

PAPER • OPEN ACCESS

Diversity of freshwater shrimp (decapoda) from bandealit rivers meru betiri national park, East Java, Indonesia

To cite this article: V E Susilo *et al* 2020 *J. Phys.: Conf. Ser.* **1465** 012009

View the [article online](#) for updates and enhancements.

You may also like

- [Quality Profiles of the Traditional Shrimp Paste of Lombok](#)
B R Handayani, Zainuri, M D Ariyana et al.
- [Production of dried shrimp mixed with turmeric and salt by Spouted Bed technique enter the rectangular chamber.](#)
P Thanthong, Y Mustafa and D Ngamrunroj
- [Strategy to re-utilization shrimp resources in the Arafura Sea](#)
Y D Sari, R Triyanti, A Zamroni et al.



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Diversity of freshwater shrimp (decapoda) from bandealit rivers meru betiri national park, East Java, Indonesia

V E Susilo¹, Suratno¹, N Fadillah¹, E Narulita¹, and D Wowor²

¹Biology Education, Faculty of Teacher Training and Education, University of Jember
Kalimantan Road No. 37 Tegalboto Campus, Jember 68121

²Division of Zoology, Research Center for Biology, Indonesian Institute of Sciences (LIPI), Jalan Raya Jakarta-Bogor Km 46, Cibinong 16911, Indonesia.

Email: vendieko29.fkip@unej.ac.id

Abstract: Freshwater ecosystems are habitat for macroinvertebrate, fish and reptile groups. One of the macroinvertebrates that can be found in freshwater habitat is shrimp which belongs to the class of Crustaceae, order of Decapoda. This study aims to determine diversity and the abiotic conditions of freshwater shrimp habitat. Determination of sampling locations was done by purposive sampling based on the habitat type of freshwater shrimp and followed by road sampling that takes the straight path from the designated sampling location. The tools used to catch freshwater shrimp are traps and tray nett. The results obtained in the Bandealit river of Meru Betiri National Park were five species of freshwater shrimp consisting of 2 families. The diversity index of freshwater shrimp in the Bandealit river was classified as moderate by the analysis of diversity index. Meru Betiri National Park has ideal abiotic conditions for freshwater shrimp life.

1. Introduction

Indonesia has a diversity of ecosystems consisting of terrestrial and aquatic ecosystems. Aquatic ecosystems were divided into two distinct ecosystem, namely freshwater and salt waters based on its obvious difference that saltwater contain salt. Freshwater ecosystems consist of rivers, lakes, reservoirs, which mainly have environmental characteristics that were dominated by waters, have temperature changes that are not too extreme, lack of light penetration, and were affected by climate and weather. The quality of freshwater ecosystems has a greater risk of disturbance compared to other ecosystems caused by the presence of pollutants and invasive species, which can cause changes in the pattern of conditions and characteristics of freshwater ecosystems. This can alter extinction into the fauna of freshwater ecosystems [1].

Freshwater ecosystems are main habitat for groups of macroinvertebrate, fish and reptile. One of the macroinvertebrates that can be found in freshwater waters ecosystems is shrimp which is included in the class of Crustaceae, Order of Decapoda [2]. The river was a form of freshwater ecosystem that being used as a residence or habitat of various organisms [3]. The water quality in the upstream area of the river is very influential to its downstream. If the upstream area has poor water quality, it can be ascertained that the condition of the downstream water will be worse. One way to assess the water quality of the rivers is to study the presence of macroinvertebrates living in those river area [4].

Macroinvertebrates are fauna without a backbone that can be seen with the naked eye, found in freshwater area and commonly belong from the group of crustaceae. Shrimp is one of the



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

macroinvertebrate groups that has a fairly wide distribution and diversity in Indo-Malaya [5]. Crustaceae is a macroinvertebrate that has a fairly high diversity reaching up to 40,000-60,000 species [6]. The spread of freshwater shrimp starting from Sundaland (Kalimantan, Java and Sumatra) and the island of Sulawesi consisting of the Palaemonidae and Atyidae families [7], [8].

