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# Diversity and abundance of mud crabs (*Scylla* spp.) living in mangrove forest ecosystems on Serangan Island, Bali, Indonesia

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**Abstract.** *Swasta IBJ, Murni IAAD, Amelia JM. 2023. Diversity and abundance of mud crabs* (Scylla *spp.*) *living in mangrove forest ecosystems on Serangan Island, Bali. Biodiversitas 24: 5664-5670.* The mangrove forest ecosystem on Serangan Island contains dozens of types of aquatic fauna, including mud crabs from the *Scylla* genus (*Scylla* spp). The objectives of this study were to obtain the variety and abundance of mud crabs and to determine the variety and abundance of mangroves on Serangan Island after the reclamation. This study's results are expected to make all parties aware of the ecological impact of reclamation activities on the coast. Data on mangrove diversity was collected through observation during a field survey. At the same time, samples of mud crabs were caught randomly using traps (*rakang*) of as many as 20 units set proportionally around Serangan Island. The fishing gear (*rakang*) is placed in the afternoon at 18.00, then taken in the morning at 06.00 to see the trapped mud crabs. The data on the diversity and abundance of mud crabs were processed to obtain a diversity index using the diversity index formula (H') from Shannon Wiener and quantitative and qualitative descriptive. The results showed that there are three types of mud crabs around Serangan Island, namely *Scylla serrata* (47.8%), *Scylla olivacea* (30.4%), and *Scylla tranquebarica* (21.8%) with a diversity index (H' ) of mud crabs was 1,047. *Scylla serrata* has the highest prevalence of 35%, followed by *Scylla olivacea* (25%) and *Scylla tranquebarica* (10%). The mangrove community on Serangan Island consists of 6 species, namely *Rhizophora apiculate*, *Rhizophora stylosa*, *Ceriop tagal*, *Sonneratia alba*, *Avicennia lanata*, and *Brugierra gymnorhiza*.

**Keywords:** Mangrove, mud crab, Serangan Island

## INTRODUCTION

The mangrove forest ecosystem has high biological productivity regarding fauna and flora (Hutchings and Saenger 1987). In terms of fauna, the mangrove forest ecosystem contains dozens of aquatic fauna species and dozens of terrestrial fauna species that live together in community bonds (Igulu et al. 2014; Lee et al. 2014; Islamy and Hasan 2020; Isroni et al. 2023). Regarding flora, the mangrove forest ecosystem contains dozens of types of mangrove vegetation, both major and minor mangroves, as well as several types of epiphytic vegetation and parasitic vegetation associated with mangrove forests (Tomlinson 1984). The complexity of life in the mangrove forest ecosystem makes mangrove forests have very important ecological and economic meanings. Ecologically, mangrove forests can be a spawning ground, a nursery ground, and a feeding ground for various aquatic biota (Jacobs et al. 2019). Mangrove forests can also be powerful carbon sinks, capturing carbon dioxide and other greenhouse gases from the atmosphere and storing them in their roots and branches (Matsui et al. 2010; Alongi 2012, 2014).

Economically, there are various mangrove forest products from timber, including firewood, charcoal, and construction materials, and from non-timber products, including tannin, dye, Nypa thatch, Nypa sap, and medicine that the local community can utilize to support their needs (Kusmana and Sukristijiono 2016). Meanwhile, talking about the aquatic fauna in the mangrove forest, there are various groups of animals, such as fish, shrimp, crabs, snails, oysters, worms, aquatic insects, and others. The existence of this aquatic fauna in the mangrove forest makes the mangrove forest ecosystem a source of food for fishermen and other coastal communities because almost all this aquatic fauna is a source of protein for humans (Kusmana and Sukristijiono 2016). Even some of them, such as shrimp, lobster, and mud crab, has higher price than fish, snails, and oysters due to their high nutritional value. According to Islam et al. (2022), mud crabs *Scylla serrata* (approximately 55-85 g), which live in their natural habitat, contain high protein between 13 to nearly 17%, low fat 5-8%, and various types of minerals such as calcium, magnesium, phosphorus, and iron. Therefore, mud crabs could be a healthy diet for humans. Therefore, it is unsurprising that mud crabs are hunted massively, and their natural stocks are decreasing. Focusing on the population of mud crabs *Scylla* spp. in their natural habitat, aside from the hunting activities, currently, their population tends to decrease due to mangrove forests' degradation and deforestation (Ulfa et al. 2018; Ismail et al. 2019). Worldwide, there are at least 4 (four) types of mud crabs from the well-known *Scylla* genus, namely *Scylla serrata*, *Scylla olivacea*, *Scylla paramamosain*, and *Scylla tranquebarica* (Keenan 1999). Of the four types of mud

