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Morphology and Length Relationship of Seahorse Weight in Morotai Island Waters, Morotai Island District, North Maluku Province

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ABSTRACT

The high level of market demand encourages intensive fishing activity, which can affect seahorse populations in nature, leading to a decline in the number of seahorse species. Seahorses are one of the marine animals that have a low survival rate. In the waters of Morotai Island, especially in the village of Sopi, the residents use seahorses as a tonic to enhance male stamina by mixing alcohol with dry seahorse extract and fermenting it. The problem in this study is the need for more research on sea horse data, covering North Maluku and the waters of Morotai Island. The purpose of this study was to identify and analyze the long-weight relationship of seahorses in Morotai Island waters covering six sub-districts, including South Morotai, South-West Morotai, Rao Island, East Morotai, North Morotai, and Morotai Jaya. Data collection on seahorses from June 2022 to July 2023 utilized a purposive sampling method, which was conducted in the seahorse fishing area based on information collected from the local community. Data were gathered for 20 points in six sub-districts. Seahorses are caught using seser tools and snorkeling. The study results revealed the presence of three types of seahorses in the waters of Morotai Island, *Hippocampus kellogi*, *Hippocampus kuda*, and *Hippocampus spinosissimus*, each displaying distinct morphological form. In total, 25 sea horses were observed during the study. At the same time, the analysis of the long-weight relationship showed a positive allometric growth pattern with a value of 3.03 where weight gain was faster, compared to the body length.

INTRODUCTION

The sea horse is known as the *Hippocampus* sp., meaning a jagged and uniquely shaped horse. Seahorses are a group of seawater ornamental fish belonging to the Syngnathidae family, known by another name as horse tangkur **(Syukri, 2016)**. Seahorse is a marine animal with a funny and unique morphology; it can live in seagrass beds, corals, seaweed, and mangroves. Moreover, it tolerates and adapts to the environmental conditions of the surrounding waters **(Setyono, 2020)**. In addition to its unique

morphology, characterized by a head resembling that of a horse, male seahorses possess an egg incubation sac, a feature which is not observed in other seahorse species **(Mulalinda, 2017)**. The incubation pouch serves as a protective environment, safeguarding and incubating the fertilized eggs until they hatch into larvae. Moreover, the pouch continues to shield the developing larvae, ensuring they are well-prepared for their transition into juvenile seahorses once they are born in their natural habitat. Another attraction is the upright body position while swimming, as well as its ability to adapt its body color to the environment, making its appearance even more attractive as an ornamental fish in aquariums and medicine **(Asri *et al.*, 2019)**.

In traditional medicine in China, seahorse is used as a traditional medicine since it is believed to be one of the most efficacious medicines in curing several diseases. **Setyono (2020)** postulated that the content of seahorse compounds could cure minor ailments, such as skin diseases, digestive, respiratory, and inflammatory disorders to quite severe diseases such as impaired function of the brain, liver, heart, and also cancer. The results of research in the field of pharmacology show that seahorse has a high content of progesterone and taurine, which are important hormones with a role in the body's metabolism **(Mulalinda, 2017)**. **Nasution *et al.* (2019)** reported that *Hippocampus kuda* extract has anti-inflammatory activity that is safe in the stomach without causing side effects. Seahorse extract possesses antibacterial properties **(Panjaitan *et al.*, 2017)**.

The content contained in sea horses until now has made the demand increase both by direct capture in nature and cultivation. Based on data by **Sadili *et al.* (2015)**, it was reported that around 77 countries had traded seahorses with a fairly high market price of around $440/ kg (low quality) and $2,600/kg (best quality), with an average requirement of up to 20 to 24 million head per year. Specifically in the Asian region, the consumption of seahorses reaches 45 tons/ year, with the largest consumption countries, being China (20 tons/ year), Taiwan (11.2 tons/ year), Hong Kong (10 tons/ year) and other Asian countries (3.8 tonnes/ year) as reported by **Santoso (2016)**, as cited in **Mulalinda (2017)**.

The high level of market demand encourages fishing which is quite intensive and can affect the seahorse populations in nature, thus the existence of seahorse species will decrease. Seahorses are one of the marine animals that have a low survival rate. In Indonesia, there has been a decline in the catches of seahorses, indicating that this species is under threat and may extinct due to overfishing, even though seahorses are a by-catch of fishermen **(Mulyawan & Saokani, 2015)**. In the waters of Morotai Island, especially in the village of Sopi, seahorses are used as a tonic to enhance male stamina by mixing alcohol with dry seahorse extract and fermenting it. Asia is the largest seahorse consumer in the world, reaching 45 tons per year (≥ 16 million head) **(Setyono, 2020)**.