The freshwater shrimp from Genus *Caridina* has been recorded as many as 54 species and 34 species among them are endemic species of Indonesia [9]. Shrimp is a type of macroinvertebrate that indicate the quality or the balance of a freshwater ecosystem. This was stated by [10] and [11] that measuring the presence of certain macroinvertebrates can be used as a very important source of information about water quality of the river.

Freshwater shrimp is one of the invertebrates that inhabit the tropical freshwaters and its presence has an important role in the trophic structure and nutrient cycling [12], [13],[14],[15]. Freshwater shrimp species have a very broad distribution pattern. This has implications for the existence and process of adaptation to the existing environment. Changes in environment condition at different habitats can cause bodily responses which result in variations at the species level [16]. Morphological variations occur due to the adaptation to diverse environmental conditions [17]. Freshwater shrimp inhabit all waters from swamps, lakes, to watersheds [18]. The data on freshwater fauna, especially crustaceans, is not yet available in Meru Betiri National Park. This is the basis for an inventory and identification of freshwater shrimp in various habitat types that exist in the Bandealit river of Meru Betiri National Park.

2. Materials and Methods

2.1 Sampling points

This research was conducted in the rivers of the Meru Betiri National Park, Jember Regency, East Java Province, Indonesia. which was divided based on the preference of habitats that are around the river (settlements, monoculture forests, primary forests, secondary forests, and coastal forests). The shrimp samples were obtained from 6 rivers consists of L1 : Settlement location, L2 : Monoculture Forest Location, L3 : Secondary Forest Location, L4 : Primary Forest 1 Location, L5 : Primary Forest 2 Location, L6 : Location of Coastal Forest. (Figure 1).

2.2 Sampling techniques

The sampling was conducted on Mei 2019. Sampling is done by conducting direct observations by taking all shrimp samples along the river of the Meru Betiri National Park with reference to differences in their habitat. Determination of the sampling site is done by purposive sampling, then proceed with road sampling [19], 200 meters long for each sampling site. The tools used to catch freshwater crabs in the water using tray net (40 x 60 cm) and trap (bubu). The tray net and trap were used to help facilitate the collection of shrimp with shifted it to the edge so that the shrimp in front of it entered the net. Catching by using traps was conducted by inserting bait then putting it in water till overnight. Several types of shrimp were located behind the rocks, so that the shrimp can only be harvested by hand. Sampling was carried out in stages, started at 06.00-17.00 WIB.

The abiotic factors measured were water velocity, water temperature, pH, Depth and substrat. The tools used in this research are tray net, trap (bubu), jar, container box, pH-Meter, GPS Garmin montana 860, thermometer, thermohygrometer, current meter, lux meter, stopwatch, Canon 600D DSLR camera, aquarium, tracing paper, label paper, 70% ethanol, clip plastic and aquadest.

2.3 Shrimp Identification

The identification of freshwater shrimp samples was carried out at the Zoology Laboratory of Biology Education, Jember University and verification of shrimp samples was carried out at the LIPI Cibinong Biology Laboratory, Bogor. Samples that have been preserved in a jar are placed in a Petri dish and then observed using a stereo microscope. These identification refers to [5][8] based on the shape and morphological characteristics at the species level of the genus *Macrobrachium* starting from observing

its body size, there are interior orbital shapes in the lower part of the carapace eye, number of rostrum teeth, second pereopod size, and the presence of preanal carina in the endopod section. Morphological characteristics at the species level of the genus *Caridina* are relatively small body size, the tip of the rostrum to the tip of the schapocerite, the rostrum teeth are spread evenly, the shape of the rostrum is flat. The remaining doubtful species of freshwater shrimps were taken to LIPI Cibinong Bogor for re-identification.



Figure 1. The point of sampling location at the Bandalit Resort.

