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Characteristics of olive ridley sea turtle (*Lepidochelys olivacea*) nesting beaches and hatcheries in Bantul, Yogyakarta, Indonesia

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Abstract. *Budiantoro A, Retnaningdyah C, Hakim L, Leksono AS. 2019. Characteristics of olive ridley sea turtle (*Lepidochelys olivacea*) nesting beaches and hatcheries in Bantul, Yogyakarta, Indonesia. Biodiversitas 20: 3119-3125.* We analyzed the ecological conditions of the beaches in Bantul, Java, Indonesia, in supporting the olive ridley sea turtle emergences and nesting. The study was performed at four beaches in Bantul, namely Pelangi, Samas, Goa Cemara, and Pandansimo. We collected data in areas where olive ridley sea turtle nests, such as beach width, slope, sand size, the percentage of magnetic mineral, daily temperature fluctuations, hatchlings rates, and vegetation. The results showed that Pelangi Beach was broader and steeper (31.26 m; slope 5.10°) than the rest ($p<0.05$). There was no difference in the sand size (diameter of 0.99 mm). The magnetic mineral content in sand ranged from 51.68-87.50%, while the daily temperature ranged from 24.3-31.0°C. The average percentage of hatchlings from 2012 to 2018 was 60.89%. Vegetation on the four beaches is almost the same, which was shrimp pine trees, runny grass, thistle, papyrus, and pandanus thorns. The average pH level of the nest hatchery was 7, supporting the hatchling embryology process. Ecologically, Pelangi Beach is the best turtle landing site in Bantul. Furthermore, transferring olive ridley sea turtle eggs to seminatural nests is recommended due to the quite high hatching rate.

Keywords: Bantul, hatchlings, nest, sea turtle, release

INTRODUCTION

Indonesia is an archipelago country with 17,500 islands with more than 81,000 km of coastline that supports sea turtle nesting (Lasabuda 2013). Indonesia has six species of turtles out of seven, and the turtle conservation areas in Indonesia are already considered to be good (Dermawan et al. 2009). Java Island has several turtle conservation areas established under the Ministry of Environment and Forestry, namely Ujung Kulon, Pangumbahan, Merubetiri, and Alas Purwo National Park. The beaches in Bantul Regency, which are on the southern coast of Java, are not generally known as turtle landing areas because there are not many turtle landing data. Bantul Regency has a beach with a length of about 16.85 km with four sea turtle rescue areas: Pelangi Beach, Samas Beach, Goa Cemara Beach, and Baru Pandansimo Beach (Budiantoro and Wijayanti 2014).

Several turtle rescue groups in 2010 monitoring several beaches in Bantul recorded the nesting turtles in the area were solely olive ridley sea turtles (*Lepidochelys olivacea*), even though one hawksbill turtle (*Eretmochelys imbricata*) was rescued from being caught in fishing nets in 2016. Bantul Regency had 35 olive ridley sea turtle (*L. olivacea*) nesting beaches recorded from 2012 to 2017: Baru Pandansimo Beach has seven; Goa Cemara Beach has five; Samas Beach has eight, and; Pelangi Beach has 15 areas. Each area has four up to 17 times landing per year (Budiantoro 2017). Sea turtles typically dig nests and lay eggs on flat and wide beaches. Horrocks and Scott (1991) and Fish et al. (2005) indicated that beaches with steeper slopes are preferable for hawksbill turtles. Sandy beaches are incubators and have a microenvironment that is suitable for turtle embryo development. Microclimate fluctuations must also be considered to determine whether there are adaptations to environmental changes (Hamann et al. 2010).

Eggs of olive ridley sea turtle incubated in optimal humidity for embryonic development will have high hatching rates (Maulany 2009). The previous study reported the hatching success of the olive ridley sea turtle in Cabo Pulmo, southern Baja California reached **73.7% (**López-Castro et al. 2004**)**. A study by Kaska et al. (2006) on loggerhead turtle reported that the average temperature in the middle third of the incubation period ranged from 26.7-32.1°C, the incubation period ranged from 49-67 days, and the hatching sex ratio was about 60-65% female on the coast of Fethiye, Turkey. Changes in global temperature can alter the time of sea turtle landings (Hamann et al. 2010) and also affect the daily temperatures of turtle nests. Limpus (2008) said that the sea turtle population in Indonesia and Papua New Guinea had not been well-recorded. Valverde et al. (2012) noted a significant decrease in the olive ridley sea turtle population from 1980-1993. In October 1980, there were 148,000 nests, but there were only 350 nests observed in August 1993. Furthermore, Tripathy et al. (2009) suggested that the long-term survival of the olive ridley sea turtle depends on how to secure their critical habitat.