Apart from being used as medicine, the decline in seahorse populations can be influenced by the quality of the waters where they live, which has degraded due to anthropogenic factors. The exploitation or utilization of seahorses due to the increasing demand can reduce the number of seahorses in nature **(Saraswati & Pebriani, 2016)**.

Several studies on the morphology and population of seahorses in nature have decreased as a result of over-exploitation and the effect of habitat degradation on seahorse populations **(Rabiansyah *et al.*, 2015; Asri *et al.*, 2019; Munandar *et al.*, 2020)**.

In Indonesia, provisions for the export of seahorses have been regulated via the regulation of the Minister of Trade No.50/M-DAG/PER/9/2013 concerning provisions for the export of natural plants and wild animals that are not protected by law and included in the CITES list **(Setyono, 2020)**. CITES included all seahorse species on the list of Appendix II in 2002. The Ministry of Marine Affairs and Fisheries (MMAF) recommends 21 priority aquatic biota species including seahorses, as protected animals.

The problem in this study is the need for more research related to seahorse data, covering North Maluku and the waters of Morotai Island. **Koroy *et al.* (2023)** reported data on the types of seahorses found in marine protected areas; they recorded eight individuals consisting of 2 species, namely the *Hippocampus kuda* and the *Hippocampus kellogi*. The purpose of this study was to identify and analyze the long-weight relationship of seahorses in Morotai Island waters, covering six sub-districts, namely: South Morotai, South- West Morotai, Rao Island, East Morotai, North Morotai, and Morotai Jaya.

MATERIALS AND METHODS

1. Study area

This research addressed the waters of Morotai Island during a period extending from June 2022 to July 2023. This work covered six districts, namely: South Morotai, South- West Morotai, Rao Island, East Morotai, North Morotai, and Morotai Jaya (Fig. 1).

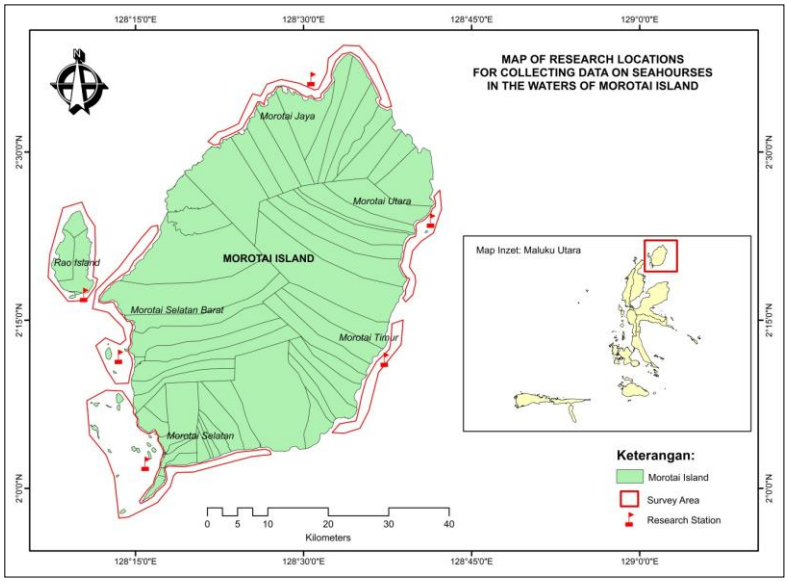

Fig. 1. Map of research locations

2. Tools and materials

The tools and materials used in this study were seser fishing gear, roller meter, raffia rope, measuring tape/ calipers, buckets, recording devices, GPS, hand refractometer, sechi disk, current meter, pH meter, thermometer, camera, underwater flashlight, camera, magnifying glass, scuba gear, and boat. To identify seahorse species, the researchers followed the identification guidelines provided by **Lourie *et al.* (2004)** and **Sadili *et al.* (2015)**.

