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Percentage of Hatching Success of Olive Ridley Turtle (*Lepidochelyis oliviceae*) Eggs in Natural and Semi-Natural Nests and the Quality of the Turtle Conservation Community (TCC), Lombok, Indonesia

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Abstract

Sea turtles are internationally and nationally protected marine reptiles. One of the turtle species that can be found in Indonesia is the Olive Ridley turtle or *Lepidochelys oliviceae*. This study aims to determine the percentage of hatching success of turtle eggs in semi-natural and natural nests at TCC (Turtle Conservation Community), Lombok, determine the physical characteristics of natural and semi-natural nests of turtle eggs, and determine the quality of hatchlings produced in natural and semi-natural nests. The research method used is the descriptive exploration method, including determining the location with purposive sampling, collecting data on the size of Olive Ridley turtle mothers, the number of eggs, the depth and diameter of turtle egg nests, beach slope, nest temperature, substrate grains, beach vegetation, threats to turtle eggs, and locomotor quality of hatchlings. The results of this study are, the percentage of success in natural nests of Olive Ridley turtles is lower at 71.99% and semi-natural nests as much as 59.01%. The average temperature of both nests was 28.67, which is still optimal for turtle egg nesting. The type of grain in the two types of nests is also relatively fine. The slope of the beach is also still relatively gentle. Based on the research conducted by TCC (Turtle Conservation Community), it is suitable to support the success of Olive Ridley turtle hatching.

1. Introduction

Turtles are ancient reptiles that can still be found today. This animal is a protected animal in the world. The status of sea turtles in Indonesia is also protected, which is stipulated in Government Regulation No. 7 of 1999 which discusses the Preservation of Plant and Animal Species. Not only in PP Number 7 of 1999, the Minister of Environment and Forestry Regulation Number 106 of 2018 which discusses the types of protected plants and animals also discusses the status of sea turtles in Indonesia. Globally, according to the IUCN in 2021, sea turtle populations have experienced a decline that has led to extinction. The decline in sea turtle populations in the world is caused by many factors such as hunting, pollution of marine waters, theft of sea turtle eggs, destruction of sea turtle habitats, and many more (Fitriani *et al.*, 2021).

Sea turtles are protected animals both internationally and nationally. This is because this animal has experienced extinction caused by hunting. Therefore, it is necessary to make efforts that can save the population of this animal. One of the ways that can be done is by conducting turtle breeding. This can be reinforced by a journal written by Ningsih and Umroh (2017), which says that turtle breeding activities are carried out with the aim of maintaining the turtle regeneration process. This activity can be started by removing turtle eggs from natural nests and transferring them to semi-natural nests. This activity can increase the percentage of hatching success of the turtle eggs. Moving turtle eggs to semi-natural nests can protect the eggs from predators such as dogs, monitor lizards, foxes, crabs, and ants. The percentage of success in hatching turtle eggs is a calculation made to determine how much success in hatching turtle eggs in a nest. Natural turtle egg nests are nests made by the mother turtle herself. Meanwhile, semi-natural nests are nests made by humans. The reason for transferring turtle eggs to semi-natural nests is to protect the turtle eggs from predators and also to increase the hatching success of turtle eggs (Fitri and Herawati, 2023).

Conservation is an effort made to preserve a biological natural resource. Sa'diyah and Nugraheni (2024), who said that conservation is an effort to maintain a natural resource to remain balanced. If there is no conservation, it can cause the extinction of an animal from the earth or can lead to scarcity. This is also in line with the establishment of sea turtle conservation. Based on the purpose of conservation, a conservation can be said to be optimal if there is an increase in the reproductive success of sea turtles that make landings and then lay eggs. Not only until the turtle lays eggs, but until the turtle eggs become a hatchling (Nabiila *et al.*, 2020).

According to Harnino *et al.* (2021), sea turtles are marine animals that reproduce by laying eggs. The reproductive age of each turtle is different, but in general, the reproductive age of turtles occurs at the age of 25 - 50 years. This can be reinforced by a journal written by Kurniawan *et al.* (2024), who said that the age range of turtle maturity is not the same, the earliest observed at the age of 25 years and the latest observed at the age of 50 years. Sea turtles will mate in the offshore area. A few weeks after mating, the female turtle will go to the beach and then nest on the beach. This can be reinforced by research conducted by Benson *et al.* (2007), which showed that leatherback turtles in the study conducted migrated to the northern hemisphere after nesting. The number of eggs produced by each turtle is not the same. This can be reinforced by a journal written by Rapi *et al.* (2024), who said that sea turtles can produce tens to hundreds of eggs in one nesting. When sea turtles nest and the success percentage of sea turtle egg hatching can be influenced by the physical characteristics of the beach. The physical characteristics of the beach are the physical characteristics of a beach. Each beach has different physical characteristics. The physical characteristics of the beach can be in the form of beach type, sediment grain type, beach vegetation, and so on (Damayanti and Ayuningtyas, 2008).

Sea turtles are threatened animals, there are 2 types of threats that lead to the extinction of sea turtles. Natural threats that occur that can threaten the existence of sea turtles are abrasion and predators. Abrasion is the erosion of beach sand. If abrasion occurs, the place where sea turtles lay eggs will be lost. In addition to abrasion, predators of hatchlings can be birds, crabs, and dogs. This can be reinforced by a journal written by Beto *et al.* (2022), who said that hatchling predators are dogs and crows. Dogs not only prey on hatchlings, but dogs will also prey on turtle eggs. Hatchlings that make it out of the nest become targets for crabs or birds. Other threats come from humans. There are several human activities that threaten the existence of sea turtles such as illegal fishing, buying and selling sea turtles and sea turtle eggs, and polluting sea turtle habitats. In addition, there is also the hunting of sea turtles, for the use of their carapace, meat, and also eggs (Nurhayati *et al.*, 2020).

Every living thing has the ability to move, this ability is called locomotor skills. Locomotor means the movement of the body to move places in various forms of movement such as walking, jumping, running, rolling, dropping, sliding, creeping. This ability is useful for animals to move and also to escape from predators. This ability is also used by hatchlings to get out of the nest, crawl into the water, swim, and justify themselves when they are upside down (Hidayat, 2017).

Locomotor is one of the indicators of turtle quality. This can be reinforced by the journal written by Hatase et al. (2018), which states that the foraging area of mother turtles can affect the quality of the hatchlings produced. Hatchling quality can be seen from morphology, emergence success, and self-rightning. Morphology includes carapace length, carapace width, and hatchling weight. Successful emergence from the nest also uses locomotor skills where hatchlings are required to crawl through the sand that descends into the nest to bring themselves to the surface. Self-righting also requires the hatchlings' locomotor skills by righting themselves when the hatchlings are flipped onto their backs.

Turtle Conservation Community is a community located in Malacca Village, Lombok. Malacca Village is one of the villages in Pemenang District, North Lombok Regency, West Nusa Tenggara Province. This community is precisely located on Nipah Beach. Nipah Beach is one of the beaches located in North Lombok Regency which is a turtle nesting site. Before the existence of this community, turtle eggs produced by sea turtle mothers were left along the panta. After the existence of this community, the turtle eggs along the beach were moved to a semi-natural nest or conservation site owned by this community. This community is engaged in sea turtle conservation. The turtle eggs in the conservation area are semi-natural nests. Due to the research conducted, community members helped researchers by dividing 3 nests into natural nests. The existence of this community has a good impact on local residents. This is because this community helps increase public awareness of the importance of sea turtles for the marine ecosystem. This community is also a place of education for tourists visiting Nipah Beach.

2. Material and methods

2.1. Materials

The materials used in this study consisted of 6 Olive Ridley sea turtle mothers at Nipah Beach, Olive Ridley sea turtle hatchlings, Olive Ridley sea turtle eggs, beach sand, natural and semi-natural nests.

2.2. Tools and Materials

The equipment used in this study is a thermometer to measure the temperature of turtle egg nests, plastic buckets for turtle egg containers before being transferred to semi-natural nests, meters used to measure the width and length of the turtle mother's carapace nesting on the beach, stationery used to record data collected during the study, cameras used to record data collected during the study, and digital *waterpasses* to measure the slope of the beach, flashlights used as a lighting tool during patrols of turtle mothers nesting. PVC pipe 1.5m long as an arena used for hatchlings to walk. Small bucket containing beach sand as a container for storing hatchlings and for turning hatchlings. Sewing meter to measure the length and width of the hatchling carapace. Digital scales to weigh the body weight of the hatchlings. The materials used in this study are turtle eggs as objects to be observed, turtle mothers as objects to be observed to determine the size of turtle mothers who are laying, natural nests and semi-natural nests of turtle eggs as objects observed to determine the percentage of hatching success of turtle eggs in both nests, and beach sand substrates to determine the size of the substrate, turtle hatchlings to determine the quality of hatchlings. *Zip lock* and label for storing beach sand.