Currently no comprehensive data available for the landing habitat along the Bantul beaches. The microhabitat of hatcheries, including sand size, magnetic mineral content, daily nest temperature, and the percentage of hatching as important data to evaluate hatcheries management. The total *L. olivacea* hatchlings data from year to year are also needed to know the trend of hatchlings number each year, which can be used as the basis of conservation management and policymaking. This study thus aimed to analyze the ecological conditions of turtle nesting habitats in Bantul and also analyze the microclimate of the hatcheries of *L. olivacea*. The data generated from this study are expected to support the efforts of sea turtles conservation in Bantul Regency, Java Island, Indonesia.

MATERIALS AND METHODS

Study area

We conducted a descriptive-exploratory investigation involving four olive ridley sea turtle nesting beaches in Bantul District, Yogyakarta Province, Indonesia, namely the western area of Pandansimo Beach, Goa Cemara Beach, Samas Beach, and Pelangi Beach. Conservation groups acting as research partners recorded 263 turtle nests at all beaches from 2012 to 2018. Data collection was carried out during the turtle nesting season each year from March to September.

Data measurement

Turtle landing zone conditions were observed using aerial photography using hexacopter drones with a GoPro camera attached (GoPro, Inc., USA). Beach width and slope data were obtained by purposive sampling with prior sampling coordinate points (latitude, longitude) using global positioning system technology (GPSmap 60CSx; Garmin, Schaffhausen, Switzerland) according to previous research (Budiantoro 2017). The slope of the beach was measured using a clinometer (Suunto Tandem 30PC/360R) from the shoreline until it reached the sea level with a unit. Beach wide (supratidal) data taken by roller meters in the same zone, replicated ten times.

The measurement of sand diameter and magnetic mineral content was carried out by taking sand samples in the hatcheries of each beach, which became the central location of turtle eggs rescue. There were four samples in each beach and 30-60 cm in depth of turtle nests. The sand samples were then taken to the Technical Laboratory, Department of Civil and Environmental Engineering, Gadjah Mada University, Indonesia for sand diameters and magnetic minerals analysis. Sand diameters were analyzed using ASTM grain size methods, and magnetic minerals were analyzed using magnetic methods. The daily temperature measurement for hatcheries nests was