3. Data collection

Data collection on seahorses used a purposive sampling method carried out in the seahorse fishing area based on information from the local community. Data were collected at 20 points in 6 sub-districts: South Morotai, South- West Morotai, Rao Island, East Morotai, North Morotai, and Morotai Jaya. Seahorses were captured using seser equipment and snorkeling techniques, involving swimming to locate and retrieve seahorses. The capture locations were recorded using GPS to estimate the sampling area. Upon identification, the seahorses were released back into their natural habitat. Additionally, environmental parameters such as water pH, salinity, current velocity, and temperature were measured. In addition, observations on seahorse habitats were conducted as part of the study.

4. Data analysis

The observations and measurements of seahorse samples were then analyzed using descriptive qualitative data in the form of pictures and tables.

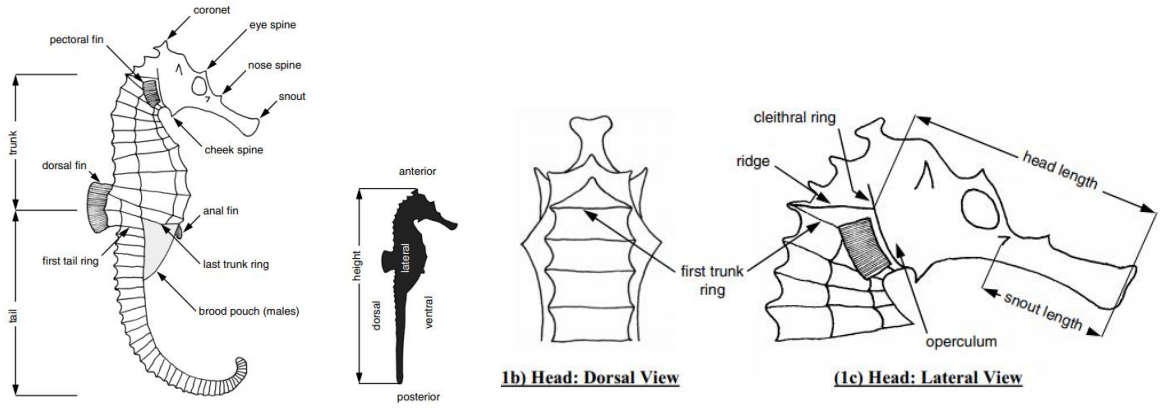

Fig. 2. Morphological identification of seahorses **(Lourie *et al.*, 2004)**

The relationship between the length and weight of the seahorse was analyzed using the following linear allometric model (LAM) equation:

$$W = aL^{b}$$

Where, W is the weight of the fish (g); L is the length of the fish (cm); a is the linear regression intercept, and b is the regression coefficient. The b- value from the results of this calculation can reflect the pattern of fish growth. If the value of b= 3, then the growth pattern is isometric, where the growth in weight and length is the same. Allometric growth patterns are divided into the positive allometric and negative allometric. If the value of b< 3, a negative allometric growth is indicated (length gain is faster than weight gain), and if b> 3, the growth is positive allometric (weight gain is faster than length gain) **(Nane, 2019)**.

RESULTS

Morphology of seahorses

Morphology identifies seahorses from the outside, such as the shape of the crown, nose, tail, spines on the eyes, abdomen, pectoral fins and brood sac. Morphological identification is carried out to determine the types of seahorses found in Morotai waters using an identification guide. Based on the research results, three types of seahorses, *Hippocampus kuda, Hippocampus kellogi and Hippocampus spinosissimus*, were spread across six sub-districts in the waters of Morotai Island. In the waters of East Morotai, one type of seahorse, *Hippocampus spinosissimus*, was found (1). While, in North Morotai, the *Hippocampus kellogi* type was detected (2); in Morotai Jaya, there were four types of *Hippocampus kellogi* and one for *Hippocampus kuda*. In the waters of South Morotai, two species were found with a total of 8 individuals, namely two *Hippocampus kuda* species and six *Hippocampus kellogi* species; in South- West Morotai, there were (8 tail), namely two *Hippocampus kuda* species and six *Hippocampus kellogi* species, while in Pulau Rao sub-district, only one type of *Hippocampus kellogi* was found. The types of seahorses found in the waters of Morotai Island have different morphometric data. The type of *Hippocampus spinosissimus* found had a total length of 9.7cm, head length of 1.5cm, nose length of 0.9cm, abdominal circumference of 0.4cm, number of spines 11 and weight of 7.3g.