2.4 Sampling techniques

The sampling was conducted on Mei 2019. Sampling is done by conducting direct observations by taking all shrimp samples along the river of the Meru Betiri National Park with reference to differences in their habitat. Determination of the sampling site is done by purposive sampling, then proceed with road sampling [19], 200 meters long for each sampling site. The tools used to catch freshwater crabs in the water using tray net (40 x 60 cm) and trap (bubu). The tray net and trap were used to help facilitate the collection of shrimp with shifted it to the edge so that the shrimp in front of it entered the net. Catching by using traps was conducted by inserting bait then putting it in water till overnight. Several types of shrimp were located behind the rocks, so that the shrimp can only be harvested by hand. Sampling was carried out in stages, started at 06.00-17.00 WIB.

The abiotic factors measured were water velocity, water temperature, pH, Depth and substrat. The tools used in this research are tray net, trap (bubu), jar, container box, pH-Meter, GPS Garmin montana 860, thermometer, thermohygrometer, current meter, lux meter, stopwatch, Canon 600D DSLR camera, aquarium, tracing paper, label paper, 70% ethanol, clip plastic and aquadest.

2.5 Shrimp Identification

The identification of freshwater shrimp samples was carried out at the Zoology Laboratory of Biology Education, Jember University and verification of shrimp samples was carried out at the LIPI Cibinong Biology Laboratory, Bogor. Samples that have been preserved in a jar are placed in a Petri dish and then observed using a stereo microscope. These identification refers to [5][8] based on the shape and morphological characteristics at the species level of the genus *Macrobrachium* starting from observing its body size, there are interior orbital shapes in the lower part of the carapace eye, number of rostrum teeth, second peripod size, and the presence of preanal carina in the endopod section. Morphological characteristics at the species level of the genus *Caridina* are relatively small body size, the tip of the rostrum to the tip of the schapocerite, the rostrum teeth are spread evenly, the shape of the rostrum is flat. The remaining doubtful species of freshwater shrimps were taken to LIPI Cibinong Bogor for re-identification.

2.6 Diversity Index Calculation

Shrimp diversity data can be calculated using mean and percentages per time period and the diversity index was calculated using the Shannon-Wiener diversity index (H') [20]. The diversity can be calculated using the Shannon-Wiener index. Analysis of species diversity index according to Shannon and Wiener is as follows:

$$H' = -\sum p_i \ln p_i \quad p_i = \frac{n_i}{N}$$

Information :

H' = Shannon-Wiener diversity index

n_i = Number of species per plot (importance value for each species)

N = Total number of types (total importance)

p_i = Opportunity of interests for each type of N_i/N

N = Number of species

Diversity index criteria include:

$H' > 3,0$: represents high diversity

$1 < H' < 3$: moderate diversity

$H' < 1$: low diversity

3. Results And Discussion

3.1 Results

Based on the morphology identification, 5 species freshwater shrimp was found in the 5 habitats of the Bandalit Resort. These freshwater shrimp species are belong to the order of decapoda, consisting of 2 families, 2 genera and 5 species of freshwater shrimp (Table 1.)

Table 1. Results of freshwater shrimp species identification in the Bandalit river

Order	Family	Genus	Species
Decapoda	Palaemonidae	<i>Macrobrachium</i>	<i>Macrobrachium latydactylus</i> (Thallwitz, 1891)
			<i>Macrobrachium lar</i> (JC Fabricius, 1798)
			<i>Palaemon carinus</i> (Linnaeus, 1758)
	Atyidae	<i>Caridina</i>	<i>Caridina serratiostris</i> (De Man, 1892)
			<i>Caridina brachydactyla</i> (De Man, 1908)

Above table shows that the freshwater shrimp species belonging to the Palaemonidae family are these 3 species, *Macrobrachium latydactylus*, *Macrobrachium lar* and *Palaemon carinus*. While two freshwater shrimp species belonging to the Atyidae family, order of Caridina are 2 species *Caridina serratiostris* and *Caridina brachydactyla*.