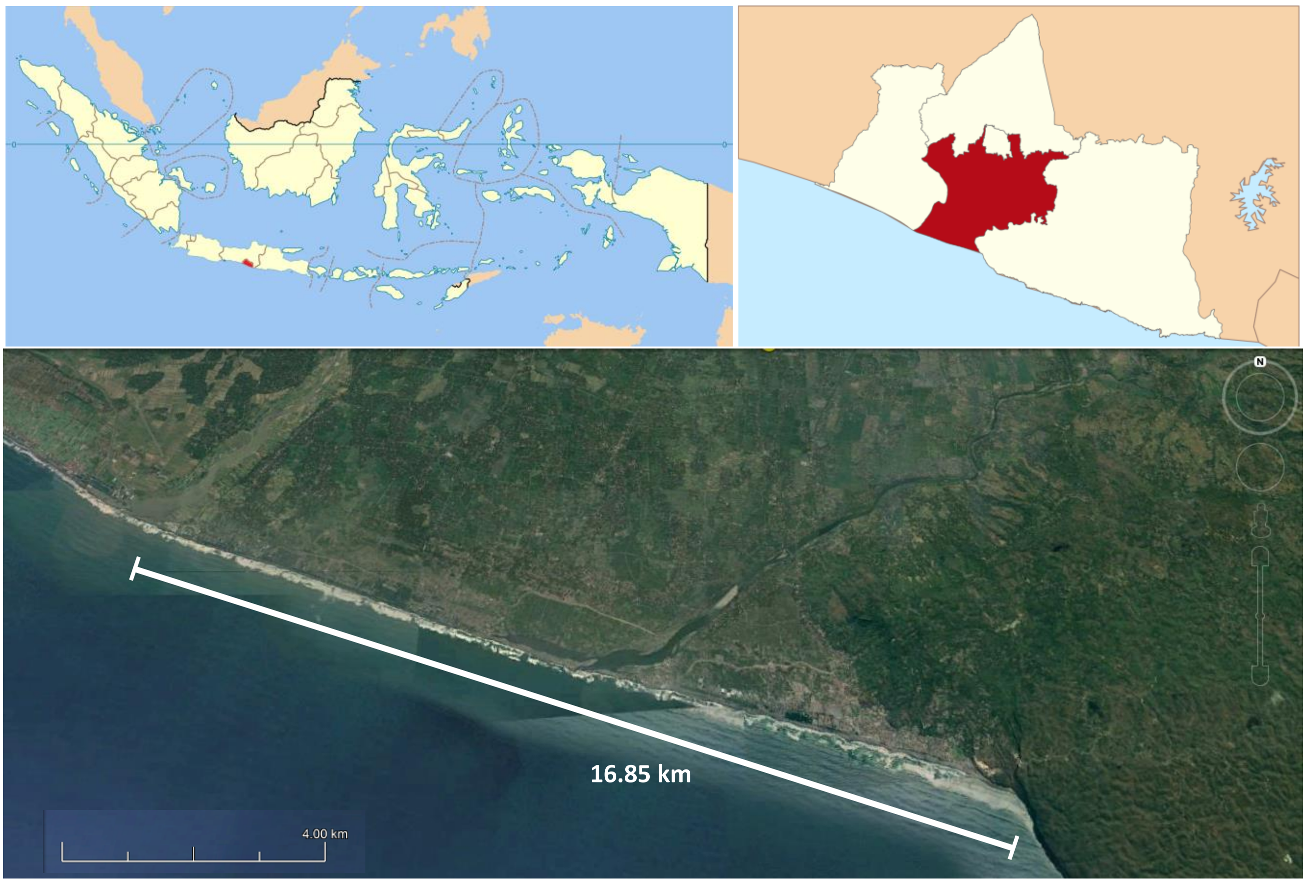

Figure 1. Location of study in Bantul beaches, Yogyakarta, Java Island, Indonesia (Google Maps, 2019)

carried out in the morning for minimum culmination, at 5:00 a.m, and the maximum culmination point in the afternoon (1:00 p.m.) using a soil thermometer (iTuin 4 in 1 Soil Survey Instrument Type AMT-300) placed at the top and bottom nests. The measurement was carried out for 50 days (13th May-15th July 2018) with four replications each. The vegetation types along the coast of Bantul were also recorded as supporting data. Additionally, the pH under the vegetation and of the hatcheries was measured with a pH meter (pocket pH tester-pHep* by HANNA).

Data analysis

Data were analyzed statistically using the Statistical Package for the Social Sciences version 21 software program (IBM Corp., USA). ANOVA test followed with Duncan multi-range test (DMRT) posthoc test was used to analyze the beach width and slope data. Sand diameter, magnetic mineral content in the sand, daily temperature, and the percentage of hatching hatchlings were analyzed descriptively. The percentage of hatching hatchlings (%) were counted using formula (total hatchlings/total egg) x 100%.

Figure 2. Research sites in Bantul Beach, Yogyakarta, Indonesia. A. Pandansimo Beach; B. Goa Cemara Beach; C. Samas Beach; and D. Pelangi Beach. E. A seminatural nesting place Samas, F. The hatchlings

RESULTS AND DISCUSSION

Beach width and slope

The landing site with the broadest beach width was Pelangi Beach and then followed by Pandansimo, Samas, and Cemara Goa. While Pelangi beach has a flatter surface than the rest, followed by Pandansimo, Pine Cave, and Samas. (Table 1).

Hatchery sand grain size

The average sand size data indicated the smallest Bantul beach was on the coast of Pelangi (0.85 mm) and the largest was Goa Cemara Beach (1.22 mm), as shown in Figure 3. There was no difference in the sand diameters among the four studied beaches in Bantul. The size of sand ranged from fine to moderate. The beach sand comes from the eruption of Mount Merapi, which was carried by the Opak and Progo rivers to the beaches in Bantul.

