Evaluation of riparian vegetation diversity as a tuntong laut (Batagur borneoensis) habitat in River Tamiang, Aceh Tamiang, Aceh Province, Indonesia

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Abstract This study evaluated the diversity of riparian vegetation as a habitat of tuntong laut (B. borneoensis) along the Tamiang River and Iyu River Aceh Tamiang, Aceh Province, Indonesia. This study was descriptive exploratory research using the Ex-Post Facto method. Five location sampling were determined by selected sampling. Observation of mangrove vegetation included the seedlings, saplings, and trees were done at each location with three replications by made sample plots (2x2 m for seedlings, 5x5 m for saplings, and 10x10 m for trees). The research results showed that total species of seedlings were 14 species, saplings 18 species, and trees seven species. The highest diversity index value (H') of seedlings, saplings, and trees were 1.56, 2.52, and 1.44, respectively, which included in the low category and indicated the degraded of riparian vegetation in all of sampling location.

1. Introduction
Tuntong laut (Batagur borneoensis) is one of the Indonesian turtle species whose status in CITES II is critically endangered [1]. Tuntong laut has been found on Asia, including Indonesia, Brunei Darussalam, Malaysia, and Thailand. In Indonesia, Sumatra, especially in Aceh Tamiang are natural distribution of the tuntong laut. Riparian vegetation is the leading ecosystem of coastal areas that important value in the development of natural resources so that it functions to provide ecosystem services [2], and are closely related in increasing species richness [3,4].

One of the river vegetation that forms a single ecosystem is vegetation that lives in the riparian zone. It is characterized by being adjacent to water bodies, without clear boundaries, linear shape, and area and includes transitions between aquatic and terrestrial ecosystems. The constituents of the riparian ecosystem are plant communities located on the right and left banks of the river in the form of seedlings, saplings, and trees. The existence of riparian vegetation influences and determines the development of river ecosystems, such as the habitat of the tuntong laut as a food source area [5].

The intervention of mangroves from humans will harm climate change and loss of food sources for aquatic biota so that mangroves deserve more consistent attention in their management [6,7]. A conservation strategy is needed in a policy to protect marine biodiversity [8]. Involving the community
in managing tuntong laut as a collaborative partner, and can actively achieve conservation according to the expected goals [9].

Changes in the function of mangroves to ponds, plantation areas, and transportation activities cause degradation of biodiversity [10]. Since tree species diversity is an essential aspect of ecosystem diversity in providing resources and habitat structures for other species [11], it is related to coastal area habitat protection services [12]. Active community involvement can carry out policies that have been jointly established [13], in developing and implementing riparian vegetation management that functions as riverbank stability, reducing erosion potential, providing forage and wildlife habitat [14]. So it can be said that community involvement in mangrove resource management is better. The Iyu River and Tamiang Rivers are natural habitats for tuntong laut.

The results of previous studies indicated that riparian vegetation was identified by one of the mangroves, Berembang (*Sonneratia caesolaris*). It develops into a source of food for the tuntong laut, while the twigs and trunks are used for sunbathing, and the tree canopy can lower the water temperature so that it is comfortable to take shelter. However, the riparian vegetation along the Iyu River and Tamiang Rivers has begun to degrade due to interventions and changes in mangrove function due to community activities. Therefore, efforts are needed to evaluate the diversity of riparian vegetation to serve as ecosystem services. It can be used as a management solution and can be applied in reducing the damage to the tuntong laut habitat. The results of this evaluation can serve as a guide for planting, maintenance, and management, especially for the Berembang species, which function as riparian vegetation. These results can be used as recommendations for a river ecosystem management strategy in Aceh Tamiang Province.

2. Methods
This research was conducted in August 2019. The research location was Sungai Iyu, Bendahara District, and along the Tamiang River, namely Batang Lawang, Kampung Baru, Pusung Kapal, and Pusung Kapal Dermaga, Seruway District, Aceh Tamiang District, Aceh Province (Figure 1). The desired output from the results of this study was the quality of riparian vegetation on the habitat of tuntong laut. This research was descriptive exploratory using *Ex-Post Facto*, which is selecting a causal effect factor that has occurred in the field. The sampling location was determined using *selected sampling*, which is based on the systematic pattern of tuntong laut tails that people often find in search of food or when they often come to the surface to bask on fallen branches or trees. The number of determined locations is five stations, and then each station is taken with GPS coordinates. The determination of the research plot was carried out on both the left and right sides of the river. At each station, three replications were carried out, with a total number of repetitions of 45.

![Figure 1. The research station is used as a research location.](image-url)
The tools and materials used in this research were meters, measuring tape, GPS, camera, and plastic strap. Vegetation analysis at three observation stations used the quadrant method. The observation group was classified into three groups, namely seedlings (2x2 m), saplings (5x5 m), and trees (10x10 m)—figure 2. The riparian plants obtained were immediately identified at the research location and assisted by an identification book. Taxa richness, density, and index diversity as parameters in this present study. The dependent variable consists of community structure and a variety of riparian vegetation. While, the independent variables are human activities and land use around the mangrove ecosystem.

