dominance. Methodological mapping revealed variation in station selection strategies, field sampling techniques, and analytical approaches. Purposive sampling was reported in 25.4% of the studies, whereas stratified random sampling was reported in only 1.6%. Multivariate analytical approaches were infrequently documented, with PCA and cluster analysis reported in three and two studies, respectively. Overall, this scoping review identified opportunities to improve methodological transparency, standardize biodiversity reporting, expand research coverage in underrepresented regions, and strengthen the use of appropriate analytical methods. Addressing these gaps may support more comprehensive and comparable assessments of mangrove gastropod research in Indonesia.

CONFLICT OF INTERESTS

The authors declare that they have no conflicts of interest related to this study.

REFERENCES

- Adamu H., Hussaini R., Mohammed E. *et al.* 2024. Modeling habitat suitability for Cerithidea rhizophorarum and Telescopium telescopium in Indo-West Pacific mangroves. Ecology and Evolution 14(10): e70384. DOI: 10.1002/ece3.70384
- Alfaro A.C. 2008. Diet of Littoraria scabra, while vertically migrating on mangrove trees: Gut content, fatty acid, and stable isotope analyses. Estuarine, Coastal and Shelf Science 79(4): 718-726.
- Alongi D.M. 2014. Carbon cycling and storage in mangrove forests. Annual Review of Marine Science 6: 195-219. DOI: 10.1146/annurev-marine-010213-135020
- Anderson M.J., Gorley R.N., Clarke K.R. 2008. PERMANOVA+ for PRIMER: Guide to software and statistical methods. PRIMER-E.

- Baiti M.W.A., Insafitri I., Ambariyanto A. et al. 2025. Gastropod community structure in mangrove ecosystems on the north coast of Bangkalan, Indonesia. *Egyptian Journal of Aquatic Biology and Fisheries* 29(2): 45-62. DOI: 10.21608/ejabf.2025.412075
- Cannicci S., Lee S.Y., Bravo H. et al. 2021. A functional analysis reveals extremely low redundancy in global mangrove invertebrate fauna. *Proceedings of the National Academy of Sciences* 118(32): e2016913118. DOI: 10.1073/pnas.2016913118
- Donato D.C., Kauffman J.B., Murdiyarso D. et al. 2011. Mangroves among the most carbon-rich forests in the tropics. *Nature Geoscience* 4(5): 293-297. DOI: 10.1038/ngeo1123
- Efriyeldi E., Syahrial S., Effendi I. et al. 2023. The mangrove ecosystem in a harbor-impacted city in Dumai, Indonesia: A conservation status. *Regional Studies in Marine Science* 62: 103092. DOI: 10.1016/j.rsma.2023.103092
- Ernawati N.M., Dewi A.P.W.K., Sugiana I.P. et al. 2024. Mangrove gastropod distribution based on dominant vegetation classes and their relationship with physicochemical characteristics on fringe mangroves of Lembongan Island, Bali, Indonesia. *Biodiversitas* 25(1): 116-125. DOI: 10.13057/biodiv/d250116
- Fauziyah F., Agustriani F., Oktavianis R.E. et al. 2023. Willingness to pay for mangrove conservation in Sembilang National Park, South Sumatra, Indonesia. *Ocean and Coastal Management* 242: 106756. DOI: 10.1016/j.ocecoaman.2023.106756
- Hadiyanto H., Cappenberg H.A.W., Widyastuti E. et al. 2026. The Wallace's Line separates the biogeographic realms of mangrove molluscs in Indonesia. *Regional Studies in Marine Science* 96: 104926. DOI: 10.1016/j.rsma.2026.104926
- Hédrl R. 2007. Is sampling subjectivity a distorting factor in surveys for vegetation diversity? *Folia Geobotanica* 42(2): 121-130. DOI: 10.1007/BF02893885
- Henderson A., Comiskey J., Dallmeier F. et al. 2007. Framework for assessment and monitoring of biodiversity. In: Levin S.A. (Ed.), *Encyclopedia of Biodiversity*. 2nd ed. Elsevier, pp. 1-15. DOI: 10.1016/B0-12-226865-2/00129-2
- Imamsyah A., Arthana I.W., Astarini I.A. 2020. The influence of physicochemical environment on the distribution and abundance of mangrove gastropods in Ngurah Rai Forest Park Bali, Indonesia. *Biodiversitas* 21(7): 3120-3127. DOI: 10.13057/biodiv/d210740
- Isoni W., Sari P.D.W., Sari L.A. et al. 2023. Checklist of mangrove snails (Gastropoda: Mollusca) on the coast of Lamongan District, East Java, Indonesia. *Biodiversitas* 24(3): 1452-1459. DOI: 10.13057/biodiv/d240341
- Kathiresan K., Bingham B.L. 2001. Biology of mangroves and mangrove ecosystems. *Advances in Marine Biology* 40: 81-251. DOI: 10.1016/S0065-2881(01)40003-4
- Kurniawansyah A., Susiloningtyas D., Manessa M.D.M. 2023. Mangrove ecosystem management in Indonesia: Review, limitation, gap, and knowledge. *Maritime Technology and Research* 5(3): 262310. DOI: 10.33175/mtr.2023.262310
- Legendre P., Legendre L. 2012. *Numerical ecology*. 3rd English ed. Elsevier.
- Magurran A.E. 2004. *Measuring biological diversity*. Blackwell Publishing.
- Mawardi A.L., Khalil M., Sarjani T.M. et al. 2023. Diversity and habitat characteristics of gastropods and bivalves associated with mangroves on the east coast of Aceh Province, Indonesia. *Biodiversitas* 24(9): 4855-4863. DOI: 10.13057/biodiv/d240959
- McLeod E., Chmura G.L., Bouillon S. et al. 2011. A blueprint for blue carbon: Toward an improved understanding of the role of vegetated coastal habitats in sequestering CO₂. *Frontiers in Ecology and the Environment* 9(10): 552-560. DOI: 10.1890/110004
- Michalcová D., Lvončík S., Chytrý M. et al. 2011. Bias in vegetation databases? A comparison of stratified-random and preferential sampling. *Journal of Vegetation Science* 22(2): 281-291. DOI: 10.1111/j.1654-1103.2010.01249.x
- Mursyid H., Daulay M.H., Pratama A.A. et al. 2021. Governance issues related to the management and conservation of mangrove ecosystems to support climate change mitigation actions in Indonesia. *Forest Policy and Economics* 133: 102622. DOI: 10.1016/j.forpol.2021.102622