3.1.1 *Macrobrachium latydactylus* (Thallwitz, 1891)

Macrobrachium latydactylus is a type of freshwater shrimp found in settlement habitat types, monoculture forests and primary forests 1. *M. latydactylus* has morphological characteristics in the form of an interior orbital shape at the end of the carapace at the bottom of the eye. Little sharp *Ocular beak* were under the rostrum and has epistome located at the base of the antenna. Rough or slippery abdominal pleuron and abdominal sternite are found in pleopod sections 1, 2, and 3. It does not have preanal carina and the second periopod has a different shape and size.

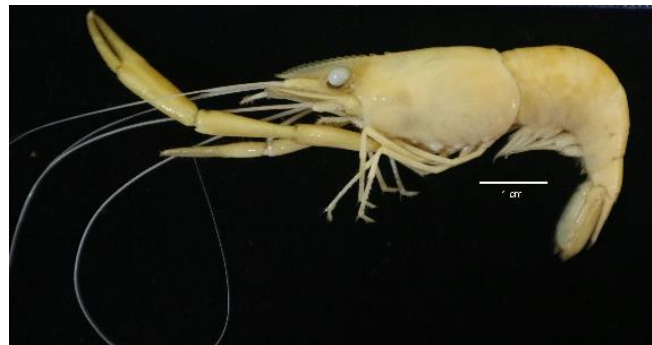


Figure 2. *Macrobrachium latydactylus*.

3.1.2 *Macrobrachium Lar* (J. C. Fabricius, 1798)

Macrobrachium lar is a type of freshwater shrimp found in primary forest area 2, found on rocks type habitat a muddy and sandy substrate. *Macrobrachium lar* has morphological characters, such as a rounded orbital interior shape and ocular beak. This shrimp epistome and thoracic sternite are round shaped. Abdominal pleuron is slippery, whereas females do not have slippery abdominal sternite. Having a thin shaped and tall preanal carina, both periopod have the same size and shape. *Macrobrachium lar*, have two large and tenuous thorn on its upper and lower rostrum, the end of the rostrum does not reach the upper third segment of the pedalcle nor the end of the scapocerite.



Figure 3. *Macrobrachium lar*.

3.1.3 *Palaemon carcinus* (Linnaeus, 1758)

Palaemon carcinus is the only freshwater shrimp species of that can only be found in the coastal forest areas. This species can generally be found in upstream brackish freshwater. The morphological characteristics of this shrimp are the clear white body, with males can be distinguished from female by looking at the fifth periopod on this shrimp that is wide and separate.



Figure 4. *Palaemon carcinus*.

3.1.4 *Caridina serratiostris* (De Man, 1892)

Caridina serratiostris is a freshwater shrimp found in settlement areas and monoculture forest. The morphological character of this shrimp is that there are 5 teeth located behind the eyes, at the tip of the rostrum to the end of the scapocerite. The teeth on the rostrum are spread evenly and the rostrum is flat. Has black, orange, blue and red elements in its body parts.



Figure 5. *Caridina serratiostris*.

3.1.5 *Caridina brachydactyla* (De Man, 1908)

Caridina brachydactyla is a type of freshwater shrimp that can be found in settlement areas, monoculture forests, secondary forests and primary forests 1. The morphological characters of this freshwater shrimp are a long and oval shape of rostrum. There are more than 12 dorsal teeth and 3 rostrum teeth in the back of the eye on its rostrum. It also have thorn at the preanal carina.



Figure 6. *Caridina brachydactyla*.

Based on the results of the freshwater shrimp identification it can be then analyzed using the diversity index (Shannon Wiener). Calculation results can be seen in Table 2.

