**Littoraria** spp. Snail (Mollusca: Gastropoda) as a Bioindicator in The Mangrove Ecosystem

Syahrial, Desrita*, R. Ezraneti  
Department of Marine Science, Faculty of Agriculture, Malikussaleh University  
*Corresponding author: desrita@usu.ac.id

**Abstract.** Coastal environmental damage often occurs in various regions, especially around the mangrove forest area. Generally caused by anthropogenic which is increasingly high and causes mangrove habitat to change and gives great pressure on the biological community that inhabits it. One of the main objectives of bioindicators is to identify species or groups of species that can indicate environmental disturbances, so this study aims to determine or assess how suitable species or groups of **Littoraria** species as bioindicators in monitoring programs in coastal environments, especially mangrove ecosystems. The results of the study concluded that **Littoraria** spp. can be used as a species or group of bioindicator species. This is because they have fulfilled the requirements that must be fulfilled by an organism to be used in the biomonitoring program. However, the criteria for **Littoraria**'s spp. relationship with other species is still unclear, so they must be used with caution.

**1. Introduction**  
**Littoraria** spp. is one of the genus of the gastropod class with its family taxa is Littorinidae which has taenioglossate type radula which is seven teeth in each row (a common feature of most caenogastropods) [1], able to survive when exposed to seawater splashes [2], are opportunistic feeders [3] and also eat small invertebrates [4, 5]. Availability of food, competition, and predation is a limiting factor for survival and distribution [6, 7], while wave heights [8] and currents [9] are limiting factors for density. In addition, the movement of **Littoraria** spp. was greatly influenced by the tidal period of the sea and the size of the shell [10].

One of the most widely used approaches to monitoring environmental quality is the use of indicator species (bioindicators), both animals [11, 12, 13, 14] and plants [15, 16, 17, 18, 19, 20, 21, 22, 23]. Bioindicators are very useful in measuring biological and non-biological changes [24] with their application depending on the conditions of reference that define the biological conditions or habitat to be achieved [25]. In simple terms, bioindicators are defined as species or groups of species that reflect the biotic or abiotic state of the environment, representing the effects of environmental changes in a habitat, community or ecosystem, and can show diversity in other species [26], so that using bioindicators is very possible assess the impact caused by human activities on surrounding organisms [27].

In tropical and subtropical regions, very dominant mangrove forests were found [28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40], growing in tidal areas between sea and land [41, 42, 43, 44], having a heterogeneous environment [45] and the most productive ecosystems [37, 46, 47, 48, 49, 50]. The global economic value of mangroves is around 14000 – 16000 US$/ha/year [51], where the service benefits of mangrove ecosystems in Southeast Asia are equivalent to 4200 US$/ha/year [52] and contribution of forest products non-timber mangroves are around 79% of the family's annual average income at Sundarban [53]. In India, the results of mangrove resources are about 30% of the household income of the population [54], while in East Kalimantan 40% [55], Thailand 83% [56] and Sundarban 90% [57]. Furthermore, economic losses that occur per household in a village protected by the embankment are more of a loss (154 US$) compared to households in a village protected by mangrove forests (33 US$) [58]. In addition, mangrove forests also support complex food webs [59, 60, 61, 62, 63], supporting biodiversity [34, 47, 64, 65, 66, 67, 68, 69], habitat for various coastal and...
marine fauna [47, 70, 71], supporting coastal fisheries [34, 72, 73, 74], storing carbon [75, 76, 77, 78], providing wood [79, 80, 81] to improve water quality [82].