2.3. Methods

The method used in this research is descriptive exploratory research method. Descriptive research is research conducted by analyzing only to the level of description, namely by analyzing and presenting data. The data is presented systematically, so it can be easier to understand and conclude. Exploratory research is research that has the aim of finding something new which can be a grouping of symptoms, diseases, or facts. Research with this descriptive-exploratory method has the aim of describing the situation that occurred at the time of conducting the research. Research conducted using this method cannot test a hypothesis. This is because this research method only describes the situation as it is (Akbar *et al.*, 2018).

2.3.1. Location Determination Method

This research was conducted at Nipah Beach, Lombok from May to July 2024. Data were collected using 3 natural nests and 3 semi-natural nests. Determination of the research location was done by purposive sampling. This is because Nipah Beach has turtle conservation. The chance of finding sea turtles nesting will be higher. In addition, with the turtle conservation, the semi-natural nests in that place will be safer than the natural nests. The research that was conducted and required 3 natural nests, therefore there were 3 Olive Ridley turtle nests that were left in their natural nests. The location of the 3 natural nests is at station 2 and the location of the 3 semi-natural nests is at station 1. Natural nests that are not moved to conservation buildings are guarded using iron mesh and the nests are also marked with stakes containing information on the type of turtle, number of eggs, nesting date, and estimated hatching date. In addition, by collecting data on the quality of the hatchlings, it was also possible to compare the hatchlings in the natural and semi-natural nests and relate this to the success of conservation in that area.

2.3.2. Time and Location

This research was conducted on April 30 – July 10, 2024. Data collection was carried out at Nipah Beach, Malaka Village, Pemenang District, North Lombok Regency, West Nusa Tenggara (Figure 1). The stages of this research began with planning, data collection, and data processing.

2.3.3. Determination of the Percentage of Hatching Success of Olive Ridley Turtle Eggs in Natural dan Semi-Natural Nests

This data collection can be done if the turtle eggs have hatched and then count the hatchlings that successfully hatch and count the number of eggs that do not succeed. After conducting field calculations, data processing is then carried out by entering data on eggs that successfully hatch and eggs that do not hatch into the formula used to calculate the percentage of hatching success. The formula used is as follows (Sinaga *et al.*, 2024).

$$\text{Percentage of eggs hatched (\%)} = : \frac{\text{Number of Live Hatchlings} + \text{Number of dead hatchlings}}{\text{Number of turtle eggs}} \text{ x } 100\%$$

2.3.3. How to Measure the Locomotor Activity of Hatchlings

Data taken to determine the liveliness of hatchlings is using 2 matrices, namely the speed of walking hatchlings and the speed of hatchlings turning themselves over. Hatchlings used in this study were all hatchlings that successfully left the nest (Maulany *et al.*, 2012):

a. Hatchling crawling speed: in this treatment, the hatchlings crawled on a 1.5 m long sand-filled PVC pipe. Hatchlings were placed at the end of the PVC and then the hatchling crawling speed was calculated from the end where the hatchling was placed until the hatchling reached the other end of the PVC. Each hatchling was repeated 3 times. Then the hatchling speed was converted into Cm.s-1. If the hatchling did not make it within 240 seconds (4 minutes) then the hatchling failed in the crawling category. In this experiment, the hatchlings will then be divided based on their success in the form of a percentage of success. 0.00% indicates that the hatchlings did not succeed at all in this experiment. 33.33% indicates that the hatchling succeeded in 1 attempt. 66.67% indicates that the hatchlings succeeded in 2 attempts. 100.00% indicates that the hatchlings made 3 attempts.
b. Hatchling reversal speed: in this treatment the hatchlings were reversed from the initial position of the plastron facing down to the plastron facing up. The same as the previous treatment is to see how quickly the hatchlings can justify themselves when they are upside down and each hatchling is done 3 repetitions. After the hatchlings had performed one repetition, they were given 30 seconds to rest before performing the next repetition. The assessment carried out in this matrix is to give a score of 0-3 to each hatchling that runs the treatment. Hatchlings will receive a score of 3 if they can successfully repair themselves in less than 1 minute 3 times. Hatchlings will get a score of 2 if they can successfully repair themselves twice in less than 1 minute. The hatchling will get a score of 1 if the hatchling only succeeds 1 time to repair itself in less than 1 minute. Hatchlings will get a score of 0 if

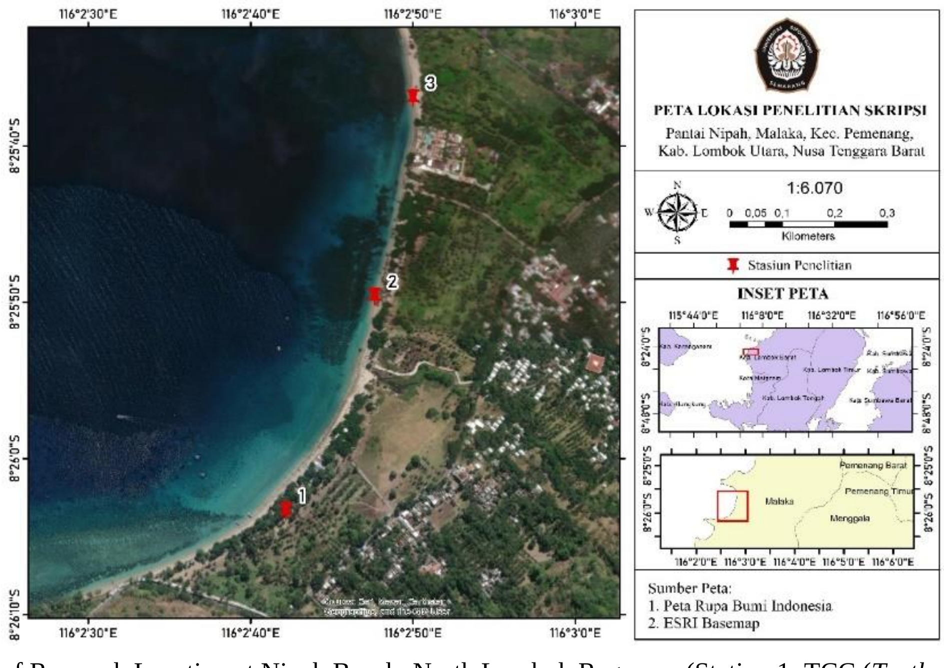

Figure 1. Map of Research Location at Nipah Beach, North Lombok Regency (Station 1: TCC (*Turtle Conservation Community*), Station 2: eastern vegetation, Station 3: natural nest and western vegetation, Station 4: natural nest and western vegetation).

they cannot repair themselves at all in less than 1 minute. In this experiment, the hatchlings will then be divided based on their success in the form of a success percentage. 0.00% indicates that the hatchling did not succeed at all in this experiment. 33.33% indicates that the hatchling succeeded in 1 attempt. 66.67% indicates that the hatchlings succeeded in 2 attempts. 100.00% indicates that the hatchlings succeeded in 3 attempts.

2.3.4. Physical Characteristics Data Collection and Measurement Procedure

2.3.4.1. Nest Temperature Data Collection

Nest temperature data were collected using a mercury thermometer. The thermometer was inserted into the turtle egg nest. The depth to insert the thermometer is about 30 cm. When inserting the thermometer, it is necessary to be careful so as not to endanger the eggs inside. After the thermometer is inserted into the nest, wait for a few minutes until the liquid inside the thermometer stops rising or falling. This indicates that the measured temperature has stabilized. After the temperature has stabilized, remove the thermometer from the nest, in this step avoid touching the bottom of the thermometer inserted into the nest. This is to avoid any changes in the temperature that has been obtained previously. The last step is to take notes. This temperature measurement was carried out on 3 natural nests and 3 semi-natural nests. Nest temperature data were collected at 06.00 (morning), 13.00 (afternoon), and 19.00 (evening) (Rianda *et al.*, 2017).