crabs, the most found in Indonesia is *Scylla serrata* (Suman et al. 2018). Meanwhile, the other three species vary in number in various regions, and even in certain areas of mangrove forests, certain mud crabs are absent (Keenan 1999).

According to the study conducted by Putri et al. (2022) regarding the importance of the healthy mangrove forest as a habitat for mud crabs, better management and conservation efforts are needed in the respective areas, and understanding the biodiversity of mud crabs is also needed to help enhance the crab population's management. Serangan Island is one of the coastal areas in southern Bali that has recently undergone a reclamation process (Segara 2019). There are also several mud crabs on Serangan Island. However, the variety and abundance are unknown because these have not been studied yet. Therefore, research on the variety and abundance of mud crabs around Serangan Island is very important to compare data on the variety and abundance of mud crabs before and after coastal reclamation. This study aimed to obtain definite data on the variety and abundance of mud crabs in the mangrove forest ecosystem around Serangan Island. Meanwhile, the benefit of this study is to provide scientific information about the impact of coastal reclamation on Serangan Island on the existence of mangroves and mud crabs on this island.

## MATERIALS AND METHODS

### Study area

Geographically, Serangan Island is a small island located in the south of Denpasar, Bali. The total area of Serangan Island after reclamation was 4.81 km$^2$ (BPS Kota Denpasar 2022) with the total area of mangrove forest in Serangan Island was 0.98 km$^2$ (Artha et al. 2019). The population in this study were all mangrove plants and mud crabs from the *Scylla* genus on the coast of Serangan Island. A field survey research method through an inventory of mangrove plant species and mud crabs from the *Scylla* genus (*Scylla* spp.) was conducted from 24 to 25 July 2021 on Serangan Island by applying a representative sampling technique (Kruskal and Mosteller 1979) (Figure 1). In general, the water temperature in Serangan Island was 28-30.5°C, pH 7.5-7.9, and salinity 26.2-32.7 ppt. The characteristics of each sampling location are described in Table 1.

**Table 1.** Description of each sampling location in Serangan Island, Bali, Indonesia

| Station | Position | Location | Substrates type | Shore topography | Mangrove existence |
|---|---|---|---|---|---|
| 1 | 8°43'30.82"S and 115°13'44.66"E | North edge | Mud sandy shore | Flat | Present (thin) |
| 2 | 8°43'57.52"S and 115°14'51.51"E | East edge | Mud sandy shore | Flat | Present (thin) |
| 3 | 8°44'58.30"S and 115°13'16.33"E | South edge | Mud sandy shore | Flat | Present (thin) |
| 4 | 8°44'7.98"S and 115°13'15.01"E | West edge | Mud sandy shore | Flat | Present (thick) |