Table 2. Analysis of Freshwater Shrimp Diversity in Bandalit River

Loc	Species	n	pi	n(n-1)/N(N-1)	ln pi	pi ln pi	H'
L1	<i>Macrobrachium latydactylus</i>	9	0,23	70,105	-1,440	0,341	0,341
	<i>Caridina Serratirostris</i>	2	0,05	1,947	-2,944	0,154	0,154
	<i>Caridina brachydactyla</i>	2	0,05	1,947	-2,944	0,154	0,154
L2	<i>Caridina brachydactyla</i>	4	0,10	11,684	-2,251	0,236	0,236
	<i>Caridina Serratirostris</i>	2	0,05	1,947	-2,944	0,154	0,154
	<i>Macrobrachium latydactylus</i>	2	0,66	1,947	-0,405	0,270	0,270
L3	<i>Caridina brachydactyla</i>	3	0,07	5,842	-2,538	0,200	0,200
L4	<i>Macrobrachium latydactylus</i>	1	0,02	0	-3,637	0,095	0,095
	<i>Caridina brachydactyla</i>	4	0,10	0,947	-2,251	0,236	0,236
L5	<i>Macrobrachium lar</i>	6	0,15	29,210	-3,691	0,582	0,582
L6	<i>Palaemon carcinus</i>	3	0,07	5,842	-2,538	0,200	0,200
	N	38	1,61	131,42	-25,74	2,33	2,33

Based on Table 2, the freshwater shrimp diversity index (Shannon Wiener) in the Bandalit river was 2.33, categorized as the medium category. The sampling point location have different abiotic factors, that can be seen in Table 3 below.

Table 3. Condition of Abiotic Factors at the Sampling Point Location

Location	Water velocity (m / s)	Water temperature (°C)	water pH	Depth (m)	Substrate
L1	0.93	26	7.4	1.3	Rocky, muddy, sandy and riparian by the river
L2	0.41	26	6.7	1.3	Rocky, sandy and riparian
L3	1.1	25	6.9	1.2	Rocky and sandy
L4	0.37	26	6.8	0.4	Big rocky, sandy and on the edge of a muddy river
L5	0.48	27	6.7	0.8	Big rocky, sandy and muddy
L6	0.73	26	7.1	1.4	Muddy, rocky and lots of leaf litter

Information:

- L1 : Settlement location
- L2 : Monoculture Forest Location
- L3 : Secondary Forest Location
- L4 : Primary Forest 1 Location
- L5 : Primary Forest 2 Location
- L6 : Location of Coastal Forest

4. Discussion

Measurement of species diversity can be calculated using the Shannon-Wiener index [8],[20]. The results of the freshwater shrimp diversity index (H') in Bandalit Resort were 2,33. Freshwater shrimp diversity found in Bandalit Resort was classified as moderate. Species diversity can be used to measure the ability of a community to maintain their stability against the changes of ecosystem or interference with other ecological components. The characteristics of freshwater shrimp that are found in Indonesia are very diverse from the *Palaemonidae*, *Atyidae* and *Alpheidae* families [21].

Freshwater shrimp diversity in the Bandalit Resort exists in different habitat types ranging from primary forests, secondary forests, monoculture forests, mountains, coastal forests and settlement

areas. Each type of habitat have freshwater ecosystem in form of the rivers. Meru Betiri National Park (TNMB) has many rivers that are types of habitat for various freshwater shrimps..

Shrimp diversity at the Bandalit resort can be said that the Bandalit river is still natural and less polluted by chemicals or waste. Bandalit River has water pH range of 6,7 -7.5. The optimum pH for freshwater shrimp ranges from 6,5 to 8.5 [22]. The water pH greatly affects the biochemical processes of freshwater ecosystem. Bandalit River has the lowest pH level of 6,7 which is located in primary forest 2, while the highest pH level is 7.4 in a settlement area.