2.3.4.2. Nest Depth and Diameter Data Collection

Data collection on the depth and diameter of the nest was carried out using a meter, data collection of depth was carried out by re-excavating the natural nest. Then the eggs from the nest were stored in a bucket containing sand from the beach. After that, the depth of the nest was measured and recorded. After the depth of the nest was recorded, the eggs in the bucket were put back into the nest. It is different to measure the depth of a semi-natural nest. The first step taken in measuring the depth of a semi-natural nest is to build a semi-natural nest first. Then measure and record the depth of the semi-natural nest. If the measurement of the depth of the nest has been done, the eggs are moved into the semi-natural nest. Diameter measurement is done by measuring the distance between the sides. Depth and diameter measurements were taken once in each nest (Benni *et al.*, 2017).

2.3.4.3. Substrate Data Collection

Substrate data collection was carried out using the *sieving* method with a *sieve shaker.* The first step is to take 200 grams of substrate at each data collection point. Then the substrate will be analyzed and also observed in the laboratory. If the sediment size has been found, the next step is to analyze it using a texture triangle (Beto *et al.,* 2022).

2.3.4.4. Beach Slope Measurement

Taking beach slope data is done using a *waterpass*. *Waterpass* is a tool used to measure objects or lines in a flat position. This tool can take measurements horizontally and vertically. *Waterpass* itself is divided into 2 types, namely conventional and digital waterpasses. Conventional waterpasses can be made using hoses and sticks to measure the slope of the beach. For this study, the slope of the beach was carried out using a digital *waterpass*. This digital waterpass will immediately provide a beach slope number on its screen (Syaputra, 2020).

The *waterpass* used in the research is a digital *waterpass*. The use of this waterpass is to turn on the *waterpass* by pressing the *on/off* button, then the *waterpass* is placed on the beach sand to measure the slope. After the number comes out on the *waterpass* layer then press the *hold* button so that when the *waterpass* is lifted the number does not change. After that, press the *unit* button on the *waterpass* to change the slope unit on the *waterpass*.

2.3.5. Calculation of Turtle Eggs Count

Data collection on the number of turtle eggs is done by making observations. The method used in this data collection is analysis. The analysis is done by counting one by one the number of turtle eggs in each nest. Data collection on natural nests can be done by counting when the turtles are nesting. Data collection on the number of turtle eggs in semi-natural nests can be done when transferring eggs from natural nests to semi-natural nests (Ningsih and Umroh, 2017).

2.3.6. Vegetation Data Collection

Vegetation data collection is carried out by making observations in the nesting area. This can be reinforced by the journal written by Tiwa *et al.* (2023), which says that vegetation data is collected by observing the nesting area. Vegetation observations are carried out directly, the results of these observations are then recorded with standing units.

2.3.7. Morphological Measurement of Olive Ridley Turtle Broodstock

This data collection first measured the length and width of sea turtle mothers who were laying and then counted the number of eggs produced (Figure 2). After that, make comparisons by reading journal references or books that discuss the relationship between the size of sea turtle mothers and the eggs produced. Measurement of turtle broodstock was carried out by measuring CCL (*Curved Carapace Length*) and CCW (*Curved Carapace Width)* using a meter. Measurement of CCL or the length of the mother turtle's carapace is done by drawing a straight line from the end of the carapace close to the mother's head to the end of the lower carapace. Measurement of CCW or the width of the turtle's carapace is done by drawing a straight line from the left side of the turtle's carapace to the right side of the turtle's carapace. This width measurement is done by measuring the widest point of the turtle's carapace (Bolten, 1999).

2.3.8. Predator Data Collection

Predator data collection is done by observing the nesting area. This can be reinforced by the journal written by Tiwa *et al.* (2023), who said that predator data was collected

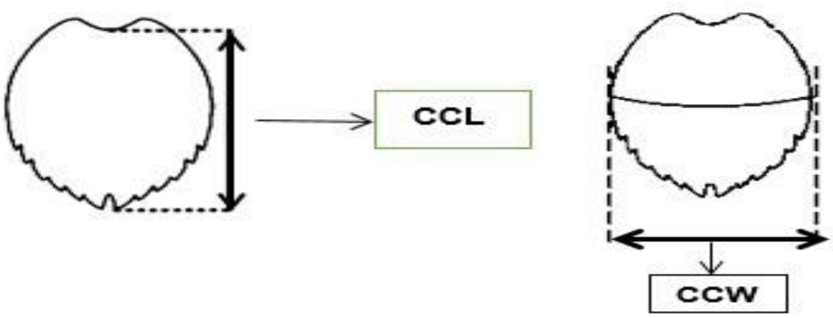

Figure 2. Measurement of CCL (Curved Carapace Length) and CCW (Curved Carapace Width) of Sea Turtles.

by observing the nesting area. Observations of predators are carried out directly and the results of these observations are then recorded.

2.3.9. Data Analysis

Data were recorded, tabulated, and analyzed using regression analysis to measure the presence or absence of a correlation and the pattern of relationships that occur between variables. Turtle eggs with turtle mother size (Suhandi *et al.*, 2018).

3. Results

3.1. Percentage of Hatching Success of Olive Ridley Turtle Eggs in Natural and Semi Natural Nests

The percentage of hatching success of Olive Ridley turtle eggs in natural and semi-natural nests is different. The percentage of hatching success of Olive Ridley Sea Turtle eggs can be seen in Tables 1 and 2 and Figure 3 as follows:

Based on the total number of eggs in both natural and semi-natural nests have differences. The highest total number of eggs in semi-natural nests is 130 eggs and the least total number of eggs in semi-natural nests is 72 eggs. While the total number of eggs in natural nests is 124 eggs and the total number of eggs in natural nests is 102 eggs. Based on the percentage of hatching success in both natural and semi-natural nests, there are differences. The percentage of hatching success in semi-natural nests is higher than in natural nests.

Table 1. Percentage of Hatching Success of Olive Ridley Turtle Eggs in Semi-Natural Nests

Turtle to	Total number of eggs	Eggs successfully hatched	Eggs did not successfully hatch	Percentage of success (%)
1	130	80	50	82.6
2	101	73	88	74.1
3	72	55	17	59.2
Average	101	69.33	51.67	71.99
± Standard Deviation	29	12.90	35.53	11.83

Table 2. Percentage of Hatching Success of Olive Ridley Turtle Eggs in Natural Nests

Turtle to	Total number of eggs	Eggs successfully hatched	Eggs did not successfully hatch	Percentage of success (%)
1	120	45	75	46.6
2	124	37	87	38.4
3	102	92	10	92.0
Average	115.33	58	57.33	59.01
± Standard Deviation	11.72	29.72	41.43	23.57

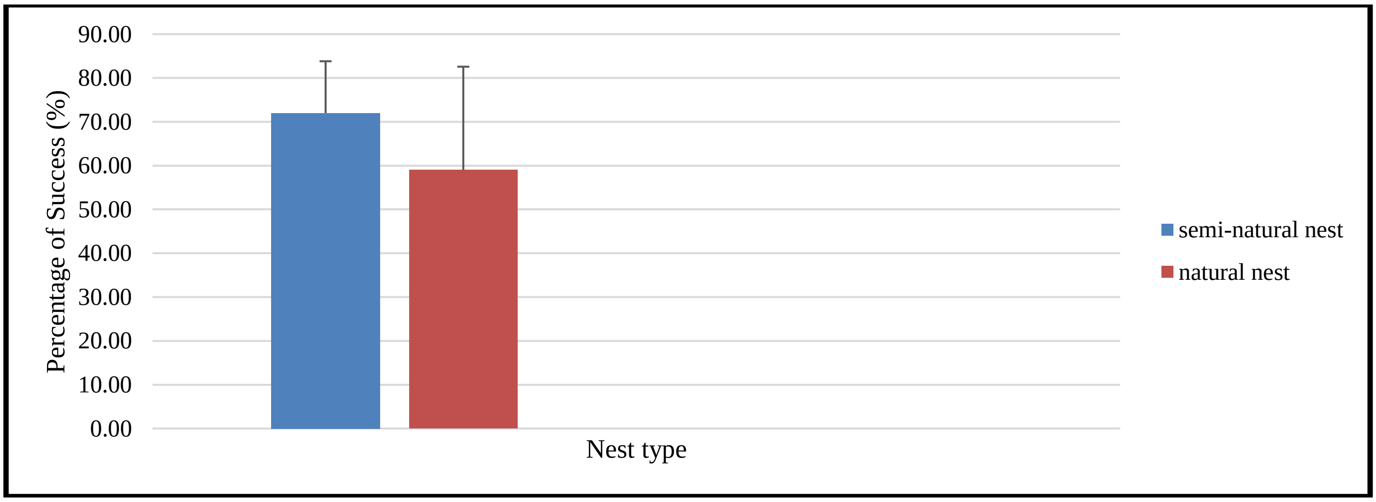

Figure 3. Hatching Percentage in 2 Types of Olive Ridley Sea Turtle Egg Nests.