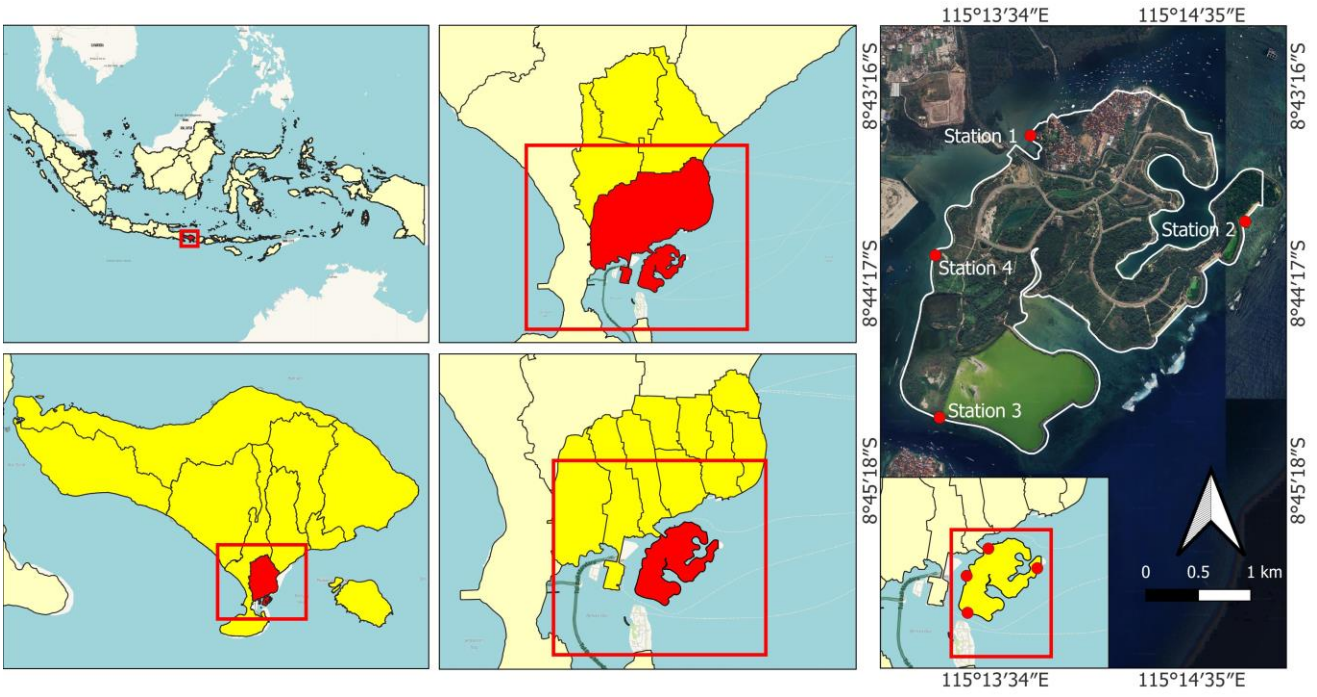


**Figure 1.** Sampling location of mud crab in Serangan Island, Denpasar, Bali, Indonesia

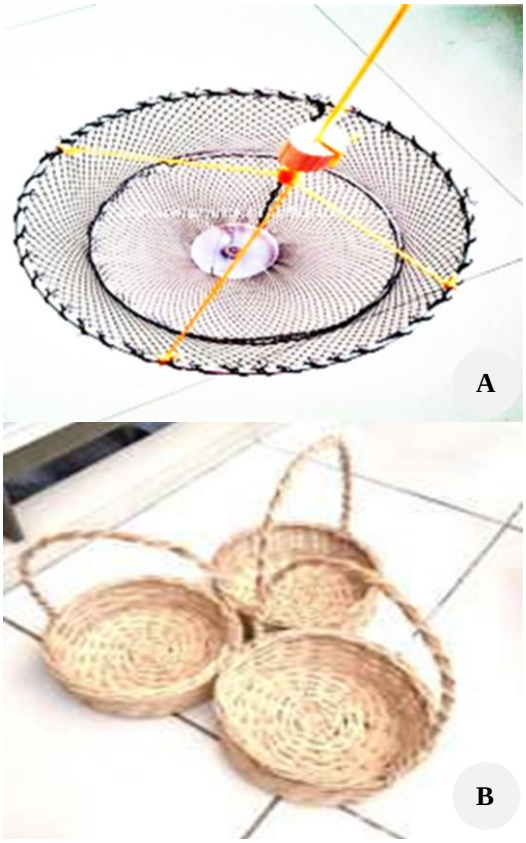


**Figure 2.** A. Crab trap (*Rakang*). B. Basket

**Materials**

Samples in this study were 23 mud crabs from the *Scylla* genus, which were caught using 20 units of crab trap called *rakang* (Figure 2). These crab traps were placed randomly at the bottom of the mangrove forest around Serangan Island. Five kilograms of bycatch were used as bait to trap mud crabs. Other tools used in this research were baskets to accommodate two mud crabs, scales for weighing crabs, a camera for capturing crab specimens, GPS for locating the sampling station, pH meter, and a refractometer for water quality measurement.