Table 1. Estimates of global mangrove forest based on reference years

| No | Reference Source | Reference Years | Mangrove’s Area (km²) |
|----|-----------------|-----------------|-----------------------|
| 1  | [83]            | 1980            | 187940                |
| 2  | [83]            | 1990            | 169250                |
| 3  | [83]            | 1993            | 141973                |
| 4  | [83]            | 2000            | 157400                |
| 5  | [75]            | 2000            | 137600                |
| 6  | [83]            | 2005            | 152310                |

The heavier the anthropogenic pressure in the mangrove region and the close relationship between living things and the environment [24] and the lack of information about bioindicator species from the genus Littoraria in the coastal environment, this study is very necessary. This aims to determine or assess how suitable the species or groups of Littoraria species as bioindicators in the monitoring program. Furthermore, to achieve this goal, Littoraria’s taxonomic nomenclature is adapted to [85], where Littoraria species have many synonym names (Table 2).

2. Categories and Selection of Bioindicator Standards

Biological indicators are used to supplement toxicity [86], chemical valuation methods [25] and serve as evaluations of environmental quality [25, 27]. The most important reason for using bioindicators is cost effectiveness [27] and is a technique that is fast in estimating several groups or the overall diversity of a species [87], so that someone (such as experts) can predict or predict and prepare future [24]. [26] divides indicators into three parts, namely environmental, ecological and biodiversity indicators. Environmental indicators detect changes and or monitor environmental conditions, while ecological indicators show the effects of stressors on biota and monitor changes that cause long-term stress, while biodiversity indicators identify the diversity of taxa in certain areas and monitor changes in biodiversity. To detect environmental changes, environmental and ecological indicators are used, while to detect the diversity of living things, biodiversity indicators are generally used [24].

The abundance of species on earth, there is at least one that fulfills it as an indicator criterion [27], although its selection is very complicated and difficult [24, 88, 89]. This is because species responses to environmental changes may be contradictory [90, 91], the activity and abundance of each species vary throughout the year [92], each species has different ecological requirements [90, 91, 93], and some species that are general in various habitats and some are special [27]. In addition, the most difficult problem in selecting bioindicators is the generalization of results [27] namely how well species or groups of species represent other species in the event of environmental changes [90, 91], so as to make as species or groups of indicators of environmental change species must have several standards or criteria, namely: 1) taxonomy, ecology and habitat characteristics must be clear, 2) spread over a wide geographical area, 3) can provide early warning of a change, 4) easy and cost-effective when surveyed, 5) have many groups of individuals who are independent and not too affected by the size of individual groups, 6) represent responses of other species, 7) represent ecological changes caused by the influence of human (anthropogenic) pressure, and 8) very important socially, economically and culturally [24, 88, 89, 94]. Furthermore, species or groups of species to be used as environmental indicators must also have been carried out studies of climate change, easily observed and emerged for a long time and formed groups with many individuals [24].

3. Testing Littoraria spp. as a Bioindicator

Studies of marine and coastal biota have been numerous and have been used successfully in various types of indicator studies [95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107], including Littoraria’s closest relative Littorina [108] most of the studies regarding responses to heavy metal
pollution (Table 3). In addition, *Littorina* species are also used to understand the spatial and temporal effects of hydrocarbon oil spills and the evaluation of biomonitoring tributyltin (TBT).

### 3.1. Has a clear taxonomy
*Littoraria*'s taxonomy has been revised and explained by Bandel and Kadolsky [119] and Reid [117, 120, 121], where previously *Littoraria* species were included in the genus *Littorina* [121] whose grouping was based on shell characters [122, 123, 124, 125]. In the family level monograph proposed by Rosewater [122], the group 'scabra' in the Indo-Pacific consists of three species, namely *L. scabra* (widespread and highly variable), *L. melanostoma* and *L. carinifera* (both spread only in Indo-Malaya). Furthermore, after switching to soft anatomical characters [126], the 'scabra' group consists of 20 species, so it must be referred to in the genus *Littoraria* and recently the number of species from the genus *Littoraria* has reached 39 species [118].

### 3.2. It has clear ecology and habitat characteristics
Thirty-nine (39) of *Littoraria* species are distributed in the tropics and subtropics, most (mainly) found in mangrove trees, although at least some are found on rocky beaches or protected rocks (Table 5) [1, 118].