The mineral content of seminatural sand nests

The magnetic mineral of sand in seminatural nests in four observation stations range from 51.59% to 87.5%, as shown in Figure 4. The areas that are closer to the river outfall (i.e., Pandansimo Beach near the outfall of the Progo River and Samas Beach close to the Opak River estuary) have higher magnetic mineral (51.69%-87.50%).

The daily temperature of seminatural nests

Daily temperature data for seminatural nests ranged from (24.3°-31°C) for 50 days, as shown in Figure 5.

Hatching success

The percentage of hatchlings that hatched from 2012 to 2018 on the four beaches in Bantul are presented in Figure 6. From the number of eggs and hatchlings that hatched seen in Figure 6, the total percentage of hatchlings that hatched on all beaches in Bantul was 60.68%.

Table 1. Width and slope of Bantul beaches

Beach	Width (m)	Slope (º)
Pelangi	31.26±3.53[a]	5.81±1.21[a]
Pandasimo	16.74±2.91[b]	7.94±2.32[ab]
Samas	7.89±2.35[c]	9.94±2.65[b]
Goa Cemara	6.76±2.43[c]	10.00±2.53[b]

Note: numbers with the different letters in the same column show a significant difference ($p < 0.05$).

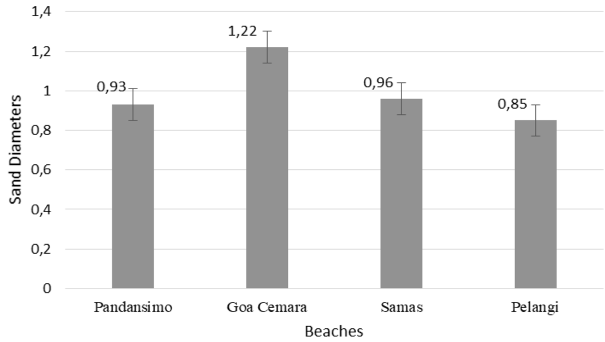

Figure 3. Sand diameter (mm) of four beaches in Bantul, Indonesia

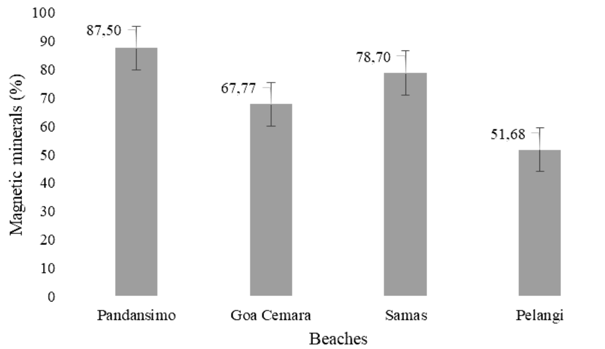

Figure 4. The magnetic mineral content of sand (%)

