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The distribution of *Corbicula fluminea* (Muller, 1774) and its outer shell colour in Sabah and Sarawak

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The distribution of *Corbicula fluminea* (Muller, 1774) and its outer shell colour in Sabah and Sarawak

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Abstract. *Corbicula fluminea* is one of the freshwater bivalves, which is small in size and lives in the river or at the bottom of the lake all over Malaysia including Sabah and Sarawak. *Corbicula fluminea* comes in different outer shell colour for different sites. The differences in outer shell colour are believed to be due to substrates composition, and land uses. Thus, to determine the distribution of *Corbicula fluminea* in Sabah and Sarawak and to determine the influence of river substrates and land uses on the outer shell colour of *Corbicula fluminea*, a survey was conducted in the selected area involving Sabah and Sarawak. The method utilized was by obtaining information from the villagers through informal conversational interview, observations, and followed by collecting the samples at the river using a special tool. The coordinate of each place where the sample was taken was recorded using the Garmin model GPSmap 62. Meanwhile, the digital calliper was used to measure shell height (H) and length (L). Statistical analysis of the chi-square test has been used to determine the relationship between the considered categorical variables in this study. Results indicate that the state of Sarawak has an irrigation canal that provides irrigation to the paddy field and one river, namely Sarawak Kanan River, which contains *C. fluminea*. As for Sabah, *C. fluminea* was found in 2 irrigation canals that also provide irrigation to paddy fields and 2 rivers, namely Tempasok River in Kota Belud and Kinarut River in Papar. Meanwhile, from the chi-square test result clearly shows that the outer shell colour of the *C. fluminea* depends on the type of substrate and landuse but not influenced by the location neither by zone nor the area such as urban, suburban or rural at the significant level of 0.05. This data is expected to be used by the authorities responsible for finding the conservation and restoration methods to ensure that *C. fluminea* does not disappear from the state of Sabah and Sarawak. This study could also help to ensure that the source of income for traditional fishermen who depend on *C. fluminea* is not affected.

1. Introduction

Corbicula fluminea (C. fluminea) belongs to the Cyrenidae family and is commonly known as Asian clam or golden freshwater clam [1]. One of the main factors that determine the distribution and abundance of *C. fluminea* is the type of substrate [2, 3] and the best substrate is sand, a mixture of

sand and silt, or a mixture of sand and clay or even just clay. This species can be found in rivers, lakes, ditches, and ponds of freshwater. This species is used for human consumption in some countries, but there are a few countries that treated *C. fluminea* as a pest because it creates a nuisance to the people. In America, for example, the reproductions of *C. fluminea* in large colonies clogged waterways and pipes [4], and this needs a lot of financial costs to be remedied. This species is now considered a problem in America because it has passively dispersed within watersheds by water currents [5, 6]. However, besides the negative angle, *C. fluminea* also has its positive points, for example, the shell can be used for producing lime, and it is also used as a material of traditional Chinese medicine [7].

The *C. fluminea* normally can be found in temperate to tropical southern Asia, western to the eastern Mediterranean region like Africa, except for the Sahara Desert [8]. Its density is influenced by habitat and geographical conditions [9]. It is a filter feeder that can remove particles from the water column and can be found in the sediment surface or slightly buried in the sand. It can reproduce by self-fertilization at different levels and has a low tolerance of cold temperature between 2°C - 30°C. The life span of *C. fluminea* has a positive relationship with the latitudinal gradient, where the populations from higher latitudes have slower growth. This is because it is reflecting a slower metabolism and a longer life span. This type of relationship has been described for other mollusk species, including freshwater bivalves. Furthermore, the availability of food may be impaired at higher latitudes due to shorter sunlight periods [10]. This species can live about one to seven years and their life cycle and reproductive stage are related in a broad ecological spectrum [8]. However, the populations of *C. fluminea* seem to be negatively affected by the combination of hypoxia and high temperatures. The species shows a clear preference for well-oxygenated sandy substrates. Despite being usually described as a freshwater bivalve, it can tolerate salinities up to 10-14 ppm, allowing the species to colonize the upstream areas of estuaries [10].