The rivers water temperature is a limiting factor for some aquatic organisms [23],[24]. Water temperature affects the distribution of aquatic organisms in these watersheds [25]. Freshwater shrimp have a good range toleration of water temperature, ranging from 28 to 31 °C. The lowest water temperature in the Bandalit river was 25 °C located in the secondary forest area, while the highest temperature was 27 °C, located in primary forest 2.

Water velocity is very important to be observed because it is a limiting factor for the presence of some freshwater organisms [23]. Water velocity fluctuates (0,09 -1.40 m/sec) which is slowing downstream. The gravity factor, the width of the river and the material carried by the water make the greater velocity of the upstream. Water velocity in the upstream, middle and downstream are 0.58 - 1.40 m/s, 0.13 m/s - 1.0 m/s and 0.09 - 0.27 m/s, respectively. *Macrobrachium* shrimps is the freshwater shrimp that can inhabit a faster flowing current and take shelter in rocks, while the types of shrimp that inhabit a calm streams and take shelter in riparians are the Atyidae and Caridina groups. The lowest water velocity in the Bandalit river was observed at 0.37 m / s in the primary forest area 1, while the heaviest current velocity was observed at 1.1 m / s in the secondary forest area. Shrimp distribution has a different pattern between types (Table 3). *Macrobrachium latidactylus*, *Caridina brachydactyla* can be found in all habitat type from lowland until highland. The distribution on both species influenced by the ability migration to various location. It means they have ability to adaptation for various ecological condition and have large home range and territory. *Caridina serratiostris* only found in 2 location (L1 and L2) that have mix ecological condition that influence by human activity such as plantation and household activities. They can't migration to habitat type that more higher. *Macrobrachium lar* have special conditions because they can only in primary forest that have pure or natural condition. *M. Lar* have specific home range because they can only found be alone which distinguishes from other types found in one community or one habitat type. *Palaemon carcinus* can only be found in coastal habitat, because they specific estuary habitat that can not migration to pure freshwater.

5. Conclusion

Freshwater shrimp diversity in the Bandalit Resort river shows that there are 5 species of freshwater shrimp in the Bandalit river. Freshwater shrimp consists of 5 species, 2 families and 2 genera. Where the species obtained include *Macrobrachium latidactylus*, *Macrobrachium lar*, *Caridina serratiostris*, *Caridina brachydactyla* and *Palaemon carcinus*. The total diversity index (H') of freshwater shrimps from all habitat types reaches 2,33 so that it can be said that the diversity of freshwater shrimp in the Bandalite river is classified as moderate.

Acknowledgement

This project is supported by Dosen Pemula Scheme 2019 from University of Jember, Indonesia

References

- [1] Revenga C, I. Campbell, R. Abell, P. de Villiers and M. Bryer 2005 Prospects for monitoring freshwater ecosystems towards the 2010 targets *Phil. Trans. R. Soc B* 360, 397–413
- [2] Wowor D, Muthu V, Meier R, Balke M, Cai Y, (2009) Evolution of life history traits in Asian freshwater prawns of the genus *Macrobrachium* (Crustacea: Decapoda: Palaemonidae) based on multilocus molecular phylogenetic analysis *Molecular Phylogenetics and Evolution*. 52(1): 340–350 doi:10.1016/j.ympev.2009.01.002