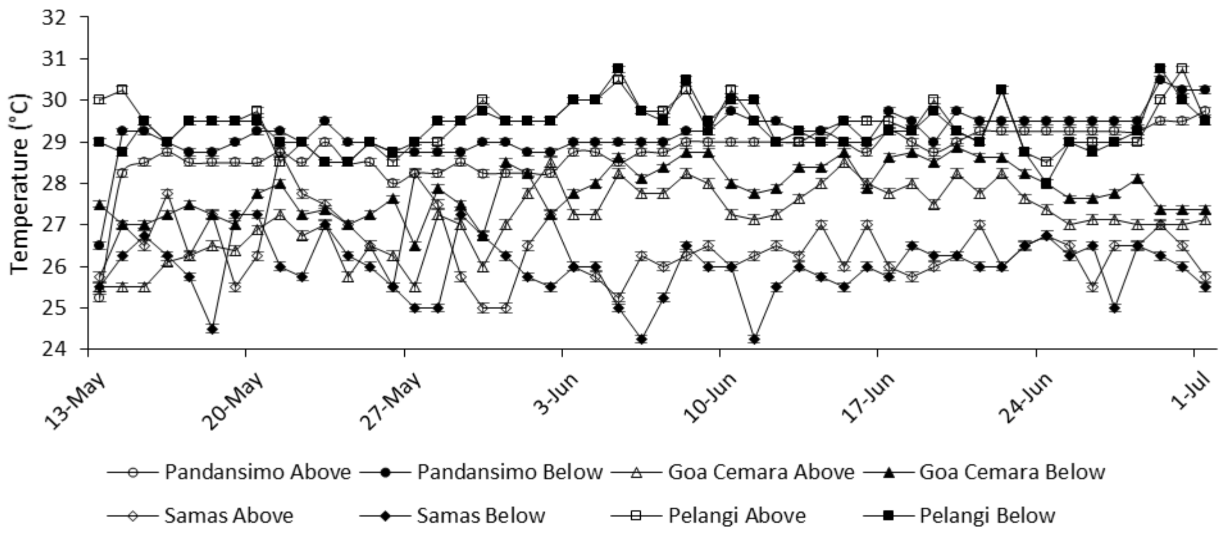

Figure 5. Daily temperature fluctuations of the seminatural nest (for 50 days)

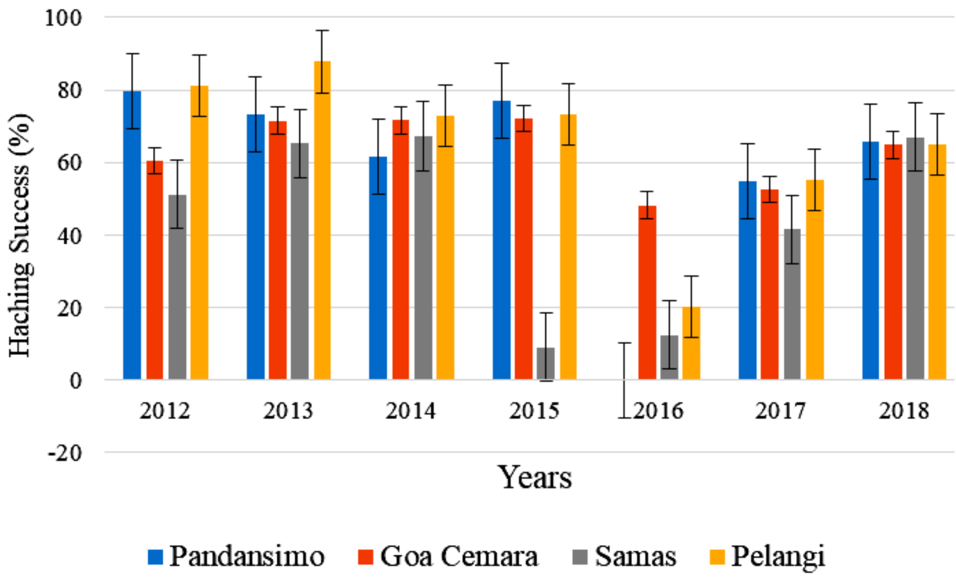

Figure 6. The hatching success of four beaches in Bantul between 2012 and 2018 in Bantul, Yogyakarta, Indonesia

Coastal vegetation and pH

The vegetation on the Bantul beaches in some places was dominated by beach she-oak trees (*Casuarina equisetifolia* L.) planted in 2000. Other types of vegetation on the four beaches were almost the same and included running grass, thistle, papyrus, and pandanus thorn. The results of pH level measurements under shrimp pine trees averaged 5.5, while in seminatural nests, the average pH was 7.

Discussion

We Retrieved data on the width and slope of the beach at the point of the location at which turtle landings occur. The widths of the beaches in Bantul range from 6.76 to 31.26 m (Table 1). From 2012 to 2018, only *L. olivacea* sea turtle was recorded. When *L. olivacea* lay eggs on Bantul, their eggs are mostly present in open areas rather than under vegetation. Their nest locations are consistent with the findings of the study of Hart et al. (2014), who found that eggs on El Naranjo Beach, Mexico were mostly present in the open coastal zone.