The type of sea horse *Hippocampus kuda* that was found had a total length of 12.3- 12.5cm, a head length of 2.7- 3.5cm, a nose length of 1.2- 1.9cm, an abdominal circumference of 5- 6cm and a weight of 6 .1- 8.12g. The color of the seahorses found is bright yellow with black spots all over the body. Data from morphometric measurements of seahorses *Hippocampus kellogi* found in the waters of South Morotai, South West Morotai, Morotai Jaya and Rao Island, Morotai Island Regency recorded a total length of 8.5- 14.5cm, head length of 0.4- 3.3cm, nose length 0.3- 1.6cm, abdominal circumference 2- 6.5cm and weight 0.28- 11g.

The classification of seahorses, according to **Burton and Maurice (1983)**, is as follows:

Phylum: Chordata
Subphylum: Vertebrata
Kelas: Pisces
Subkelas: Teleostomi
Ordo: Gasterosteiformes
Famili: Syngnathidae
Genus: *Hippocampus*
Species: *Hippocampus spinosissimus*

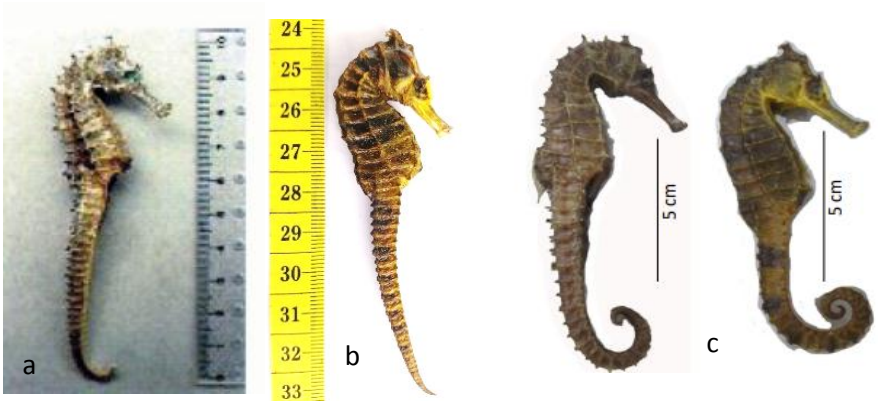

Fig. 3. Types of *Hippocampus spinosissimus* found
Source: a. **(Lourie *et al.*, 2004)**, b. Research documentation (2023), c. **(Putri *et al.*, 2019)**

The classification of seahorses, according to **Burton and Maurice (1983)**, is as follows:
Phylum: Chordata
Subphylum: Vertebrata
Kelas: Pisces
Subkelas: Teleostomi
Ordo: Gasterosteiformes
Famili: Syngnathidae
Genus: *Hippocampus*
Species: *Hippocampus kuda*

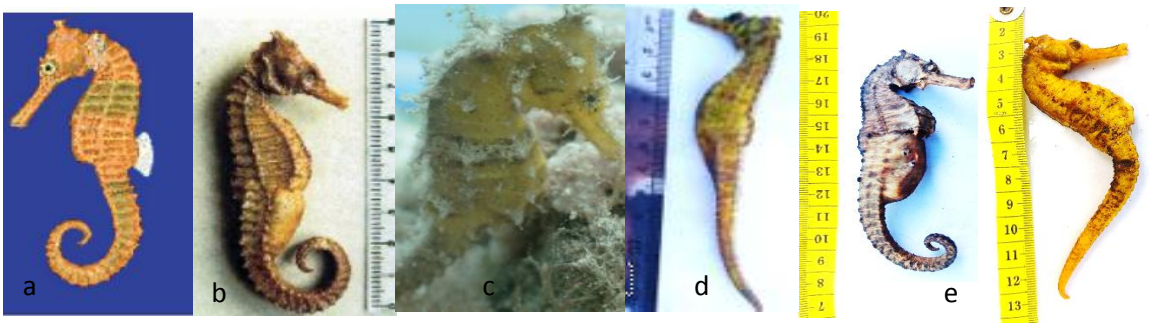

Fig. 4. Types of *Hippocampus kuda* found
Source: a. Cada LA, b. **(Lourie *et al.*, 2004)**, c. **(Kalisiak *et al.*, 2022)**, d. **(Koroy *et al.*, 2023)**, e. Research documentation (2023)

The classification of seahorses according to **Burton and Maurice (1983),** is as follows:

Phylum: Chordata
Subphylum: Vertebrata
Kelas: Pisces
Subkelas: Teleostomi
Ordo: Gasterosteiformes
Famili: Syngnathidae
Genus: *Hippocampus*
Species: *Hippocampus kellogi*