### 3.3. Spread over a wide geographical area
The geographical distribution of *Littoraria* is widespread in the Indo Pacific, Atlantic and Pacific Oceans [70, 118, 121, 122, 126, 127, 128, 129], where *Littoraria* is almost exclusively found in tropical regions compared to subtropics, both spread and biodiversity [121] (Table 5).

### 3.4. Can provide an early warning of a change
The most well-known mangrove-related Littorinidae are *L. scabra* (Linne) in the Indo-Pacific and *L. angulifera* (Lamarck) in the Atlantic [126]. The destruction of mangrove forests caused by land conversion for residential settlements and agricultural land causes gastropod *L.scabra* not found in Ambon Bay mangrove forests [130]. Then the area that experienced physical pressure by aquaculture, industry, residential settlements and tourism, also caused gastropod *L. scabra* not to be found in the mangrove forest of Tugurejo Village, Semarang [131]. While in the mangrove rehabilitation program area, gastropod *L. scabra* was only found with a low attendance rate at some points [132].

### 3.5. Easy and economically inexpensive during the survey
In conducting surveys, *Littoraria* can be collected by hand (collected without using a tool). This is because his life tends to be relatively sedentary [133] and its movements are very slow [10].

### 3.6. Have many groups of individuals who are independent and not too affected by the size
*Littoraria* is typically found on tropical and subtropical beaches [1, 118, 126] and has geographical variations in shell size. As many as 50 individuals of *L. scabra* have been collected by [70] on the Southwestern side of Nananu-i-Ra Island in the Fiji Islands and obtained the size of the shell between 13 – 28 mm, while [10] measured 30 shell lengths of *L. scabra* on the beach Tawiri Ambon Island (Indonesia) ranges from 10 – 24 mm. If the survey/study is carried out in several locations (replication), it will reduce the problem of inequality of a species, where the more number of locations carried out, the species will be evenly distributed and the results will be more accurate [134].

### 3.7. A represent the response of other species
Specifically, the response of other species due to changes in *Littoraria* (increased or lost) is still less studied. However, changes in *L. littorea*, the closest relative of *Littoraria* [108] have been studied and greatly influence algal cover [135, 136, 137] and barnacles *Balanus balanoides* [137]. This has similarities with *Littoraria*, where *Littoraria* is a herbivorous gastropod [5, 129, 138, 139] with food types such as microalgae, macrophyte sheets, algal filaments and mangrove tissue [3, 129].
Table 2. The names of synonyms and real names of species *Littoraria*.