The south coast of Java Island has high waves that can pass the open beach and reach to the vegetation in the high wind season, risking the turtle eggs to abrasion. There is a contour change wherein the coastal supratidal zone was reduced on the southern coast of Bantul and may threaten the turtle landing habitat during the high wind season. According to research by Cahyani et al. (2013), from 2006 to 2012, the beaches in Bantul decreased in size by 9.17 ha. The coastal erosion is the reason that the eggs were moved to hatcheries. This is in concordance with the statement of Tripathy and Rajasekhar (2009), who suggested that the threats to sea turtles recorded in India are the changes in coastal uses, coastal erosion, and Casuarina cultivation near the coast.

Pelangi beach indicated as an ideal landing site for turtles because it has slope and beach width that is more suitable. Pelangi Beach has an average beach width of 31.26 m which is ideal for landing turtles in comparison to other beaches in Bantul, even though Pelangi Beach showed a lower percentage of hatchling success than Goa Cemara Beach. We suspected that the high intensity in Pelangi Beach affects the hatchling activity, so the hatchling success in this place are lower than Goa Cemara Beach. In addition, the turtle nests on Pelangi Beach are safer from waves. However, they are at risk if they are left to hatch naturally due to the tourism activities on the beach.

Moreover, the entire beach in Bantul is open for tourism. Ideally, landing beach is free of human activities due to the time needed by the turtles to lay its eggs; for *L. olivacea* it will take an hour to lay its eggs completely (Namboothri et al. 2012). Tripathy and Rajasekhar (2009) hypothesized that the decrease in the *L. olivacea* sea turtle population is due to anthropogenic pressures, such as degradation, transformation, and destruction of beach landing conditions.

Beach slope is another factor that affects beach landings in addition to beach width, cleanliness, community activities, and tides (Anshary et al., 2014). The steeper beach caused the sea turtle more difficult to see the object in from of them to find the right place to lay eggs. Increased steepness also requires more energy by the turtles to achieve the ideal landing spot (Anshary et al. 2014). The slope of the coast in Bantul in the landing zone ranges from 5.10° to 9.67° (Table 1), and the most gentle-sloping area is Pelangi Beach.

The width of a sandy beach is usually related to the slope of the beach. Sloping beaches tend to have a more extended beach width compared to a steeper one (Anshary et al. 2014). A steep coast is thought to be a barrier to the turtle's journey back to the water (Prakoso et al. 2019). A sloping beach makes it easy for turtles to land and lay eggs, while a gentle beach makes it easier for turtles to move away from the waves. When the waves are at maximum, the turtle will find a gentler slope for landing. Even though Samas Beach, Goa Cemara and Pandansimo Beach have an average slope of more than 7.7°, there are sloping places that make *L. olivacea* to land and lay eggs. According to Nuitja (1992), the slope criteria for the beach is as follows: sloping if the slope is less than 8°, slightly sloping if the slope is 8° to 16°, and steep if the slope is more than 16°. Some places on the Bantul coast do have steeper beaches (> 16°), but these places generally not used as landing zones.

Steep beaches will have a narrower supratidal zone, which increases the risk of being hit by waves (Anshary et al. 2014). Considering the data, Pelangi Beach is the most supportive of a turtle landing site in Bantul. This is supported by the existing data that the Pelangi Beach has the most landing spots (15 landing spots) when compared to other beaches in Bantul (Budiantoro 2017). Sandy beaches with magnetic minerals that store heat act as incubators and have a suitable microenvironment for turtle embryo development. Ackerman (1997) said that the physical character influences the microclimate of the nest. The diameter of seminatural nest sand along the coast of Bantul is moderate to fine, with an average size of 0.99 mm, supporting the regulation of aeration and humidity of the nest.

The average total hatching rate from 2012 to 2018 was only 60%, which could be attributed to the high rainfall during the landing season in 2016. The high rainfall led the seminatural turtle nests to become moist and wet, resulting in a low hatching rate, only 23.92%. If the 2016 data were excluded, the average would rise to 70.36%. The magnetic mineral content is very influential on the microenvironment of the hatchery, which is consistent with the statement of Ackerman (1997) that the nesting beach is the incubator for sea turtle embryonic development. The magnetic minerals in seminatural nests in Bantul show an average of 51.69% to 87.50%. This result is consistent with the previous study by Satriadi et al. (2004) in Samas Beach, which reported 76.86% of magnetic material content. Magnetic minerals are metals that have heat conductivity and are capable of storing a solar radiation heat amount of 30% to 80%, thus supporting the egg incubation.