**Procedures**

There were two main activities in this research: observing and making an inventory of mangrove plant species and making an inventory of mud crabs (*Scylla* spp.) on Serangan Island. The inventory of mangrove species was carried out by direct observation, while the inventory of mud crabs (*Scylla* spp.) was carried out by installing a crab trap (*rakang*). Mangrove and crab data were collected in 4 (four) sub-locations: the north coast, east coast, south coast, and west coast of Serangan Island. A sampling of mud crabs was carried out by placing as many as 20 units of crab traps containing bait in each sub-location in the afternoon around 18:00. Then the crab traps were lifted and observed the next morning at 06:00. The mud crabs trapped in the crab trap was then taken, observed, and identified as its species. The identification of mud crabs was based on the mud crab identification guidelines in Keenan et al. (1998) and Sulistiono et al. (2016).

**Data analysis**

Data analysis was carried out with a descriptive quantitative approach, a descriptive qualitative, and ecological statistics. Assessment of the abundance status of crabs can be seen from the prevalence of crabs in the trap, which is calculated by the following formula:

$$\text{Prevalence} = \frac{\text{number of traps caught crab}}{\text{number of traps installed}}$$

Crab's diversity index was calculated based on Shannon Wiener's diversity index (H') (Ludwig and Reynold 1988) as the following formula:

$$H' = -\sum \left(\frac{ni}{N} \ln \frac{ni}{N}\right)$$

## RESULTS AND DISCUSSION

**Various types of mangroves**

Based on the observation in this study, the mangrove forest on Serangan Island had an area of approximately 33 hectares with a total of six species, namely *Rhizophora apiculate*, *Rhizophora stylosa*, *Sonneratia alba*, *Avicennia lanata*, *Ceriop tagal*, and *Brugierra gymnorhiza*. According to the proportion, the mangrove community on Serangan Island appeared to be dominated by *Rhizophora apiculate* (45%). In comparison, others had a much smaller proportion, such as *Rhizophora stylosa* 15%, *Sonneratia alba* 15%, *Ceriops tagal* was 10%, *Avicennia lanata* was 10%, and *Bruguierra gymnorhiza* was only 5%. In terms of distribution, the mangrove community on Serangan Island was only spread out over a part of its coast, especially the west, northwest, and north coasts. Regarding stand age, most of the mangroves on Serangan Island were old, and some were young stands because of the mangrove rehabilitation program (Figure 3).

**Types of mud crab**

Three mud crabs were observed in Serangan Island's mangrove forest (Figure 4). According to the calculation of the diversity index (H') of crabs was relatively low, which was 1.047. In general, the ratio between males and females was imbalanced, where the female mud crabs were dominant observed in the mangrove forest on Serangan Island. The average weight and the prevalence of mud crabs observed on Serangan Island are displayed in Table 2. The morphology of each species of mud crabs is described in Table 3.

**Discussion**

The variety of mangrove species found above largely follows the results of previous research by Artha et al. (2019), where Rhizophora and Sonneratia dominated the mangrove forest area on Serangan Island. Mud crabs were mostly found in habitats with a high density of mangroves. A study by Setiawan and Triyanto (2012) showed that the Scylla serrata mangrove crabs prefer mangrove forests dominated by the mangrove genus *Rhizophora*. A study by Tahmid et al. (2015) also showed a positive correlation

between mangroves' density and *Scylla serrata*'s abundance. Based on their observations, mud crabs tended to live in the mangrove vegetation with dense root systems capable of holding more silt substrate and forming small caves to hide and food.

Similarly, Krauss et al. (2014) also revealed that dense root systems from tree assemblages can influence the structure and consistency of soil for burrowing. Moreover, Leoville et al. (2021) confirmed that the substrate and shade (mangrove density) were positively related to the occurrence of *S. serrata* burrows. The shade or the canopy cover produced by the mangrove vegetation is important in regulating soil temperature and evaporation rate, indirectly influencing habitat conditions (Nobbs 2003). There are a lot of fallen mangrove leaves in the area with a high density of mangroves that can be a food source for juvenile mud crabs (Pambudi et al. 2019). Not only juvenile mud crabs but mangrove litter can be utilized as a source of food for gastropods, herbivorous fish, and shrimp, which are the prey of larger juvenile mud crabs (Alberts-Hubatsch et al. 2016). The larger mud crabs preferred habitats with high mangrove densities with sufficient food availability, such as detritus, plankton, and benthic organisms (Siringoringo et al. 2017). In addition, according to research conducted by Azra and Ikhwanuddin (2016), mussels, small bivalves, and squid were important in the crabs' maturation diet, which can improve the fecundity of broodstock mud crabs.