| No | Species Name                  | Synonyms Name          | Real Name                                      |
|----|-------------------------------|------------------------|------------------------------------------------|
| 1  | *L. aberrans* (Philippi, 1846) | -                      | -                                              |
| 2  | *L. albicans* (Metcalfe, 1852) | *Littorina albicans* Metcalfe, 1852 | *Littorina albicans* Metcalfe, 1852 |
| 3  | *L. angulifera* (Lamarck, 1822) | *Littorina angulifera* (Lamarck, 1822) | *Phasianella angulifera* Lamarck, 1822 |
| 4  | *L. ardouiniana* (Heude, 1885) | -                      | -                                              |
| 5  | *L. articulata* (Philippi, 1846) | *Littorina intermedia var. articulata* Philippi, 1846 | *Melarhaphe blanfordi* Dunker, 1871 |
| 6  | *L. bengalensis* Reid, 2001    | -                      | -                                              |
| 7  | *L. carinifera* (Menke, 1830)  | *Littorina carinifera* (Menke, 1830) | -                                              |
| 8  | *L. cingulata cingulata* (Philippi, 1846) | *Littoraria cingulata* (Philippi, 1846) | *Littoraria cingulata* Reid, 1986 |
| 9  | *L. cingulata pristissini* Reid, 1986 | -                      | -                                              |
| 10 | *L. cingulifera* (Dunker, 1845) | *Litorina cingulifera* Dunker, 1845 | -                                              |
| 11 | *L. coccinea* (Gmelin, 1791)   | *Litorina coccinea* (Gmelin, 1791) | -                                              |
| 12 | *L. conica* (Philippi, 1846)   | *Litorina conica* Philippi, 1846 | -                                              |
| 13 | *L. filosa* (Sowerby, 1832)    | *Litorina filosa* G. B. Sowerby I, 1832 | *Litorina filosa* G. B. Sowerby I, 1832 |
| 14 | *L. flava* (King & Broderip, 1832) | *Littorina flava* P. P. King, 1832 | *Littorina flava* P. P. King, 1832 |
|    |                               | *Litorina fasciventris* Boettger, 1891 | *Litorina fasciventris* Boettger, 1891 |
|    |                               | *Melaraphe columna* (d’Orbigny, 1840) | *Melaraphe columna* (d’Orbigny, 1840) |
|    |                               | *Melaraphe columna* (d’Orbigny, 1840) | *Melaraphe columna* (d’Orbigny, 1840) |
| 15 | *L. glabrata* (Philippi, 1846) | -                      | -                                              |
| 16 | *L. ianthostoma* Stuckey & Reid, 2002 | -                      | *Littoraria ianthostoma* Stuckey & Reid, 2002 |
| 17 | *L. intermedia* (Philippi, 1846) | *Litorina ambigua* Philippi, 1848 | *Litorina intermedia* Philippi, 1846 |
|    |                               | *Litorina scabra var. articulata* Philippi, 1847 | *Litorina fraseri* Reeve, 1857 |
|    |                               | *Litorina fraseri* Reeve, 1857 | -                                              |
Littorina intermedia Philippi, 1846
Littorina intermedia var. punctata Philippi, 1846
Littorina newcombi Reeve, 1857
Littorina scabra var. rhodea Biggs, 1958

18 L. irrata (Say, 1822) Turbo irratus Say, 1822
Litorina irrata (Say, 1822)

19 L. lutea (Philippi, 1847) -
Litorina luteola Quoy & Gaimard, 1833

20 L. luteola (Quoy & Gaimard, 1833) -
Litorina filosa var. subcingulata Nevill, 1885
Litorina luteola Quoy & Gaimard, 1833

21 L. mauritiana (Lamarck, 1822) -
Litorina mauritiana (Lamarck, 1822)
Phasianella vitrea Deshayes, 1863

22 L. melanostoma (Gray, 1839) -
Litorina melanostoma Gray, 1839
Litorina melanostoma var. articulata Nevill, 1885

23 L. nebulosa (Lamarck, 1822) -
Litorina nebulosa (Lamarck, 1822)

24 L. pallescens (Philippi, 1846) -
Litorina pallescens Philippi, 1846
Litorina pallescens var. subcingulata Nevill, 1885

25 L. philippiana (Reeve, 1857) -
Litorina philippiana Martens, 1900
Litorina philippiana Reeve, 1857

26 L. pintado pintado (Wood, 1828) -
Litoraria pintado (Wood, 1828)
Litoraria pintado (Wood, 1828)
Litoraria pintado pintado (Wood, 1828)
Litorina pullata Carpenter, 1864
Litorina pullata Carpenter, 1864
Litorina schmitti Bartsch & Rehder, 1939