In addition to the mineral content, the temperature in the nest eggs was measured to ensure the successful incubation of the eggs. According to Hamann et al. (2010), the microclimate fluctuations must be recorded to determine whether there is an adaptation to environmental changes, so this research needs to be carried out more frequently. Moreover, the combination of the environment and the whole season in nesting sites will affect the sex ratio of the hatchling (Mrosovsky 1994). Daily temperature fluctuations in seminatural nests of the Bantul beaches ranged from 24.3°C to 31°C for 50 days of measurement (Figure 5). From the incubation carried out in the laboratory, a constant temperature of 26°C produced all-male hatchlings, while 29°C yielded all female turtles. Thus, it can be said that a higher temperature nest will form a more predominantly female sex ratio (Laloe et al. 2014). Using these studies as the basis, the temperature of seminatural nests in Bantul can produce both male and female hatchlings.

Maulany (2009) stated that the higher the incubation temperature, the faster the incubation period to hatching. A significant relationship can be noticed between the temperature of the nest and the smaller morphological parameters of the hatchlings. The hatchlings tend to increase the carapace size at a higher temperature. Thus it is concluded that the nest temperature influences the dimensions of the carapace. However, some reports indicate that sea turtle hatchlings emerging from eggs incubated at lower temperatures tend to have slightly larger carapace size (reviewed by Booth 2017). In general, larger hatchlings will have faster movements. Covered hatcheries sites tend to have lower temperatures with lower hatching rates than open hatcheries.

From the data in Figure 6, it can be seen that the average hatch rate in Bantul during the study period was 60.68%. Hart et al. (2014) reported that the hatching rate was also quite high, at 74.7% in Naranjo Beach, Mexico. In addition, López-Castro et al. (2004) reported that the hatching success of the olive ridley sea turtle (*L. olivacea*) in Cabo Pulmo, southern Baja California reached 73.7%. The average hatching rate in Bantul is rather low, but, actual hatching rate among seminatural nests of the Bantul beaches varies greatly. If the rain continues to fall and the nest is wet, then the percentage is 0% (early landing season), but during the dry season, the hatching rate could reach above 90%. Maulany (2009) stated that eggs must have optimum humidity for embryo development to be able to hatch normally.

Bantul beaches had varied daily nest temperatures, making it suitable for the development of both sexes. A high temperature will yield a female embryo, while a lower temperature will yield a joint male and female embryo. This is because turtles do not have sex chromosomes that express specifically into sex (Milton and Lutz 2010). If the gender is balanced, it will support the turtle conservation act. The beach vegetation in Bantul was dominated by evergreen shrimp pine, which has been deliberately planted since 2000 to reduce abrasion. In micro terms, it can have an adverse effect if the turtle lays its eggs under a shrimp pine tree. This shrimp pine leaves are difficult to decompose and decrease the pH of the sand (5.5 based on the measurement), which does not support the embryo development process. This is different from the seminatural pH, which has a neutral average of 7.0.

The microclimate is very influential in the growth and development of hatchling embryos (Hamman et al., 2010). Other vegetation recorded on the coast of Bantul includes runny grass, thistle, papyrus, and pandanus thorn. Unlike the green turtles that choose beaches with vegetation, the olive ridley sea turtle chooses open coastal areas. The activity of the nesting green turtle (*Chelonia mydas*) is more commonly found in a vegetated environment with *Pandanus tectorius*, *Barringtonia asiatica*, and *Hibiscus tiliaceus* vegetation, while, in places where only propagated vegetation, such as *Ipomoea pes-caprae* exist, the green turtle is generally not nesting (Dewi et al. 2016). Laying eggs on open beaches have a risk of being eaten by wild animals. This threat must be avoided in turtle conservation (Leighton et al. 2010).

Ecologically, the beaches in Bantul have beach slope and sand type that support sea turtle landings and have become the frequent area for turtle landings. The transfer of eggs to hatcheries nests is the best practice, to avoid exposure to high tides, threats from wild animals, and acidic sand conditions that can affect hatchling embryogenesis.

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