According to the weight of mud crabs observed on Serangan Island, they were classified as medium size (not maximal) because the average weight was only 305 g, whereas the maximum size can reach 500-600 g for each crab individual (Alava et al. 2007; Pattiasina et al. 2012). Likewise, regarding abundance, the presence of the *Scylla* on Serangan Island was classified as rare, with an average prevalence in traps of 23.33%.


**Figure 3.** A. Old mangrove. B. Young mangrove on Serangan Island, Bali, Indonesia

**Table 2**. Variety of mud crabs in the mangrove forest around Serangan Island, Bali, Indonesia

| Type of crab | Number of crabs | Sex ratio (male/female) | Percentage of crabs | Average weight (g) | Prevalence inside a crab trap |
|---|---|---|---|---|---|
| *Scylla serrata* | 11 | 4/7 | 47,8% | 285±12.25 | 35 % (7 of 20) |
| *Scylla olivacea* | 7 | 2/5 | 30,4% | 302±4.32 | 25 % (5 of 20) |
| *Scylla trasquebarica* | 5 | 1/4 | 21,8% | 328±2.55 | 10 % (2 of 20) |

**Table 3.** Morphology of mud crabs in the mangrove forest around Serangan Island, Bali, Indonesia

| Body characters | *Scylla serrata* | *Scylla olivacea* | *Scylla tranquebarica* |
|---|---|---|---|
| The pattern of walking legs and cheliped | Obvious and perfect polygon patterns in both sexes | It may have a very faint pattern in both sexes | Chela and two pairs of first legs have polygon patterns, and a pair of the last leg has various patterns. Obvious polygon patterns also exist in the female abdomen but are absent in the male abdomen |
| Color of carapace | Varies from violet to green until brownish-black | Varies from orange to brown until blackish brown | Varies from violet to green until brownish-black |
| Height and shape of spines at the forehead | High, thin, and blunt point | Low and rounded with narrow space | Moderate, blunt, and narrow space |
| Spines at cheliped | Two sharp spines at propodus and a pair of sharp spines at carpus | No spines at the inner carpus and reduced at the outer carpus. Spines at propodus also become reduced | Two sharp spines at propodus and a pair of sharp spines at carpus |

**A** **B** **C**

**Figure 4.** Type of mud crab found on Serangan Island, Bali, Indonesia. A. *Scylla serrata*, B. *Scylla olivacea*, C. *Scylla tranquebarica*

*Scylla serrata* was the most common species found on Serangan Island. The dominance of the *Scylla serrata* species was because *Scylla serrata* was known to be the dominant crab species in mangrove forests in Southeast Asia, including Indonesia (Alberts-Hubatsch et al. 2016). Avianto et al. (2013) showed that *Scylla serrata* in mangrove forests, Cibako, Garut, West Java, preferred habitats with a substrate balanced between sand and silt content. This follows the post-reclamation substrate conditions on the Serangan Island coast, with balanced sand and silt substrates on the east and south edges (Martha et al. 2019), and mud sandy shores on the north and west edges (Herlinawati et al. 2018; Ariawan et al. 2021). This condition is possibly causing the depressed populations of *Scylla tranquebarica* and *Scylla olivacea* found on Serangan Island because these species require a substrate dominated by mud (Avianto et al. 2013). Aside from the mangrove species and substrate factors, the low abundance of mud crab *Scylla tranquebarica* particularly might be caused by some anthropogenic factors, including continual crab hunting by local fishermen around Serangan Island, deforestation of mangroves due to reclamation and the expansion of the community's settlement (Darmawan 2015). Those anthropogenic factors have a direct impact on crab reproduction and crab survival. Changes in environmental conditions, like the availability of food sources and habitat conditions after reclamation, possibly resulted in a slow growth rate of the mud crabs. Moreover, massive hunting activities could reduce the opportunity for mud crabs to grow to their maximum size (mature size).