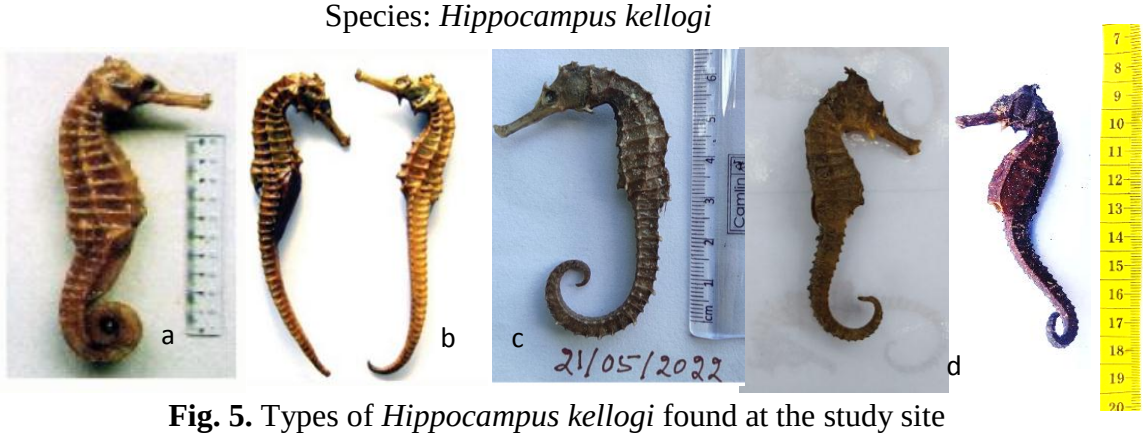

Fig. 5. Types of *Hippocampus kellogi* found at the study site
Source: a. **(Lourie *et al.*, 2004)**; b.GBIF (2010); c. **(Behera *et al.*, 2023)**; d. Research documentation (2023)

Hippocampus kellogi is the type with the highest number in the waters of South Morotai (6 individuals), South- West Morotai (6 individuals), Morotai Jaya (4 individuals) and Rao Island (1 individual). *Hippocampus kellogi* has a long and slender body shape, a tall crown with five short spines shaped like a plate, a thick prominent body ring, a thick snout, blunt eye spines and black and white spots. For morphometric data, *Hippocampus kellogi* found in Morotai waters, on average, has a slender body, a tall crown of 5 parts, a total length of 8.5- 14.5, a mouth length of 0.3- 1.6, with a head length of 0.4- 3.3cm (Table 2).

Table 1. Types of male and female seahorses found at the study site

Species	Sampling sites	Sex
	South Morotai District	
Hippocampus kellogi	*Armydock	1 Male, 1 Female
	* Kokoya Island	2 Males, 2 Females
	* Mitita Island	Not Found
	South Morotai District	
Hippocampus kuda	*Armydock	1 Male, 1 Female
	* Kokoya Island	Not Found
	* Mitita Island	Not Found
	West South Morotai District	

Species	Sampling sites	Sex
Hippocampus kellogi	*Cucumare Village	2 Males, 2 Females
	*Wayabula Village	1 Male
	* Ngele Ngele Island	1 Female
Hippocampus kuda	*Cucumare Village	1 Female
	* Wayabula Village	Not Found
	*Ngele Ngele Island	1 Male
	Rao Island District	
	* Rao Village	Not Found
Hippocampus kellogi	* Saminyamau Village	1 Male
	* Leo Leo Rao Village	Not Found
	East Morotai District	
	* Sangowo Village	Not Found
Hippocampus spinossisimus	* Sambiki Village	1 Female
	* Wewemo Village	Not Found
	North Morotai District	
	* Bere Bere Village	Not Found
Hippocampus kuda	* Gorua Village	2 Females
	* Korago Village	Not Found
	Morotai Jaya District	
Hippocampus kellogi	* Sopi Village	4 Females
	* Hapo Village	Not Found
	* Titigogoli Village	Not Found
Hippocampus kuda	* Sopi Village	1 Male
	* Hapo Village	Not Found
	* Titigogoli Village	Not Found