According to [17], the only freshwater mussels found in Sabah are *Ctenodesma borneensis, Schepmania nieuwenhuisi, Schepmania parcesculpta, and Sinannodonta woodiana*. On the other hand, in Sarawak, *Ctenodesma borneensis, Pseudodon crassus, Pseudodon walpolei, Rectidens sumatrensis,* and *Sinanodonta woodiana* were recorded. Therefore, the report on distributions and the consumption of *C.fluminae* in Sabah and Sarawak is scarce. It is might also due to its small distribution as well as its small size, which is not suitable to be consumed as food or side dishes. Nevertheless, it is believed that some villagers have harvested it for their side dishes. Thus, to obtain information on the distribution of *C. fluminea* in the state of Sabah and Sarawak, this survey was conducted. Besides that, it is believed that the substrate compositions and land uses can influence the colour of outer shell *C. fluminae*. Therefore, this study was also conducted to determine the influence of those factors on the outer shell colour of *C. fluminea*.

2. Materials and Methods

Since Sabah and Sarawak is two states of Malaysia and covered a large area, the survey was only focusing on five districts in Sabah (Kota Belud, Papar, Putatan, Ranau, and Tuaran) and eight districts in Sarawak (Kuching, Bau, Lundu, Kota Samarahan, Asajaya, Simunjan, Serian, and Tebedu) (Figure 1). The study began with a desktop analysis by gathering all information related to rivers which are available in every division and district. The next step was utilizing informal conversational interviews with the local community to get information on the places where *C. fluminea* can be found as well as carrying out observations. The observation was carried out to assess the sign of *C. fluminea* shell on the river sandy bed or on the riverbank to get information on the existence of *C. fluminea* in any specific area. Finally, the physical or insitu sampling was conducted at a predetermined 100m river reach of each station where three sampling lines were identified, consisting of the left, middle and right bank. There was no fixed duration or period time for data collections because this study is just conducted to determine the distribution of *C. fluminea* in the selected divisions in Sabah and Sarawak.

A special scoop was used to collect the C. fluminea sample consists of a bucket made from an iron bar of about 1 cm in diameter with 1 – 2 meter round woody handle (Figure 2). The iron rod is woven into a net with an opening size of less than 1 cm to allow C. fluminea larger than 1 cm to be trapped in

the bucket and avoid sand from coming in. Global Positioning System (GPS) was used to record the coordinate of each place where C. fluminea was found. The shell height (H) and length (L) of collected samples were measured using a digital calliper. This data was used to identify the sample based on shell characters published by [18] (Table 1). Substrate streams were collected using the Ekman Grab Sampler to identify substrate types for individual rivers that were found to have C. fluminea. All of this information and GIS data were used to portray the distribution information in the form of maps by using ArcGis.