3. Results and Discussion

3.1 Analysis of riparian seedling vegetation

Analysis of riparian vegetation at the seedling level was carried out at five stations. The total abundance was 97, 31, 24, 4, and 0, as shown in (Figure 2a). Diversity index from highest to lowest consecutively, namely Kampung Baru (1.56), Pusung Kapal (0.92), Pusung Kapal Dermaga (0.41), Batang Lawang (0.28), and Iyu River (0.00) (Figure 2b). The diversity of seedlings in Kampung Baru was classified as moderate with an $H'$ value (1.56), namely $1 < H' < 3$. The state of riparian vegetation in Pusung Kapal, Pusung Kapal Dermaga, and Batang Lawang is low because these 3 locations directly face residents' settlements and agricultural lands such as rice fields and oil palm plantations. Likewise, the Iyu River has absolutely no seedlings because on the left and right sides of the river are directly opposite residential areas and residents' charcoal pots. Therefore, the diversity of riparian vegetation at seedling levels in the five research locations was moderate.

Figure 2. Community structure and diversity of seedlings of riparian vegetation in Aceh Tamiang river

The evenness index of the research results found that Kampung Baru was classified as high, reaching 1.0, while what was not there at all was in the Iyu River. Then it shows the number of individuals at
each research station of each type is not the same. The dominance index shows that the total species found were 14 species, with the values obtained were (0.9) at the Pusung Kapal Dermaga and Batang Lawang locations, while Kampung Baru (0.3) and Iyu River (0.00) (Figure 2c). The results of observations of riparian vegetation for the critical value index at these five stations are as shown in (Figure 2d). The most types of seedlings found were Sonneratia alba at the Pusung Kapal Dermaga (149%), Batang Lawang (146%), and the Pusung Kapal (107%). Then followed by the location of Kampung Baru by the types of Centrosema pubescens and Mikania micrantha (71%), and Ipomea pes-caprae (58%).

3.2 Analysis of sapling riparian vegetation

The riparian vegetation analysis at the sapling level was carried out at the same location as the seedlings, the total abundance of saplings was 13, 4, 4, 4, and 4, as shown in (Figure 3a). The diversity index from highest to lowest was Kampung Baru (2.52), Pusung Kapal Dermaga (2.44), Batang Lawang (1.95), Pusung Kapal (1.35), and Iyu River (0.59), respectively (Figure 3b). The diversity of the state level, namely Kampung Baru, Pusung Kapal Dermaga, Batang Lawang, Pusung Kapal, is classified as moderate with an $H^\prime$ value of $1 < H^\prime < 3$. Meanwhile, the riparian vegetation on the Iyu River is low. Therefore, the diversity of sapling-level riparian vegetation in the five study locations was moderate.

![Figure 3](image-url)

**Figure 3.** Community structure and diversity of saplings of riparian vegetation in river Aceh Tamiang

The evenness index of the research results found in the Iyu River was classified as high, namely 0.71, while the lowest was in Kampung Baru, which was 0.05. The dominance index shows that the total species found were 17 species, with the results obtained were (0.98) at the location of Kampung Baru, Pusung Kapal Dermaga (0.87), Batang Lawang (0.75), Iyu River (0.59), and the Pusung Kapal (0.52) (Figure 3c). The observations of riparian vegetation for the significance value index at these five stations
are as shown in (Figure 3d). The most species of saplings found were *Nypa fruticans* in the Iyu River (222%). Then the *Sonneratia caesolaris* at Pusung Kapal (172%) was followed by the *Barringtonia racemosa* in Kampung Baru (140%) and *Sonneratia caesolaris* in Batang Lawang (136%).

### 3.3 Analysis of riparian vegetation

Analysis of tree-level riparian vegetation with the highest total abundance was four at the Pusung Kapal location, as shown in (Figure 4a). The diversity index from highest to lowest was Pusung Kapal (1.44), Iyu River (0.92), Batang Lawang (0.26). At the same time, for Kampung Baru and Pusung Kapal Dermaga, there were no tree species found (Figure 4b), since there were cut down for expansions of oil palm plantations and rice fields. The tree-level diversity in Pusung Kapal was moderate with the value of $H'$ (1.44), namely $1 < H' < 3$. Meanwhile, the riparian vegetation conditions in the Iyu River (0.92) and Batang Lawang (0.26) classified as low. Therefore, the diversity of tree-level riparian vegetation in the five study locations was moderate.