3.2. Quality of Hatchlings Produced from Semi-Natural and Natural Nests

Hatchling quality was measured using two parameters: hatchling walking speed and hatchling flipping speed. The quality of hatchlings and the average size of Olive Ridley Sea Turtle hatchlings produced in natural and semi-natural nests can be seen in Tables 3-8 and Figures 4-6 below:

Based on the percentage of hatchlings that successfully crawled, there were also differences between semi-natural and natural nests in each experiment. Based on the table, the percentage of hatchlings successfully crawling is higher in natural nests than in semi-natural nests.

Based on the percentage of hatchlings that successfully turned themselves over, there were also differences between semi-natural and natural nests. Based on the table, the percentage of hatchlings successfully turning themselves over is higher in natural nests than in semi-natural nests.

Table 3. Total percentage of success of hatchlings crawling in semi-natural nests

Semi Natural Nest							
No.	**Number of Eggs**	**Number of Hatchlings**	**Total Hatchling Weight (g)**	**Number of hatchlings successfully walked**			
				0x	**1x**	**2x**	**3x**
1	130	80	45	10	4	12	54
2	101	65	134	33	3	4	25
3	72	57	101	0	1	0	56
Total	303	202	280	43.00	8.00	16.00	135.00
Percentage of Hatchling Success				21%	4%	8%	67%

Table 4. Total percentage of successful hatchlings crawling in the Natural Nest

Natural Nest							
No.	**Number of Eggs**	**Number of Hatchlings**	**Total Hatchling Weight (g)**	**Number of hatchlings successfully walked**			
				0x	**1x**	**2x**	**3x**
1	102	92	124	0	0	3	89
2	124	37	126	1	0	3	33
3	120	46	90	1	1	2	42
Total	346	175	340	2	1	8	164
Percentage of Hatchling Success				1%	1%	5%	94%

Table 5. Total percentage of success of hatchlings flipping in semi-natural nests

Semi Natural Nest							
No.	**Number of Eggs**	**Number of Hatchlings**	**Total Hatchling Weight (g)**	**Number of hatchlings successfully fledged**			
				0x	**1x**	**2x**	**3x**
1	130	80	45	1	1	4	74
2	101	65	134	1	6	9	49
3	72	57	101	5	7	12	33
Total	303	202	280	7	14	25	156
Percentage of Hatchling Success Reversing				3%	7%	12%	77%

Table 6. Total percentage of success of hatchlings turning over in the Natural Nest

Natural Nest							
No.	**Number of Eggs**	**Number of Hatchlings**	**Total Hatchling Weight (g)**	**Number of hatchlings successfully fledged**			
				0x	**1x**	**2x**	**3x**
1	102	92	124	0	1	1	90
2	124	37	126	0	1	0	36
3	120	46	90	7	8	7	24
Total	346	175	340	7	10	8	150
Percentage of Hatchling Success Reversing				4%	6%	5%	86%

Descr:
0 x= 0.00% = failed or could not reverse themselves
1 x= 33.33%= successful 1x self-reversal
2 x= 66.67%= successful 2 x self-reversing
3 x= 100%= successful 3 x self-reversing

Table 7. Average weight, width, and length of hatchlings in semi-natural nests

No.	**Number of Eggs**	**Number of Hatchlings**	**Average Hatchling Weight (g)**	**Average Hatchling Width (cm)**	**Average Hatchling Length (cm)**
1	130	80	14.2	5.09	5.04
2	101	65	19.2	4.72	4.74
3	72	57	18.7	4.64	4.82
Total	303	202	52.1	14.45	14.6
Average	101	67.33	17.37	4.82	4.87
± Standard Deviation	29	11.68	2.75	0.24	0.16

Table 8. Mean weight, width, and length of hatchlings in Natural Nests

No.	Number of Eggs	Number of Hatchlings	Average Hatchling Weight (g)	Average Hatchling Width (cm)	Average Hatchling Length (cm)
1	102	92	16.6	4.4	4.58
2	124	37	16.2	4.3	4.19
3	120	46	19.8	4.77	4.72
Total	346	175	52.6	13.47	13.49
Average	115.33	58.33	17.53	4.49	4.50
± Standard Deviation	11.72	29.50	1.97	0.25	0.27

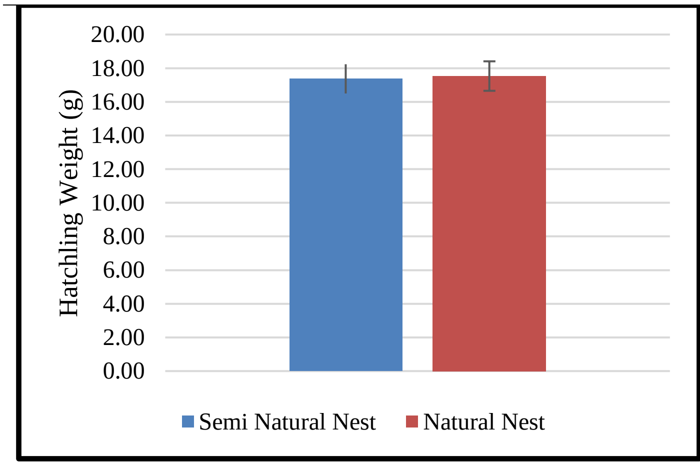

Figure 4. Average Weight of Hatchlings in Natural and Semi Natural Nests

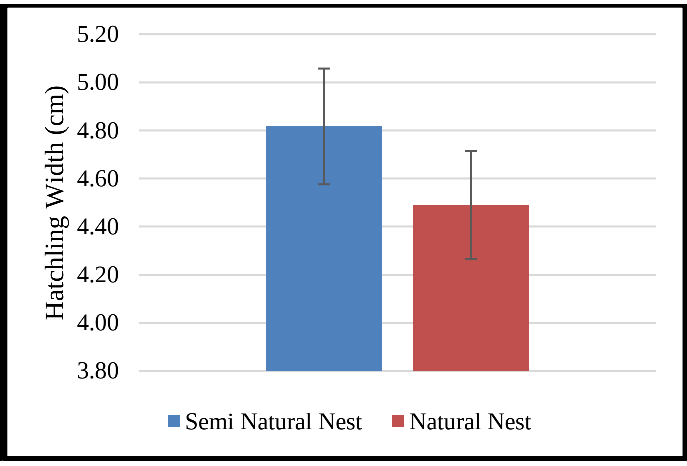

Figure 5. Average Width of Hatchlings in Natural and Semi-Natural Nests

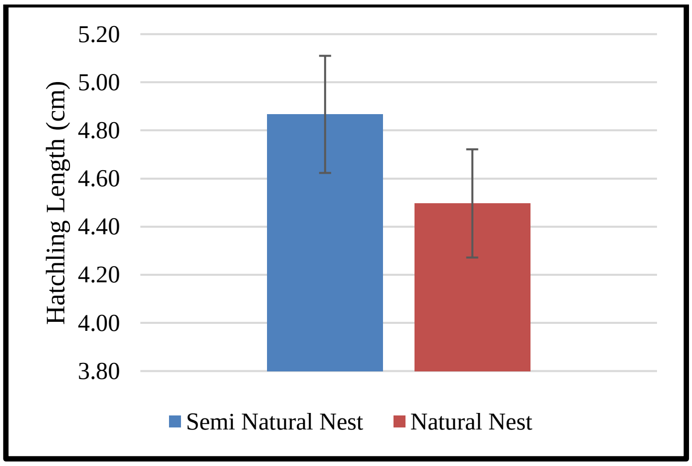

Figure 6. Average Length of Hatchlings in Natural and Semi-Natural Nests

Based on measurements of the weight, width, and length of hatchlings taken in natural and semi-natural nests, the weight, width, and length of hatchlings produced in the two nests were not too different.

3.3. Physical Characteristics

Each beach has different physical characteristics, and the physical characteristics of Nipah Beach will not be the same as those of other beaches. Beach characteristics can be in the form of beach slope, beach width, and beach sand grains.