Note: * sampling points in each district

Table 2. Data on *Hippocampus kellogi* morphology measurements

Number	Morphological variables	Measurements
1	Height	8.5- 14.5cm
2	Head length	0.4- 3.3cm
3	Snout length (SnL)	0.3- 1.6cm
4	Abdominal circumference	2- 6.5cm
5	Weight	0.28- 11g
6	Coronet	high with five short spines
7	Dorsal fin rays	18
8	Pectoral fin rays	17

Table 3. Data on *Hippocampus kuda* morphology measurements

Number	Morphological variables	Measurements
1	Height	12.3- 12.5cm
2	Head length	2.7- 3.5cm
3	Snout length (SnL)	1.2- 1.9cm
4	Abdominal circumference	5- 6cm
5	Weight	6.1- 8.12g
6	Coronet	Low to medium
7	Dorsal fin rays	17
8	Pectoral fin rays	17

Table 4. Data on *Hippocampus spinosissimus* morphology measurements

Number	Morphological variables	Measurements
1	Height	9.7cm
2	Head length	1.5cm
3	Snout length (SnL)	0.9cm
4	Abdominal circumference	0.4cm
5	Weight	7.3g
6	Coronet	crown of sharp thorns
7	Dorsal fin rays	17
8	Pectoral fin rays	16

Seahorse weight and length relationship

The relationship between the length and weight of seahorses was assesed based on morphometric data on the total length and weight of each type of seahorse in six districts. The graph of the long-weight relationship can be seen in Fig. (6).

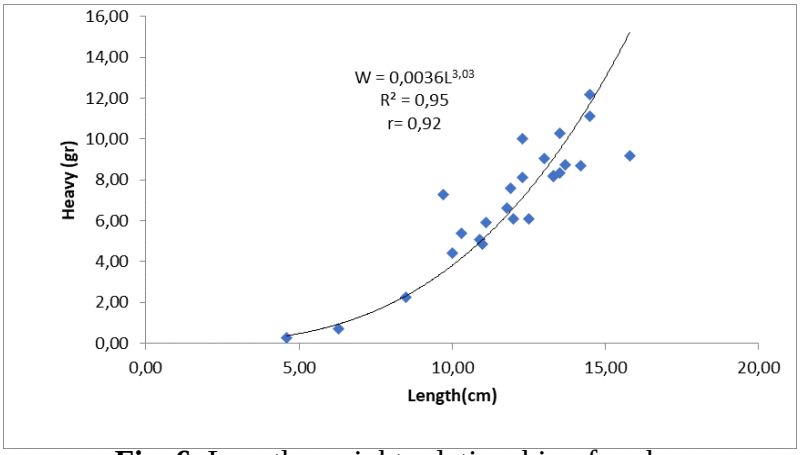

Fig. 6. Length- weight relationship of seahorse

Based on the analysis of the length-weight relationship of seahorses from a sample of 25 individuals, the average length was 11.78, and the average weight was 6.99. The relationship between weight (W) and length (L) was determined using the equation $W = 0.0036L^{3.03}$. The correlation analysis results for the seahorse samples demonstrated a strong linear relationship with an r-squared value of 0.95, indicating that 95% of seahorse weight variation can be explained by length, while 5% is attributed to other factors. Additionally, the value of the exponent (b) in the equation (3.03) is greater than 3, suggesting a positive allometric growth pattern for seahorses.

DISCUSSION

Based on identification at the research location, *Hippocampus spinosissimus* has a light greenish-brown color and a dark tail with a sharp crown shape. In this context, **Sadili *et al.* (2015)**, stated that *Hippocampus spinosissimus* has a light brown, greenish color, a dark tail and a crown of sharp thorns. On the head and eyes, there is a black pattern like a regular pattern that surrounds the eyes, while the lower protrusion of the head is dominated by white. However, on the tail, the color pattern forms a crossing line between yellow-black and the dominant black color.

Morphologically, the *Hippocampus kuda* has a brownish-black to a yellowish color, with black spots all over the body, and it has a round and low crown compared to the *Kellogi Hippocampus* type. The coloration of the seahorse, *Hippocampus kuda*, can vary depending on environmental factors and the stress experienced by the seahorse. As illustrated in Fig. (4), *Hippocampus kuda* exhibits differences in coloration, which are attributed to environmental conditions and factors, leading to the growth of skin filaments over time as an adaptation to the surroundings. Additionally, alterations in skin color can occur during the mating process between male and female seahorses.