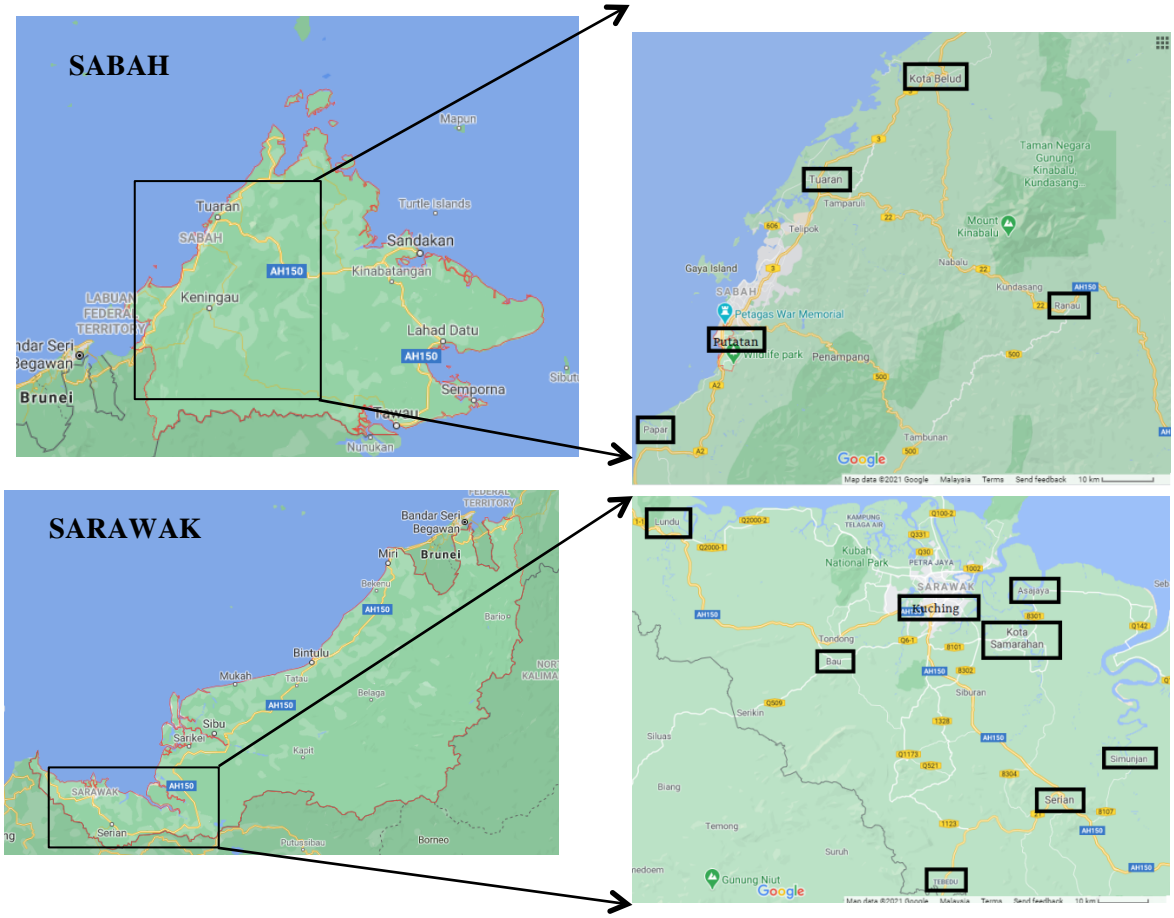

Figure 1. Study area maps (source: Google maps)

Table 1. Shell characters of *Corbicula fluminea*.

Shell Characters	
Form	Round and broad form
Concentric ridges	More widely spaced and coarser
Length	Average maximum values of 30-40 mm
Height	Always lower than the length
Asymmetry	Asymmetrical shell
Umbo	Slightly protruded; does not match the middle vertical axis
Lateral teeth	Reach mid-height
Teeth	Clearly serrated lateral teeth
Colour	With a whitish inner surface

Figure 2. Special sampler for *C. fluminea*.

Chi-square test of independence was used to determine if there is a significant relationship between two nominal (categorical) variables. The frequency of each category for one nominal variable is compared across the categories of the second nominal variable through two by two contingency tables. This approach consists of four steps: (1) state the hypotheses, (2) formulate an analysis plan, (3) analyze sample data, and (4) interpret results. The hypothesis of this test is listed:

Ho: Variable A and Variable B are independent.
Ha: Variable A and Variable B are not independent.

The test statistic is a chi-square random variable (X^2) defined by the following equation.

$$X^2 = \Sigma \left[(O_{r,c} - E_{r,c})^2 / E_{r,c} \right]$$

where $O_{r,c}$ is an observation frequency count for level r of Variable A and level c of Variable B, $E_{r,c}$ denoted as ($E_{r,c} = (n_r * n_c) /n$) is the expected frequency count for level r of Variable A and level c of Variable B, n_r is the total number of sample observations at level r of Variable A, n_c is the total number of sample observations at level c of Variable B, and n is the total sample size. This test was automatically computed by using statistical software.