27 L. pintado pullata (Carpenter, 1864) -

28 L. rosewateri Reid, 1999 -
Litoraria rosewateri Reid, 1999

29 L. scabra (Linnaeus, 1758) -
Buccinum lineatum Gmelin, 1791
Helix scabra Linnaeus, 1758
Litorina scabra var. punctata Philippi, 1847
Litorina scabra var. rhæbra Philippi, 1847
Litorina novaehiberniae Lesson, 1831
Litorina pallescens var. erronea Nevill, 1885
Litorina scabra (Linnaeus, 1758)
| No. | Species                          | Author Date                          |
|-----|----------------------------------|--------------------------------------|
| 30  | *L. sinensis* (Philippi, 1847)   | *Melarhaphe scabra* (Linnaeus, 1758) |
|     |                                  | *Littorina sinensis* Philippi, 1847  |
|     |                                  | *Littorina strigata* Lischke, 1871   |
|     |                                  | *Littorina adonis* Yokoyama, 1927    |
| 31  | *L. strigata* (Philippi, 1846)   | *Littorina intermedia* var. *strigata* Philippi, 1846 |
| 32  | *L. subvittata* Reid, 1986       | *Littorina borbonica* Barnard, 1951  |
| 33  | *L. sulculosa* (Philippi, 1846)  | *Littorina sulculosa* Philippi, 1846 |
| 34  | *L. tessellata* (Philippi, 1847) | *Littorina undulata* Reid, 1986      |
| 35  | *L. undulata* (Gray, 1839)      | *Melarhaphe undulata* Gray, 1839     |
|     |                                  | *Littorina undulata* (Gray, 1839)    |
| 36  | *L. varia* (Sowerby, 1832)      | *Littorina variegata* Souleyet, 1852 |
| 37  | *L. variegata* (Souleyet, 1852)  | *Littorina variegata* Souleyet, 1852 |
| 38  | *L. vespacea* Reid, 1986        | *Littoraria pulchra* Gray, 1833      |
|     |                                  | *Littoraria pulchra* G. B. Sowerby I, 1832 |
| 39  | *L. zebra* (Donovan, 1825)      | *Littorina zebra* (Donovan, 1825)    |
|     |                                  | *Turbo zebra* Donovan, 1825          |
Table 3. Bioindicator studies of *Littorina* species (mollusks: gastropods).

| The Purpose of The Studies                                      | Location                                      | The Result of The Studies                                                                 | References |
|----------------------------------------------------------------|-----------------------------------------------|-----------------------------------------------------------------------------------------|------------|
| Consider evidence of the use of heavy metal indicators against *L. littoralis* | Various estuaries and coasts in England       | Gastropod *L. littoralis* is a good indicator of Cd heavy metal contamination             | [109]      |
| Assess *L. littorea* gastropods as an indicator of heavy metal contamination | United Kingdom Estuary                        | *L. littorea* is still far away as an ideal bioindicator of heavy metal contamination in estuaries and coastal waters | [110]      |
| Evaluation of biomonitoring tributyltin (TBT))                  | Along the North Sea coast of East Frissier between Emden and Cuxhaven | Changes in the pallial (intersex) channel at *L. littorea* are a response to TBT pollution | [111]      |
| Test the application of the *L. littorea* intersex phenomenon for monitoring the biological effects of TBT pollution | German coastline                              | The intersex phenomenon in *L. littorea* can be used as a monitoring of the biological effects of TBT pollution | [112]      |
| Monitor pollution of TBT using intersex *L. littorea*           | Waters of Cork Harbor, Ireland                | *L. littorea* can be used as a bioindicator of TBT pollution                              | [113]      |
| Assessing contamination of heavy metals Cd, Pb, Cu and Zn in gastropod *L. brevicula* Philippi and seawater | Korea Onsan Bay                              | *L. brevicula* can be used as a bioindicator for metal pollution in the estuary and coastal regions of Korea | [114]      |
| Ensure the use of *L. brevicula* as biomonitor in the coastal waters of Korea | The waters of the Korean coast                | *L. brevicula* is a good biomonitor for assessing metal pollution                         | [115]      |
| Understand the spatial and temporal effects of oil spills on *L. littorea* gastropods | Ondo State, the Southwestern part of Nigeria  | *L. littorea* can be used as a bioindicator of oil pollution                              | [116]      |
Table 4. Classification of littorinid gastropods by Reid [117].