3.3.1. Nest Incubation Temperature with Percentage of Hatching Success and Locomotors

Temperature is an important factor in the successful hatching of turtle eggs. In the research conducted, the conditions of natural and semi-natural nests were quite different. Semi-natural nests are found in conservation areas, where the nests are protected from direct sunlight. Whereas in natural nests there are 2 turtle egg nests that are in open areas and there is no shade on the nests. The following are the results of temperature data collection carried out on each turtle egg nest (Figure 7-12):

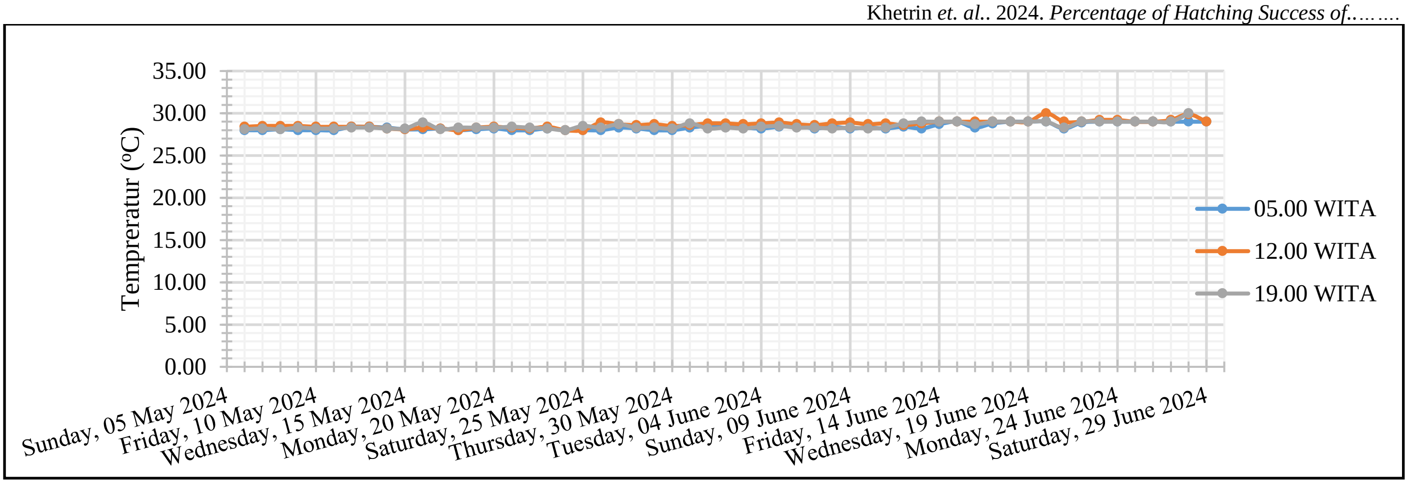

Figure 7. Incubation Temperature in Semi-Natural Nest of 130 Turtle Eggs

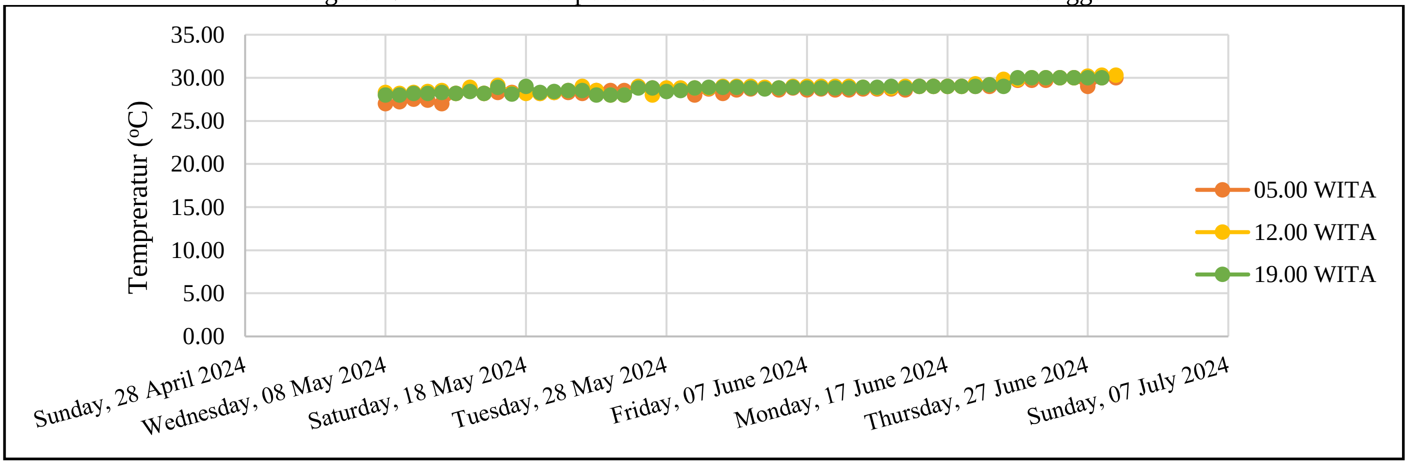

Figure 8. Incubation Temperature in Semi-Natural Nest of 101 Turtle Eggs

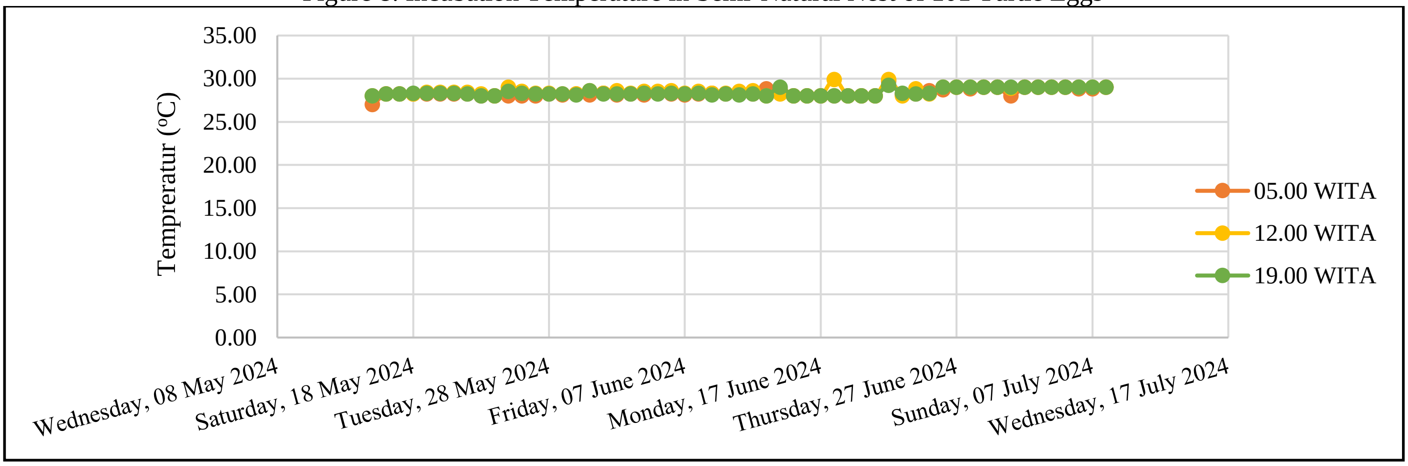

Figure 9. Incubation Temperature in Semi-Natural Nest of 72 Turtle Eggs

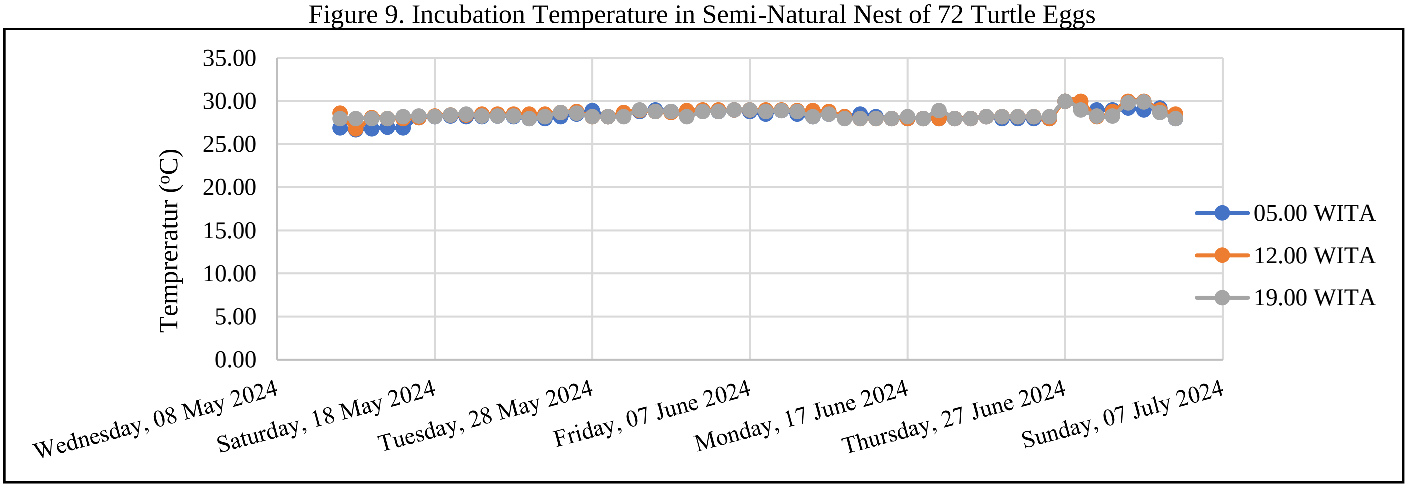

Figure 10. Incubation Temperature in Natural Nest of 102 Turtle Eggs

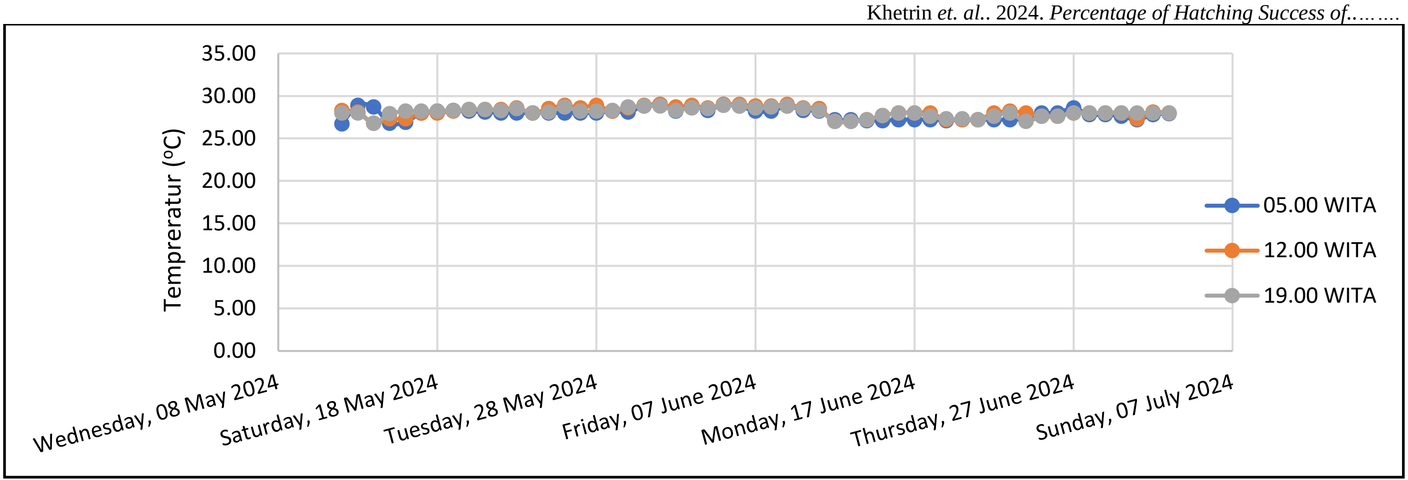

Figure 11. Incubation Temperature in Natural Nest of 120 Turtle Eggs

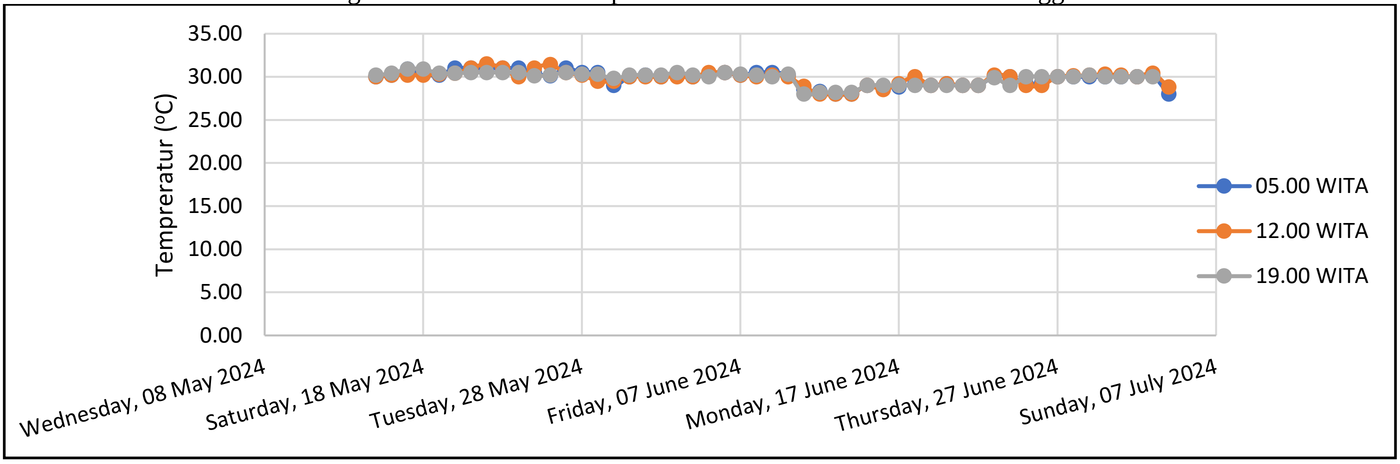

Figure 12. Incubation Temperature in Natural Nest of 124 Turtle Eggs

3.3.2. Nest Size

The size of nests in natural and semi-natural nests has the same size which can be seen in Table 9 as follows:

The table above shows that the depth and diameter of the nest mouth between natural and semi-natural nests are almost the same. This is because the size of the semi-natural nest is equalized to the size of the natural nest before the eggs are transferred.

Table 9. Nest size

		Nest Depth		
No.	**Number of eggs**	**Nest Type**	**Depth (cm)**	**Diameter (cm)**
1	130	Semi-natural	30	30
2	101	semi natural	30	25
3	72	Semi-natural	30	25
		Average	30	26.67