3. Results and Discussion

All collected samples have a height that is lower than the length, with round and broad form and whitish inner shell colour, which is an indication of the *Corbicula fluminea* species. The results indicate that out of 5 districts surveyed in the West Coast Division of Sabah, there are only two districts namely Kota Belud and Papar which have *C. fluminea*, but the numbers were so small and not economical to be harvested. The places where *C. fluminea* was found and collected in Kota Belud were Sg. Tempasok is located in Kg. Timbang Dayang, and one irrigation canal located in Kg. Jawi Jawi. Similarly, in Papar, *C. fluminea* was found and collected in one river which is Kinarut River and one irrigation canal in Kg. Suok Rampazan. Meanwhile, Putatan, Ranau, and Tuaran did not record any existence of *C. fluminea*. The rivers found in these two areas may be of rapids water and have many cobbles and boulders and lacking food which is not suitable for *C. fluminea* habitat. This is because [19] reported that, *C. fluminea* densities within a waterbody would depend on a suitable substrate and food availability. The breakdown of the number of places and regions are Kota Belud, and Papar, which recorded 2 places, respectively (Figure 3). On the other hand, out of 3 divisions and 9 districts in Sarawak where the survey was done, only one irrigation canal was located in Kg. Payang, Siburan, Padawan, and one river, namely Sg. Sarawak is located in Kg. Buso, Bau has recorded the existence of *C. fluminea*.

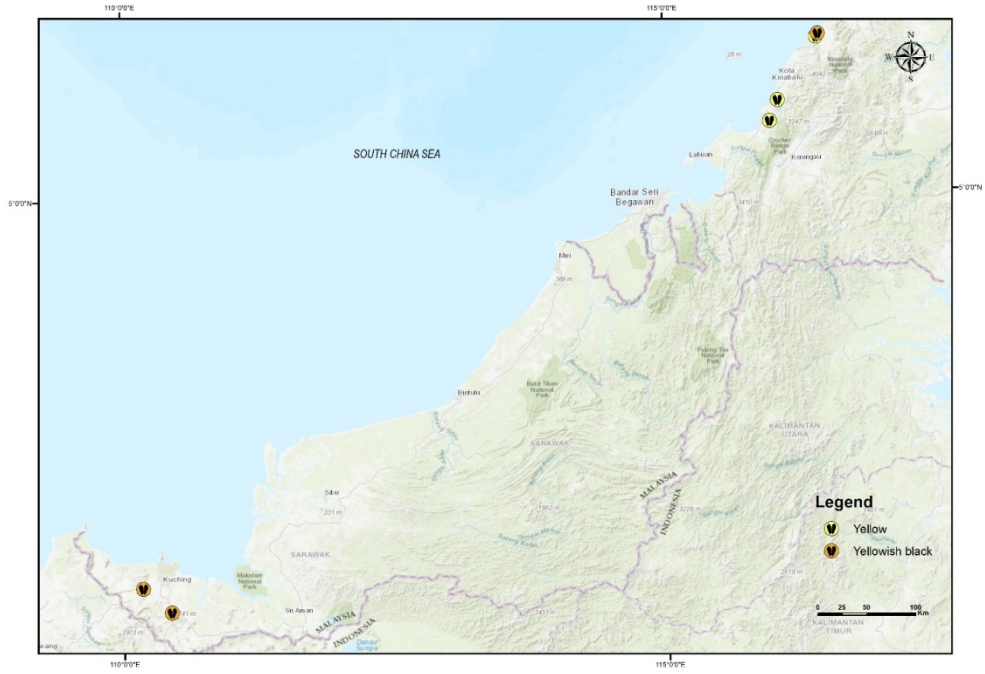

Figure 3. Distribution of *C. fluminea* in Sabah and Sarawak.