| Family       | Subfamily     | Genus        | Subgenus   | Estimated Number of Species |
|--------------|---------------|--------------|------------|----------------------------|
| Lacunidae    | Lacuna        | *Lacuna*     |            | 5                          |
|              |               | *Epheria*    |            | 6                          |
|              |               | *Temanella*  |            | 2                          |
|              | Sublacuna     |             |            | 2                          |
|              | Carinolacuna  |             |            | 1                          |
|              | Aquilonaria   |             |            | 1                          |
|              | Mainwaringia  |             |            | 1                          |
|              | Haloconcha    |             |            | 2                          |
| Littorinidae | Bembiciinae   | Bembicum     |            | 3                          |
|              |               | Risellops    |            | 1                          |
|              |               | Peasiella    |            | 5                          |
|              | Littorininae  | Laevilitorina| *Laevilitorina* | 13                         |
|              |               |              | *Corneolitorina* | 3                          |
|              | Macquariella  |             |            | 4                          |
|              | Laevilacunaria| *Laevilacunaria* | 3            |
|              |               |              | *Pellilacunella* | 1                          |
|              | Rufolacuna    |             |            | 1                          |
|              | Rissolittorina|             |            | 1                          |
|              | Pellilitorina |             |            | 2                          |
|              | Littorina     | *Littorina*  | *11*       |
|              |               | *Littoraria* | *9*        |
|              |               | *Littorinopsis* | 8            |
|              |               | *Austrolitorina* | 15          |
|              |               | *Melarhaphe* |            | 3                          |
|              |               | *Fossarilitorina* | 2            |
|              |               | *Algamorda*  |            | 1                          |
|              | Nodilittorina | *Nodilittorina* | 5            |
|              |               | *Echinolitorina* | 1            |
|              | Tectariinae   | Tectarius    | *Tectarius* | 5                          |
|              |               |              | *Cenchritis* | 1                          |
|              | Echinininae   | Echininus    |            | 2                          |
|              |               | Tectinus     |            | 1                          |
|              |               | *Cremnoconchus* | 2            |

*Estimated 18 species [108]
*bEstimated 39 species [118]

In addition, *Littoraria* contributes to the dynamics of food webs in mangroves [70] or rocky substrates, where the presence of *Littoraria* on the surface of mangrove mud and rocks can provide food for macro-organisms and microalgae and other small invertebrates [4].
| No | Species *Littoraria* | Ecological Environment | Distribution Region |
|----|----------------------|------------------------|---------------------|
| 1  | *L. aberrans* (Philippi, 1846) | Mangrove | West Panama |
| 2  | *L. albicans* (Metcalfe, 1852) | Mangrove | Borneo |
| 3  | *L. angulifera* (Lamarck, 1822) | Stone and mangrove | Tropical West and East Atlantic Ocean |
| 4  | *L. arduiniana* (Heude, 1885) | Stone and mangrove | North and West Pacific Ocean |
| 5  | *L. articulata* (Philippi, 1846) | Stone and mangrove | Central Indo Pacific |
| 6  | *L. bengalensis* Reed, 2001 | Mangrove | Indian Ocean |
| 7  | *L. carinifera* (Menke, 1830) | Mangrove | North and East Indo Central Pacific |
| 8  | *L. cingulata cingulata* (Philippi, 1846) | Mangrove | North and West Australia |
| 9  | *L. cingulata pristissini* Reid, 1986 | Mangrove | Shark Bay, Western Australia |
| 10 | *L. cingulifera* (Dunker, 1845) | Stone and mangrove | West Africa |
| 11 | *L. cocinea* (Gmelin, 1791) | Stone and mangrove | Pasific Ocean |
| 12 | *L. conica* (Philippi, 1846) | Mangrove | Central Indo Pacific |
| 13 | *L. filosa* (Sowerby, 1832) | Mangrove | North Australia |
| 14 | *L. flavia* (King & Broderip, 1832) | Stone and mangrove | West of the Atlantic Ocean |
| 15 | *L. glabrata* (Philippi, 1846) | Stone and mangrove | Indian Ocean |
| 16 | *L. ianthostoma* Stuckey & Reid, 2002 | Mangrove | Joseph Bonaparte Bay, North Australia |
| 17 | *L. intermedia* (Philippi, 1846) | Stone and mangrove | Indo Pasific |
| 18 | *L. irritora* (Say, 1822) | Mangrove | South and East of the United States |
| 19 | *L. lutea* (Philippi, 1847) | Mangrove | West of the Pacific Ocean |
| 20 | *L. luteola* (Quoy & Gaimard, 1833) | Mangrove | East Australia |
| 21 | *L. mauritiana* (Lamarck, 1822) | Stone and mangrove | West of the Indian Ocean |
| 22 | *L. melanostoma* (Gray, 1839) | Mangrove | Central Indo Pacific |
| 23 | *L. nebulosa* (Lamarck, 1822) | Stone and mangrove | West of the Atlantic Ocean |
| 24 | *L. pallescens* (Philippi, 1846) | Mangrove | Indo Pasific |
| 25 | *L. philippiana* (Reeve, 1857) | Mangrove | North and East Australia |
| 26 | *L. pintado pintado* (Wood, 1828) | Stone and mangrove | Indo Pasific |
| 27 | *L. pintado pullata* (Carpenter, 1864) | Mangrove | East of the Pacific Ocean |
| 28 | *L. rosewateri* Reid, 1999 | Stone and mangrove | East of the Pacific Ocean |
| 29 | *L. scabra* (Linnaeus, 1758) | Stone and mangrove | Indo Pasific |
| 30 | *L. sinensis* (Philippi, 1847) | Mangrove | North and West Pacific Ocean |
| 31 | *L. strigata* (Philippi, 1846) | Mangrove | Central Indo Pacific |
| 32 | *L. subvittata* Reid, 1986 | Mangrove | West of the Indian Ocean |
| 33 | *L. sulcifera* (Philippi, 1846) | Mangrove | North and West Australia |
| 34 | *L. tessellata* (Philippi, 1847) | Mangrove | Caribbean Sea |
| 35 | *L. undulata* (Gray, 1839) | Stone and mangrove | Indo Pasific |
| 36 | *L. varia* (Sowerby, 1832) | Mangrove | East of the Pacific Ocean |
| 37 | *L. variegata* (Souleyet, 1852) | Stone and mangrove | East of the Pacific Ocean |
| 38 | *L. vespea* Reid, 1986 | Stone and mangrove | Central Indo Pacific |
| 39 | *L. zebra* (Donovan, 1825) | Mangrove | East of the Pacific Ocean |