Hippocampus kellogi is similar to the type *Hippocampus spinosissimus* in the shape of the crown and spines on the eyes. *Hippocampus kellogi* is found in greater numbers, compared to the other types of seahorses. However, this number is still in the small or low category. This is due to environmental conditions and other factors. Based on information from the public, fishermen have found this in several waters, such as Sangowo and Wewemo villages, in the last 1 to 2 years. The appearance of seahorses usually depends on the season from February to May and October, with peaks in March and April. According to **Lourie *et al.* (2008)**, Indonesia and other parts of the world are included in the category of low seahorse numbers. Apart from that, weather factors at the time of collecting weather data were unsupported because of heavy rain and wind. According to **Behera *et al.* (2023)**, seahorses can move or immigrate due to rubbish, fishing nets, and currents carried up to 1300km.

The morphometrics of seahorses found have different lengths and weights. The difference in size depends on the place where the seahorses live. The morphometric data for *Hippocampus kuda* seahorses indicate a total length ranging from 12.3 to 12.5cm, head length varying from 2.7 to 3.5cm, and mouth length falling within the range of 1.2 to 1.9cm. These seahorses possess 17 upper fins and 17 lower fins, with a crown shape that is slightly lower in comparison to *Hippocampus kellogi*, as detailed in Table (3). On the other hand, *Hippocampus spinosissimus* has a length of 9.7cm, a head length of 1.5cm, a nose length of 0.9cm, an abdominal circumference of 0.4cm, a weight of 7.3, 17 upper fins, 16 lower fins and a sharp, spiny crown shape. **Behera *et al.* (2023)** reported

that the total length of the seahorse *Hippocampus kellogi* found in the Indian waters was 12.5cm, the head length was 2.5cm, the nose length was 1cm, and the spines were on the eyes.

Saher *et al.* (2021) reported that the *Hippocampus kellogi* found in Pakistani waters had a total length of 9.9cm, a head length of 2cm, the Pakistani had a slender body shape, five high crowns, 18 upper fins and 17 lower fins. Morphometric data from a research conducted by **Lourie *et al.* (2004)** reported that the number of upper fins was 17- 19, and lower fins were 17– 19, and added that a high crown shape was observed, with a maximum length of 28cm. While, **Lourie *et al.* (2004)** stated that the total length is 17cm, the upper fin is 17- 18cm, the lower fin is 15- 18cm, and the crown shape is not too high. **Shapawi *et al.* (2015)** reported the size of the *Hippocampus kuda* as having a total length of 12.6cm, mouth length of 1.1cm, head length of 2.3cm, 17 upper fins and 16 lower fins. According to **Lourie *et al.* (2004)**, the total length of the *Hippocampus spinosissimus* is 17.2, with a sharp, spiny crown shape, and several upper fins ranging from 16- 20 and lower fins from 16- 19.

It was noticed that, the increment in seahorse body weight is greater than that of the body length. If the r^2 value approaches 1, the total length of the fish increases as the seahorse's body weight increases. This illustrates a passive swimming seahorses' growth pattern, which gains weight faster than it grows in length. **Ibrahim *et al.* (2017)** stated that if the value of b= 3, then the increase in weight and length is balanced (isometric), whereas if the value of b> 3, then the increase in weight is faster than the increase in length. **Shasia *et al.* (2021)** reported that snakehead fish's relationship between length and weight showed a positive allometric growth pattern with a b> 3. In this respect, **Nasir *et al.* (2016)** explained that the b coefficient value is influenced by fish behavior; active swimming fish show lower b values compared to passive swimming fish; this is related to the allocation of energy spent on movement and growth. **Faizah and Anggawangsa (2019)** reported differences in b values due to the influence of biological and ecological factors. **Nurhayati *et al.* (2016)** stated that in the positive allometric growth, fish weight increases faster than length so that the shape of the fish looks fuller. Changes in fish weight can result from changes in feed and the amount of energy for growth and reproduction **(Kresnasari, 2020)**. The growth pattern of seahorses, also included in the fish class, is not always positive. Furthermore, **Balasubramanian and Murugan (2017)** elucidated that the growth pattern of seahorses in the Indian waters is negative allometric due to water parameter conditions.

CONCLUSION

The study results found three types of seahorses in the waters of Morotai Island, namely: *Hippocampus kellogi*, *Hippocampus kuda*, and *Hippocampus spinosissimus*, with different morphological forms. At the same time, the analysis of the length-weight relationship showed a positive allometric growth pattern with a value of 3.03, where weight gain was faster compared to body length.

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