Other factors contributing to the dominance of *Scylla serrata* on Serangan Island were habitat quality, including temperature, pH substrate, and salinity of sea waters on Serangan Island. A temperature of 27°C and a pH of 7.6 measured on Serangan Island were suitable as the living requirements of *Scylla serrata* crabs based on the research by Setiawan and Triyanto (2012) stated that the best temperature range for *Scylla serrata* crabs was 25-35°C and pH substrate was 7-7.6. In addition, mud crabs can grow quickly in water temperatures ranging from 28.8 to 36°C (Walton et al. 2007). Acidity is important in the mud crabs' metabolic activities and the decomposition process of organic material in mangrove areas; the higher the pH value, the quicker the demineralization of organic matter to fulfill their needs (Kamaruddin et al. 2019). Meanwhile, the water salinity affects mud crabs' osmotic condition, determining their survival and growth. The water salinity measured on Serangan Island was 29 ppt, within the appropriate salinity range (10-35 ppt) that mud crabs can live well (Siple and Donahue 2013). All the studies above revealed that habitat quality correlated to *Scylla serrata*'s abundance and mud crabs' growth (carapace width and body weight).

The only crab type not found on Serangan Island was *Scylla paramamosain*. The most likely reason for the absence of *Scylla paramamosain* is that the massive reclamation process on the coast of Serangan Island made the mud substrate much harder. Consequently, it does not support the life of the *Scylla paramamosain* that tends to live in soft, muddy habitats, as the research conducted by Sunarto et al. (2015) on the coast of Indramayu. Soft mud substrate makes it easier to make shelter holes when molting (Sara 2000). The second possible reason for the absence of *Scylla paramamosain* on Serangan Island is the massive degradation of the mangrove forest. According to Keenan et al. (1998) in Hia et al. (2013), *Scylla paramamosain* requires a habitat type with dense mangroves and brackish water' salinity. The salinity of coastal waters on Serangan Island was 29 ppt, which was higher than the optimal condition for *Scylla paramamosain*. The third reason is possible this type of *Scylla paramamosain* is currently experiencing extinction due to being hunted by humans (overexploitation). Lastly, *Scylla paramamosain* probably has not existed since long ago on that site.

Since the lack of previous studies about mud crabs in Serangan Island before the reclamation, data comparison of the ecological condition before and after the reclamation appears difficult. However, according to Wayan Karma (Head of Serangan Village), many years before the reclamation project on Serangan Island, mud crabs were plenty and easy to collect by the local fisherman. At that time, he said local fishermen hunted the crab intensively and traped the crab at least 1.5 tons per month. However, after the reclamation, he said there were changes and degradation of environmental conditions. Local fishermen frequently failed in their efforts to hunt the crab. He mentioned that mud crabs were a bit difficult to collect with the highest catches reaching 25 kg per day by the local communities. Considering the current condition, he also mentioned that there is a raising in the local community's awareness about sustainable fishing by preventing fishermen from catching berried females (egg-carrying females) mud

crabs. Moreover, based on the study conducted by Fitri et al. (2017), there are some management strategies for mud crabs, including controlling the mud crab fishing gear and fishing season, restricting the size of allowable mud crabs for consumption, monitoring the proper handling of mud crab catch, ensuring the implementation of the regulation by the management institutions, and implementing mud crab aquaculture.

From the results obtained, it can be concluded that there are 6 types of mangroves observed on Serangan Island, namely *Rhizophora apiculate*, *Rhizophora stylosa*, *Sonneratia alba*, *Ceriop tagal*, *Avicennia lanata*, and *Bruguierra gymnorhiza*. *Scylla serrata*, *Scylla olivacea*, and *Scylla tranquebarica* were species of mud crabs spread throughout the research station. The most abundant species observed during this study was *Scylla serrata*. Based on the size of the sample in this study, continual sampling in further research should be applied to get a broader view of the diversity of mud crabs on Serangan Island. Based on the results of this study, to ensure the sustainability of mud crabs on Serangan Island, it can be suggested that the protection of the mangrove forest should be strengthened by encouraging local fishing communities to do selective fishing by not catching young crabs and crabs that contain eggs. Furthermore, the local communities on Serangan Island should not destroy, cut, or change the land use of mangrove forests on Serangan Island. In addition, we appreciate existing local communities' efforts, supported by the local government, to protect the mangrove ecosystem by strengthening the mangrove ecotourism conservation concept to provide an alternative livelihood for local communities.

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