- [3] Vannote, R. L., G W Minshall, K W Cummins, J R Sedell, C E Chusing 1980. The River Continuum Concept. *Can. J. Fish. Aquat. Sci*
- [4] Panjaitan, Poltak, Wardoyo, Eko Supriyono, Rodiana, Sofian 2011 Water Quality Monitoring in the Upper Cisadane River Using Macroinvertebrate Indicators *Jurnal Sains Natural Universitas Nusa Bangsa*. 1 (1) 58-72
- [5] Ng, PKL 2004 Crustacea: Decapoda, Brachyura Freshwater invertebrates of the Malaysian Region eds C M Yule and H-S Yong (*Kuala Lumpur Academy of Sciences Malaysia*) pp 311–336
- [6] Giribet G, Edgecombe G D 2012 Reevaluating the arthropod tree of life *Annu, Rev, Entomol* 57: 167-186
- [7] Holthuis L B 1980 Shrimps and prawns of the world: An annotated catalogue of species of interest to fisheries. *FAO Fisheries Synopsis*. 125 (1)
- [8] Chan T Y 1998 Shrimps and prawns FAO species identification guide for fishery purposes *The living marine resources of the Western Central Pacific* 2. 851-972
- [9] Annawaty, Wowor D 2015 The atyid shrimps from Lake Lindu Central Sulawesi Indonesia with description of two new species (Crustacea: Decapoda: Caridea) *Zootaxa*. 3957(5):501-519
- [10] Purwati U S dan I Sutapa 1999 Microbiota Biodiversity in Several Prokasi Rivers *Jurnal Studi Pembangunan, Lingkungan & Kemasyarakatan*. 1 (3) 12-24
- [11] Trihadiningrum Y and I Tjondronegoro 1998 Macroinvertebrates as Bioindicators of Freshwater Body Pollution in Indonesia *Jurnal Lingkungan dan Pembangunan*. 18 (1):80-90
- [12] Pringle CM, Blake GA, Covich AP, Buzby KM, Finley A 1993. Effects of omnivorous shrimp in a montane tropical stream: sediment removal, disturbance of sessile invertebrates and enhancement of understory algal biomass *Oecologia*. 93(1):1–11
- [13] Covich AP, Palmer MA, Crowl TA 1999 The role of benthic invertebrate species in freshwater ecosystems: zoobenthic species influence energy flows and nutrient cycling *BioScience*. 49(2):119–127
- [14] Crowl TA, McDowell WH, Covich AP, Johnson SL 2001 Freshwater shrimp effects on detrital processing and nutrients in a tropical headwater stream *Ecology*. 82(3): 775–783
- [15] Synder MN, Freeman MC, Purucker ST, Pringle CM. 2016 Using occupancy modeling and logistic regression to assess the distribution of shrimp species in lowland streams, Costa Rica: does regional groundwater create favorable habitat *Freshw. Sci*. 35(1): 80–90
- [16] Rossi, Natália, and Fernando Luis Mantelatto 2013 Molecular Analysis of the Freshwater Prawn *Macrobrachium Olfersii* (Decapoda, Palaemonidae) Supports the Existence of a Single Species throughout Its Distribution.” *PLoS. ONE*. 8(1): 1–13
- [17] Yang Z, Ranala B 2010 Bayesian species delimitation using multilocus sequence data *Proceedings of the National Academy of Science of the United States of America*, 107 (20): 9264–9269
- [18] Wowor D, Cai Y, and Ng P K L 2004 Crustacea: Decapoda, Caridea, Freshwater Invertebrata of the Malaysian Region *Department of Biological Sciences National University of Singapore*. 337-357
- [19] Garton E O, Ratti J T and Giudice J H 2005 Research and experimental design Techniques for wildlife investigations and management *Bethesda: The Wildlife Society*. pp 43–71.
- [20] Magurran A E 2004 Measuring Biological Diversity *Blackwell Science Ltd*. United Kingdom.
- [21] De Grave S, Wowor D, Ahyong S and Shy J 2013 *Macrobrachium latidactylus* *The IUCN Redlist of Threatened Species* 2013:e.T197860A2503002.
- [22] Daryanto, Hamidah A, Kartika WD 2015 Diverisity of Freshwater Shrim in Teluk Kota Lake Jambi *Biospecies*. 8: 13–19
- [23] Anglier E 2003 Ecology of streams and river *Science Publishers. Inc*. Enfield & Plymouth
- [24] Cech TV 2005 *Principles of Water Resource: History, Development Management, and Policy* Ed Ke-2. Hoboken: John Wiley & Sons.
- [25] Macan TT. 1978. *Freshwater Ecology*. London: Longman