4	120	Natural	40	30
5	102	Natural	30	25
6	124	Natural	30	25
Average			33.33	26.67

Table 10. Sand grain types in natural and semi-natural nests

Grain Type	**Nest type**			
	Experience	**Experience**	**Experience**	**Semi Natural**
very coarse sand	0.90%	0.60%	0.78%	2.50%
coarse sand (hard)	14.20%	12.18%	7.42%	29.40%
medium *sand*	9.45%	11.80%	6.58%	10.40%
fuse sand (fine)	51.30%	66.22%	64.80%	43.80%
fuse sand (fine)	23.95%	12.03%	24.80%	15.68%
very fine *sand*	3.55%	1.07%	2.52%	1.38%
silt	0.75%	1%	0.97%	0.90%

3.3.3. Grain Type of Natural and Semi-Natural Nesting Sand

The size of sand grain types in natural and semi-natural nests can be seen in Table 10 as follows:

Based on the grain analysis conducted on natural and semi-natural nests, it shows that there are different sizes of grain types in the two types of nests. Table 13 shows that the types of very hard, hard, and medium grains are highest in semi-natural nests. The percentage of fine sand grain type is high in both types of nests. While the type of very fine grains is highest in natural nests. Silt grain type is highest in natural nests

3.3.4. Beach Slope and Width

Slope and width of the beach in Table 11 as follows:

Based on the slope and width measurements conducted, it was found that the slope of each nest varied. According to Table 11, the average slope at station 1 was smaller compared to stations 2 and 3.

3.3.5. Vegetation Type

Vegetation can only be found in the area around the natural nest. The types of vegetation in natural nests can be seen in Table 12 as follows:

Based on observations made, coastal vegetation is only at stations 2 and 3 where natural nests are located. While in the semi natural nest at station 1 no vegetation was found. This is because the semi-natural nest is inside the conservation building.

Table 11. Slope and Width of Nipah Beach.