Based on the data obtained, it can be suggested that rivers with soft clay or muddy substrates produce yellowish black colour *C. fluminea* and sandy substrates rives produce either yellow or golden colour *C. fluminea*. Usually, the food for *C. fluminea* is in organic matter or nutrients that can be found in the water column or sediment. This organic matter usually stems from the runoff, bringing together fertilizer waste used for the cultivation of rice or other agricultural plants such as rubber and oil palm. This organic matter [20, 21] can also come from sewage or animal waste (in small quantities). However, the large amount of sewage and waste of this livestock will cause water pollution, which will eventually lead to the death of *C. fluminea*. Based on the data obtained, the sites where *C. fluminea* was recorded, are located in the paddy fields and village where they have planted orchards trees. This data is in line with the information which indicates that organic matter is the food for *C. fluminea*. This is because the above-mentioned land uses have all produced organic matter or nutrients that are carried along with the surface runoff into the river and deposited in the river sediment.

Table 2 presents the distributions of *C. fluminea* in Sabah and Sarawak with the information of land use, type of substrates and, outer shell colour. *C. fluminea,* which was collected from irrigation canal has a soft clay substrate and is yellowish black in colour, while, in the sandy substrate sample, it possesses a yellow outer shell colour respectively. On the other hand, for Sungai Sarawak Kanan which has a mixture of sand and silt substrate, the outer shell colour of its *C. fluminea* has turned to be yellowish black as well. *C. fluminea,* which was collected from rivers flowing through village and orchards area with sandy substrates has indicated the presence of the yellow outer shell colour *C. fluminea*.

Based on the distribution data in Table 2, four categorical variables have been developed for further investigation using the Chi-Square test. The variables are Location, Substrate, Landuse, and Outer shell colour. In this analysis, the association between the first three variables with the variable of outer shell colour was being compared and studied. The chi-square test's results clearly shows that the outer shell clour of the *C. fluminea* depends on the type of substrate and landuse but not influenced by the location such as urban, suburban, or rural at the significant level of 0.1.

Table 2. The distribution and outer shell colour of *Corbicula fluminea* (Muller, 1774) in Sabah and Sarawak.

No.	State	Location	Latitude	Longitude	Substrate	Landuse	Outer Shell Colour
1.	Sarawak	Irrigation Canal, Kg. Payang, Siburan, Padawan, Sarawak	1.243341	110.434749	Soft clay	Paddy field	Yellowish black
2.	Sarawak	Sg. Sarawak Kanan, Kg. Buso, Bau, Sarawak	1.461278	110.172003	Sandy & Silt	Forest	Yellowish black
3.	Sabah	Sg. Tempasok, Kg. Timbang Dayang, Kota Belud.	6.379388	116.413865	Sandy	Village & Paddy field	Yellow
4.	Sabah	Irrigation Canal, Kg. Jawi Jawi, Kota Belud.	6.406251	116.432046	Soft clay	Paddy field	Yellowish black
5.	Sabah	Sg. Kinarut, Papar.	5.819559	116.046532	Sandy	Orchard & Village	Yellow
6.	Sabah	Irrigation Canal, Kg. Suok Rampazan, Papar.	5.634613	115.969489	Sandy	Paddy field	Yellow

4. Conclusion

In conclusion, there are still 4 places in 2 districts out of 5 districts where *C. fluminea* was found in Sabah and 2 places out of 9 districts in Sarawak. The chi-square test has given a significant result of the association between the outer shell colour of the *C. fluminea* with the type of substrate and landuse. This result has supported the significant finding for this study whereby the type of substrate of the river and landuse of the area can affect the minerals that cause the discolouration of the *C. fluminea* outer shell. Most of the rivers where *C. fluminea* is found are located in the paddy fields and villages where villagers have planted orchards tree that supplies food, ensuring the existence of *C. fluminea*. The location category such as urban, suburban and rural does not affect the outer shell colour of the *C. fluminea*. This is further strengthened by the chi-square test's results, where indicates that the outer shell clour of the *C. fluminea* depends on the type of substrate and landuse but not on the location such as urban, suburban, or rural at the significant level of 0.1.

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