[^1]: [1]
[^2]: [118]
3.8. Representing ecological changes caused by the influence of human pressure
[140] study show that the presence of *L. scabra* in non-polluted areas has a greater total weight, length and width of the shell compared to the polluted area. Likewise, the density is lower in polluted areas when compared to non-polluted areas.

3.9. A study of climate change has been carried out
[141] examined the variable environment temperature of *L. scabra* related to climate change and showed that the maximum limit of environmental temperature that could be tolerated by *L. scabra* only reached 33.40ºC, then they showed better-locating behavior if the temperature exceeded 33.40ºC.

3.10. Easy to observe, appear for a long time and form groups with many individuals
The *Littoraria* lifestyle tends to move up and down mangrove trees or perpendicular to the coastline [137]. To move down the mangrove tree, *L. scabra* requires a slower time than upward [70], so they are very easy to observe and appear for a long time. In addition, *Littoraria* is the only arboreal gastropod most abundant in the intertidal region [126] and its dispersal pattern forms groups with many individuals [142]. This statement is also supported by [143] that gastropods live in groups.

3.11. Important socially, economically and culturally
*Littoraria* can be considered economically important because it has the properties of grazers that affect the density of algae and barnacles. [144] states that Littorinidae density is a key factor in barnacle population dynamics, where barnacles are often a serious problem for a building that is affixed (eg dock/port pole) which can damage and shorten the life of a building [145].

4. Conclusion
Changes and sensitivities of *Littoraria* in coastal areas, especially mangrove ecosystems, can cause them to be used as species or groups of bioindicator species. This is because they have fulfilled the requirements that must be fulfilled by an organism to be used in biomonitoring programs, although their response to represent other species or groups of species is unclear.

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