	Station			
	Station 1	**Station 2**	**Station 3**	**Station 4**
Slope	7.50^o	8.20^o	9.60^o	5.60^o
	9.50^o	6.70^o	9.40^o	4.90^o
	12.10^o	6.00^o	10.60^o	4.40^o
Average	9.70^o	6.97^o	9.87^o	4.97^o
Width	6,5m	10,3m	24,6m	21,9m

Table 12. Vegetation of Nipah Beach

No.	Beach Vegetation			Total Stand
	Common Name	**Local Name**	**Scientific Name**	**Station 3&4**
1	Pandan Laut	Pandan Laut	*Pandanus odorifer*	21
2	Waru	Waru	*Hibiscus tiliaceus*	44
3	Keranji	Keranji	*Dialium indum*	5
4	Sea Bidara	Sea Bidara	*Strychnos lucida*	0
5	Coconut	Coconut	*Cocos nucifera*	40
6	Ketapang	Ketapang	*Terminalia chebula*	1
7	Katang-Katang	Horse Treads	*Ipomoea pescaprae*	12
8	Biduri	Rembiga	*Calotropis gigantea*	9
9	Nyamplung	Nyamplung	*Calophyllum inophyllum*	3
10	Gelagah	Sea Sugarcane	*Saccharum spontaneum*	23

3.4. Threats to Turtle Eggs

Sea turtles have predators in every phase of their lives, whether they are eggs, hatchlings, or adults. Some of the things that pose a threat to the existence of panyu eggs in this study are the presence of stray dogs and small crabs. These stray dogs live around Nipah Beach. Based on the experience during the research, the stray dogs would even wait and bark at the turtle hatchlings that were laying eggs. The stray dogs would then wait for the turtle to finish laying eggs and then dig up the nest. Therefore, the conservation members' effort to protect the turtle eggs is to move the eggs to semi-natural nests located in the conservation area. In addition, a fence is placed around each nest to prevent it from being dug up by stray dogs. The next threat is small crabs that live in the sand. This is a threat that is difficult to avoid because crabs are sand-dwelling animals and turtle eggs are stored in the sand. The crabs can eat the turtle eggs that are being stored in the sand. However, this can be avoided by storing turtle eggs in an incubator (Ario *et al.*, 2016).

In addition to predators, threats to the success of turtle egg hatching are climate and abrasion. Abrasion is a threat to sea turtle nesting habitat, abrasion is also a dominant factor that greatly affects the coastline. This can be reinforced by a journal written by Mustaqim et al., (2020), which says the occurrence of abrasion on a beach can change the width and slope of a beach. The occurrence of abrasion on a beach can also degrade coastal vegetation. Temperature changes can have the greatest impact on sea turtles. This is because sea turtles are ectotherms where the nature of sea turtles is strongly influenced by the temperature of their environment. An increase in ambient temperature can affect turtle eggs that are in the incubation process. The increase in temperature can affect embryo development, hatching success, hatchling sex ratio, and hatchling characteristics (Fuentes *et al.*, 2011).

4. Discussion

4.1. Percentage of Success

This study was conducted by comparing the percentage of success in 2 types of turtle egg nests, namely semi-natural nests and natural nests. Semi-natural turtle egg nests are nests made by humans, so turtle eggs from their natural nests are moved into semi-natural nests that have been made by humans. While the natural nest of turtle eggs is a nest of turtle eggs made by the mother turtle herself. Based on the percentage value of success, each nest produces a different percentage value of hatching success. The average percentage of hatching success in semi-natural nests is 71.99% with a standard deviation value of 11.83. The average percentage of hatching success in natural nests is 59.01% with a standard deviation value of 23.57. based on these data, the percentage value of hatching success in semi-natural nests has a higher value than in natural nests.

The high percentage value of hatching success in semi-natural nests can be influenced by many things such as temperature, grain type, predators, and several other things. The semi-natural nests in the TCC (Turtle Conservation Community) are located inside the building, so the semi-natural nests are under the roof of the conservation building. The presence of this shade can be the reason for the high percentage of hatching success. This is because semi-natural nests are not exposed to direct sunlight. This can be reinforced by a journal written by Rosalina and Prihajatno (2022), which says that the presence of shade will protect the nest from sunlight and rainwater.

The success of hatching turtle eggs is influenced by many things nest depth, sand grains, predators, and many others. Based on research conducted by Sheavtiyan and Lovadi (2014) percentage value of turtle egg hatching success with a value of 69.7% - 79.3% can be said to be quite good. That way, the percentage of success in semi-natural and natural nests can be said to be quite good. However, in one of the natural nests there was 1 nest that had a success percentage value of 38.4%. The low percentage value of success in natural nests can be influenced by many things such as nest temperature, nest location, nest depth, nest environmental conditions, and several other things. This can be reinforced by a journal written by Maulana *et al.* (2017), which says that the nest location environment can also affect the development of egg embryos. Based on the research conducted, there is 1 natural nest that has plant roots in the nest. These tree roots can interfere with the development of turtle egg embryos. Tree roots can enter the eggshell which can then cause death to the eggs. In addition, the presence of roots in turtle egg nests can block the exit of hatchlings to get out of the nest.

4.2. Quality of Hatchlings in Natural and Semi-Natural Nests

Based on the locomotor data obtained, each nest produced a different average hatchling size, weight, walking speed, and flipping hatchlings. The body size of the hatchlings can be seen from the size of the eggs produced by the mother turtle. The larger the eggs, the larger the hatchlings. However, hatchling size was not affected by incubation temperature. The size of a turtle's body is not influenced by its incubation temperature, but rather by its genetics. Hatchlings' locomotor activity can be influenced by nest incubation temperature. The higher the nest temperature, the slower the hatchlings will walk and take longer to correct themselves. The influence of temperature not only affects the movement of hatchlings on land but can also affect their swimming activity. Prolonged exposure to high incubation temperatures in sea turtle egg nests can affect the developing physiological system so that hatchlings experience impaired locomotor performance which can ultimately reduce hatchling fitness. This is not only the case for turtles but also for tortoises. Decreased locomotor performance of hatchlings increases their potential to be preyed upon (Maulany *et al.*, 2012).

Based on the results obtained, it shows that the good quality of locomotor activity of hatchlings is produced from natural nests. This is indicated by the percentage value of the success of hatchlings crawling and turning themselves over. Based on the results, the percentage of success of hatchlings crawling and turning themselves over was higher in natural nests than in semi-natural nests. These differences can be influenced by the egg hatching environment. One of the environmental factors that can influence this is beach sand as a medium for turtle egg incubation. The type of sand grains in semi-natural nests based on the results of grain analysis has a hard grain type. Another thing that can affect the locomotor of hatchlings is the cleanliness of semi-natural nests. Based on research conducted on several semi-natural nests, there are still some remnants of turtle eggs in the sand of semi-natural nests. The cleanliness of semi-natural nests can affect the locomotor of the hatchlings produced. It can reduce the risk of contamination caused by fungi, bacteria, or parasites from previous egg remains. Therefore, it is necessary to change the sand to reduce the risk of contamination (Samosir *et al.*, 2018).

According to Booth (2017), the journal states that the optimal temperature for hatchling locomotion is 28°C - 32°C. Hatchling performance will decrease if eggs are incubated at temperatures greater than the maximum temperature or lower than the minimum temperature. Based on the average temperature in semi-natural nests and natural nests, it is still considered optimal for hatchling locomotion. Based on the data above, hatchling performance is quite good. This is because the average temperature of all nests is still considered optimal for hatchling locomotor performance.

4.3. Nest Size of Olive Ridley Sea Turtle Eggs

In this study, data were collected on the depth and diameter of sea turtle nests. The depth of the nest in semi-natural nests is made to adjust the depth and diameter of the previous natural nest. This is done to avoid damage or failure of turtle eggs. Based on the data contained in Table 3 , the average depth of turtle egg nests is 31.66 cm and the average width is 26.66 cm. Based on the average depth of the nest is still classified as reasonable. This can be reinforced by a journal written by Bahri *et al.* (2022), based on research conducted, the depth of semi-natural nests made has the same characteristics as the depth of natural nests, namely with a depth of 45 cm and the width of the nest mouth is 21 cm.

Nest depth can affect the success of hatching in turtle egg nests. However, the depth of the nest is also followed by the type of sand grains on a beach. If the nest is dug too deep, it can put too much pressure on the eggs inside. In addition, it can also inhibit the entry of oxygen into the nest. In the development of turtle eggs, oxygen is needed so that the eggs can develop into hatchlings. In addition, if the nest is too deep, it can prevent the hatchlings from rising to the surface of the sand. This is because hatchlings need a lot of energy to find a way out of the sand (Sara and Halili, 2024).