![Figure 4](image_url)

**Figure 4.** Community structure and diversity of trees of riparian vegetation in river Aceh Tamiang

The evenness index of the research results found in Pusung Kapal was high, namely 0.72, while the lowest is in Batang Lawang, which is 0.26. The dominance index shows that the total species found were 17 species, with the results obtained were (1.00) at the location of Pusung Kapal Dermaga and Kampung Baru, Batang Lawang (0.91), Sungai Iyu (0.64), and Pusung Kapal (0.42) (Figure 4c). The results of observations of riparian vegetation for the significance value index at these five stations were as shown in (Figure 4d). The most tree species found were *Sonneratia caesolaris* in Kampung Baru and Pusung Kapal Dermaga (300%), and Batang Lawang (276%), followed by *Nypa fruticans* in the Iyu River (219%). *Sonneratia caesolaris* and *Nypa fruticans* were the dominant tree species in the study area. Based on the results of research in the five locations, it was found that the riparian diversity indexes of seedlings and saplings were found in Kampung Baru, namely 1.56 and 2.52. Whereas for the tree level, there are many in the ship center location, which is 1.44 and monetized by the *Sonneratia caesolaris* species. Proves from the results of observations of adult sea guides and hatchlings that are
found basking in the location of Batang Lawang, Kampung Baru, Pusung Kapal, Pusung Kapal Dermaga. The bigger the mangrove canopy makes the adult marine tuntong and hatchlings like this area because it makes the surrounding cool. Therefore, it is necessary to maintain the existence of the Sonneratia caesolaris species as natural, because the sea guidance is very dependent on the existence of this type of mangrove as food and shelter.

The profile of the diversity of riparian vegetation as shown as Figure 5. The seedlings and saplings dominate Pusung Kapal. Pusung Kapal Dermaga and Batang Lawang index of variety from the stake. The diversity of riparian vegetation of the Iyu and Tamiang rivers needs to be preserved and maintained, given the functions and benefits of riparian vegetation, which are essential in maintaining the quality of the marine pond habitat. A decrease in riparian vegetation due to logging impacts the aquatic habitat in Aceh Tamiang waters, and the loss of the factors that influence it [6]. The higher the diversity index, the more stable the ecosystem.

The higher the diversity index, the more stable the ecosystem. The diversity of riparian vegetation of the Iyu River and Tamiang River needs to be preserved and maintained because the functions and benefits of riparian vegetation are essential in maintaining air quality and the guidance of tuntong laut habitats. Decreasing riparian vegetation has an impact on reducing water quality and habitat. The amount of plant at the seedling, sapling and tree levels tends to dominate. It has a more significant number in the locations of Batang Lawang, Kampung Baru, Pusung Kapal, and Pusung Kapal Dermaga, so it can be said that it is in normal conditions. The number of seedlings, saplings, and trees that dominate a population can be said to be natural habitats and essential for the maintenance of biodiversity [15], unlike the location of the Iyu River, which is only dominated by the tree level. If tree species are dominant in an area, conservation measures for the ecological and ecological value of the species are needed [16].

**Figure 5.** Riparian vegetation in Pusong Kapal and Iyu River only in the form of trees and in the other location only in the way of saplings. It was indicated that the quality of riparian in all place has degraded.

Riparian has essential functions and benefits, but if riparian is threatened due to human activities, it will lose its primary purpose and extinction of aquatic fauna. Riparian vegetation has an essential and invaluable role in maintaining biodiversity landscapes and accommodating various vegetation communities [17], useful as sediment in resisting river abrasion and texture control of water quality [18]. The diversity of riparian vegetation is influenced by the activities of the people along the river, and the continuous disturbance might disrupt riparian regeneration [19]. The community living on the banks of the river used the riparian zone as agricultural land and disturbed the habitat for the tuntong laut tails.

The profile of seedlings can be seen as follow. This result showed that Pusong Kapal has the highest taxa richness and total density of riparian vegetation, but in Iyu River, there are no seedlings we found. But the diversity index of the seedling is low in all of the research locations. This is thought to have an
impact on riparian vegetation that will become extinct in the future. Observations on saplings show almost the same amount in both taxa richness and total density in all locations except the river Iyu with species diversity, including of low category even though it was more than 1.

The degraded of riparian vegetation quality also can be seen from the tree category. Some locations only have 1 to 4 taxa richness with a low of total density and diversity index. Iyu river and Pusong Kapal have the highest tree taxa richness, overall density, and diversity index. And from biplot analyses using Principal component analyses (Fig. 5), we can see that Riparian vegetation in Pusong Kapal and Iyu River only in the form of trees and in the location of the other only in the way of saplings.

4. Conclusion
The diversity of riparian vegetation in the Iyu River, Batang Lawang, Kampung Baru, Pusung Kapal, and Pusung Kapal Dermaga located in Aceh Tamiang Provinsi of Aceh has degraded indicated by low of the diversity of seedlings, saplings and also trees. The riparian vegetation found were 14 species for seedlings, 18 species for saplings, and seven species for trees. For suggestions to improve riparian vegetation quality in the river as a habitat of tuntong laut (B. borneoensis), it is needed revegetation along with the river. Also, human activities need to be controlled.

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