- Nagelkerken I., Blaber S.J.M., Bouillon S. et al. 2008. The habitat function of mangroves for terrestrial and marine fauna: A review. *Aquatic Botany* 89(2): 155-185. DOI: 10.1016/j.aquabot.2007.12.007
- Page M.J., McKenzie J.E., Bossuyt P.M. et al. 2021. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *PLoS Medicine* 18(3): e1003583. DOI: 10.1371/journal.pmed.1003583
- Peters M.D.J., Marnie C., Tricco A.C., Pollock D., Munn Z., Alexander L. et al. 2020. Updated methodological guidance for the conduct of scoping reviews. *JBIM Evidence Synthesis* 18(10): 2119–2126. DOI: 10.11124/JBIES-20-00167.
- Peres-Neto P.R., Legendre P., Dray S. et al. 2006. Variation partitioning of species data matrices: Estimation and comparison of fractions. *Ecology* 87(10): 2614–2625. DOI: 10.1890/0012-9658(2006)87[2614:VPOSDM]2.0.CO;2
- Purnama M.F., Prayitno S.B., Muskananfolo M.R. et al. 2024. Tropical gastropod density and diversity in the mangrove forest of Totobo Village, Southeast Sulawesi, Indonesia. *Biodiversitas* 25(4): 1436-1445. DOI: 10.13057/biodiv/d250436
- Quevedo J.M.D., Lukman K.M., Ulumuddin Y.I. et al. 2023. Applying the DPSIR framework to qualitatively assess the globally important mangrove ecosystems of Indonesia: A review towards evidence-based policymaking approaches. *Marine Policy* 146: 105354. DOI: 10.1016/j.marpol.2022.105354
- Rahman R., Lokollo F.F., Manuputty G.D. et al. 2024. A review on the biodiversity and conservation of mangrove ecosystems in Indonesia. *Biodiversity and Conservation* 33(5): 1573-1598. DOI: 10.1007/s10531-023-02767-9
- Reid D.G., Dyal P., Lozouet P. et al. 2008. Mudwhelks and mangroves: The evolutionary history of an ecological association (Gastropoda: Potamididae). *Molecular Phylogenetics and Evolution* 47(2): 680-699. DOI: 10.1016/j.ympev.2008.01.003
- Roux E., Gaborit P., Romaña C.A. et al. 2013. Objective sampling design in a highly heterogeneous landscape - Characterizing environmental determinants of malaria vector distribution in French Guiana, in the Amazonian region. *BMC Ecology* 13: 45. DOI: 10.1186/1472-6785-13-45
- Rudiastuti A.W., Rahadiati A., Pratama B.B. et al. 2026. Bibliographic analysis of mangrove conservation in Southeast Asia: Insights, trends and future direction. *Journal of Marine and Island Cultures* 15(1): 20. DOI: 10.21463/jmic.2026.15.1.20
- Safitri I., Maharani E., Sofiana M.S.J. et al. 2025. Assessing mangrove gastropod biodiversity: Composition, abundance, and ecological indices in Mempawah, West Kalimantan, Indonesia. *Egyptian Journal of Aquatic Biology and Fisheries* 29(3): 211-228. DOI: 10.21608/ejabf.2025.416697
- Setyadi G., Rahayu D.L., Pribadi R. et al. 2021. Crustacean and mollusk species diversity and abundance in the mangrove communities of Mimika District, Papua, Indonesia. *Biodiversitas* 22(10): 4305-4314. DOI: 10.13057/biodiv/d221004
- Skilleter G.A., Warren S. 2000. Effects of habitat modification in mangroves on the structure of mollusc and crab assemblages. *Journal of Experimental Marine Biology and Ecology* 244(1): 107-129. DOI: 10.1016/S0022-0981(99)00133-1
- Smith S.G., Swanson D.W., Chiappone M. et al. 2011. Probability sampling of stony coral populations in the Florida Keys. *Environmental Monitoring and Assessment* 183(1-4): 121-138. DOI: 10.1007/s10661-011-1912-2
- Tricco A.C., Lillie E., Zarin W., O'Brien K.K., Colquhoun H., Levac D. et al. 2018. PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine* 169(7): 467–473. DOI: 10.7326/M18-0850
- Suhardi R.M., Rahardi W., Shih H.-C. et al. 2024. A review of the mangrove ecosystem in Indonesia: Biodiversity, conservation, and challenges in sustainable management. *Ecological Genetics and Genomics* 31: 100282. DOI: 10.1016/j.egg.2024.100282

- Wintah, Nuryanto A., Pribadi R. et al. 2021. Distribution pattern of gastropods and physical chemical factors in the Kebumen mangrove forest, Indonesia. *AACL Bioflux* 14(4): 2143-2154.
- Zvonareva S., Kantor Y. 2016. Checklist of gastropod molluscs in mangroves of Khanh Hoa province, Vietnam. *Zootaxa* 4162(3): 401-437. DOI: 10.11646/zootaxa.4162.3.1