The depth of turtle egg nests can also affect the length of incubation of the eggs. Based on the data obtained, the length of egg incubation days in semi-natural nests has an average of 54.3 and the average length of incubation in natural nests is 52.6. Based on these data, natural nests have a lower average incubation, which indicates that the incubation period of eggs is faster. The speed of the incubation period can be influenced by temperature or sunlight. Based on the research conducted in this study, the natural nests of turtle eggs are around the nipah beach and the condition of the nests is open or there is no vegetation around the natural nests. These nests will be more often exposed to sunlight compared to nests in the conservation building area. This can also be reinforced by a journal written by Rizki *et al.* (2024), who said that the incubation period of turtle eggs will be shorter if the nests are free from shade. This is because the nest is more often exposed to sunlight.

4.4. Nipah Beach Vegetation

Coastal vegetation is a type of plant that grows in intertidal areas ranging from tidal areas to land areas that are still affected by tides. Coastal vegetation also has a role to prevent abrasion. In addition, coastal vegetation can also be a breakwater, this is because coastal vegetation usually has long and strong roots. Coastal vegetation found on a beach can be a habitat for sea turtles to nest. This is because sea turtles will nest under the vegetation so that the eggs are safe. Beach vegetation is also a natural shade for turtle egg nests, with the presence of vegetation, turtle eggs in the sand will not be exposed to excessive sunlight. Not only that, the existence of beach vegetation can also protect turtle egg nests from sea water disturbances and also predatory animals (Darwati *et al.*, 2022).

Based on observations made around Nipah Beach, 10 types of beach vegetation were found with different amounts. The beach vegetation found are sea pandanus, waru tree, keranji tree, sea thistle tree, coconut tree, ketapang tree, katang-katang (horse tread), biduri tree, nyamplung tree, and gelagah. The discovery of this vegetation can be strengthened by a journal written by Septiana *et al.* (2019), who said that the coastal area is overgrown by 3 types of plants, namely horse tread, sea pandanus, and sea cypress. Horse tread is also one of the coastal vegetation that is often found in coastal areas. This plant grows creeping on the shoreline that is still exposed to the highest tide or areas that are still slightly submerged by sea water during high tide. Vegetation types that are closer to land are usually dominated by trees or large trees and several types of shrubs. This is because the sand in the area is already mixed between sea sand and soil. Some types of trees that can be found are ketapang, coconut, and nyamplung.

4.5. Effect of Temperature on Nesting of Turtle Eggs and Hatchlings Produced

The temperature range in semi-natural nests is 27 - 30oCwith an average of 28.02 - 29.84o. The length of incubation days in semi-natural nests is 54 and 55 days. Meanwhile, Table 13 shows the average temperature per day in natural nests. The temperature range in natural nests is around 27 - 30oCwith the length of incubation days being 52 - 54 days. A good incubation temperature for Olive Ridley sea turtle eggs is 25oC- 33oC. If the nest temperature exceeds the maximum temperature, it can result in a decrease in the percentage of hatching success of sea turtle eggs. The temperature of both natural and semi-natural turtle egg nests is in accordance with the temperature that should be (Umama *et al.*, 2020).

Incubation temperature is one of the abiotic factors that can affect the hatching success of turtle eggs. If the nest incubation temperature is too low or too high, it can result in failure in embryo development. Failure of embryo development can be seen from the deflated egg shape. Nest temperatures of more than 34o C for 3 consecutive days can have an impact on the hatchlings produced and also reduce the percentage of hatching success. This is due to disturbances in the development of the hatchlings' movement system. This results in decreased fitness of the hatchlings so that they cannot climb to the surface of the nest. The presence of vegetation or shade on turtle egg nests can provide stability to the humidity of turtle egg nests. The presence of such shade will not expose the nest to continuous sunlight and will not be directly exposed to rainwater. Nests of turtle eggs that are exposed to rainwater can change the humidity and temperature of the turtle egg nests which can then reduce the percentage of hatching success in a turtle nest (Rosalina and Prihajatno, 2022).

In addition to affecting the percentage of success, the role of temperature in turtle eggs is to determine the sex of the hatchlings. This can be reinforced by a journal written by Dima *et al.* (2015), who said that gonadal development and sex differentiation of sea turtles depend on temperature. Nest incubation temperature can also determine the incubation period and phenotype of hatchlings. In addition, incubation temperature can affect hatchling quality and locomotor performance. Based on a journal written by Hasanah *et al.* (2024), who said that the locomotor performance of turtles in warm temperatures had lower locomotor work.

4.6. Beach Slope

There are several factors that make a beach a turtle nesting site such as beach slope, vegetation, and sand grains, beach length and width, and many others. The slope of the beach is one of the factors that greatly affects sea turtle nesting. The slope of a beach can affect how sea turtle hatchlings move to the beach to nest. Turtles will prefer beaches that have a gentle slope. This is because turtles will more easily access the area. Beaches that have steep slopes are less favored by turtles to be used as nesting sites. This is because turtles will find it more difficult to access the area. In addition, the turtles will have more energy if the beach is steeper (Fitriani *et al.*, 2021).

Slope data were collected at 4 stations or 4 points. The data collection point is based on the frequency of sea turtle hikes. Slope data collection was carried out using a digital waterpass and 3 repetitions were made at each point. Based on the data obtained in Table 6, each station has a different slope. The average value of the slope at station 1 is 9.70o, station 2 is 6.97o, station 3 is 9.87o, and station 4 is 4.97o. Based on these data, the slope of Nipah Beach is still ideal for sea turtles to nest. This is because sea turtles like beaches that have a slope of ± 30o (Pratama and Romadhon, 2020).

4.7. Sand Grains in Semi Natural Nests and Natural Nests

Based on the results of data on the types of sand grains in semi-natural nests and natural nests contained, it shows that each nest has different types of grains. Based on the data, 7 types of sand grains can be found in both types of nests. Very hard, hard, and medium grain types are highest in semi-natural nests. Fine grain types were most common in natural nests. The types of very fine grains and silt were most commonly found in natural nests. Based on the data, it can also be seen that the fine grain type has the highest percentage in each type of nest. The type of nest grain can affect the locomotor of hatchlings, this can be reinforced by a journal written by Stewart *et al.* (2019), who said that the locomotor performance of hatchlings is better when incubated in medium or fine sand. This is because it will help hatchlings grip when leaving the nest.

The type and size of sand grains on a beach can be one of the factors determining the suitability of the place as a nesting site. This is because sea turtles prefer beaches that have fine sand compared to beaches with coral or rock fragments. This can be reinforced by a journal written by Yustina et al. (2004), which says that turtles may not lay eggs if the sand on a beach is in the form of broken coral or gravel. In addition, sea turtles do not like beaches that have sand that is too fine. This is because it can interfere with the mother turtle when digging holes to lay her eggs. Beach sand that is too fine will more often landslide when the mother turtle digs a hole for her eggs.

Based on the data obtained, it shows that the highest value at each sand sampling point is fine sand. This is in line with research conducted by Teuf *et al.* (2023), who said that sea turtles prefer beaches with fine and medium sand substrates. The size of the sand does not disturb the hatchlings that will leave the nest. In addition, when the mother turtle will dig a hole, it will not collapse. The composition of the substrate can affect the temperature of the nest which can then affect the percentage of success of the nest.

3 Conclusions

The findings indicate that the success rate in semi-natural nests was 82.6%, 74.1%, and 59.2%, while in natural nests it was 46.6%, 38.4%, and 92.0%. Therefore, an overall success rate of 69.7% - 79.3% can be considered quite good. Additionally, the physical characteristics of both natural and semi-natural nests, such as temperature, vegetation, nest depth, and beach slope, were found to be within acceptable ranges, indicating favorable conditions for turtle egg hatching. Furthermore, the quality of hatchlings from each nest was quite good, as the incubation temperatures were optimal for their locomotor performance

Ethics approval

No permits were required.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Author contributions

K., E.: Conceptualization, Data curation, Formal analysis, Investigation, Software, Visualization, Roles/Writing -original draft, Funding acquisition, Methodology, Project administration, Resources. K., E., G.W. S., E. Y.: Supervision, Validation, Writing -review & editing.

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Declaration of competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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