A note on the investigation of morphometric differentiation among mantis shrimp (Stomatopods) in South Madura Waters, Indonesia

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Abstract. Mantis shrimp is one of the fishery resources with a high species variation and wide distribution area that cause differences in morphometric characteristics and population mixing. This study purposed to identify and compare the morphometric characters of mantis shrimp (Stomatopods) as well species kindship in South Madura waters, Indonesia. The study was conducted from October 2019 until January 2020 with specimen collecting from three locations south of Madura. Three types of dominant mantis shrimp caught were chosen for the investigation of morphometric differentiation. Morphometric characters were observed with the standard method and truss network analysis (TNA). Based on certain morphological characters, those mantis shrimp species were Harpiosquilla harpax, Miyakella sp., and Oratosquillina sp. Kruskal Wallis analysis resulted in a difference of 14 from 15 characters with the standard method, and 47 from 56 characters with truss network analysis. Cluster analysis showed that Miyakella sp. and Oratosquillina sp. have a close relationship compared to Harpiosquilla harpax. Moreover, the dominant mantis shrimp populations in the south of Madura formed two species of kindship groups.

Keywords: Harpiosquilla harpax; Miyakella sp.; Oratosquillina sp.; species kinship; TNA methods

1. Introduction

Mantis shrimp belongs to the order Stomatopods within the class Malacostraca with five superfamilies, i.e. Bathysquilloidea, Squilloidea, Erythrosquilloidea, Lysiosquilloidea, and Gonodactyloidea [1]. In Indonesia, the distribution of mantis shrimp is spread almost in all waters. There are 12 species of mantis shrimp in the Anambas Natuna Islands, i.e. Gonodactylellus affinis, G. viridis, G. chiragra, Aerosquilla indica, Carinosquilla carinata, C. multicarinata, C. thailandensis, Cloridina chlorida, Oratosquilla perpena, O. quinuedentata, Quollastria gonyptes, and Q. subtilis [2]. Moreover, Harpiosquilla raphidea and Oratosquillina gravieri were found in Kuala Tungkal, Jambi [3]. H. raphidea was also
found in Bengkulu [1], and Haplosquilla glyptocerus, Gonodactylus annularis, G. viridis, Chrisuilla hystrix found in the coastal waters of Pemuteran Bali [4].

The wide distribution of mantis shrimp can cause variations in morphometric characters. Variations of morphometric characters are not only useful for determining taxonomy but also describing the population character, evaluating population structure for stock and population identification [5]. The wide distribution also causes population mixing that makes stock consist of different populations and this affects its management. Morphometric analysis was conducted to determine the differences in morphological intraspecies and diverse species of mantis shrimp.

The study on the morphometric of mantis shrimp in Indonesia is still limited, including in the southern waters of Madura. Several morphometric studies of mantis shrimp in Indonesia were conducted on Harpiosquilla raphidea [6], Oratosquillina gravieri and H. raphidea [7], H. raphidea and O. gravieri [3]. In the southern waters of Madura, the types of mantis shrimp were obtained several unidentified species. Previous studies have shown that mantis shrimp represent 14.8% of the total bottom trawl catch in those waters [8].

Information on the identification and morphometric analysis of mantis shrimp in the southern waters of Madura is needed as a basis for fisheries resource management in Madura. Therefore, the study purposed to identify and compare the morphometric characters of mantis shrimp (Stomatopods) as well species kindship in South Madura waters, Indonesia.

2. Material and methods

2.1. Time and location of research

The study was conducted from October 2019 until January 2020. The specimens were obtained from three locations in the southern waters of Madura, East Java Province, Indonesia (figure 1). In this location, mantis shrimp was caught by fishermen using bottom trawl. Identification and morphometric measurement were performed at the Aquatic Molecular Biology Laboratory, Department of Aquatic Resources Management, IPB University.

Figure 1. The sampling location is in the southern waters of Madura.
2.2. Data collection

Three dominant species were chosen and the total sample was 272 individuals. The samples were placed in a bottle sample and preserved with 80% alcohol for analysis in the laboratory. Morphological identification of mantis shrimp refers to book identification [9, 10]. Morphometric characters were measured by photography with the standard and truss network analysis (TNA) method. Morphometric characters were taken a photo using the Canon 1200D camera and were measured with the standard and truss network analysis (TNA) method. Fifteen morphometric characters were measured by the standard method using ImageJ (Figure 2). The characters were length from the anterior of the thorax to the tip of the telson (PTO), length from the anterior of the thorax to the tip of the abdomen (PTA), length from the anterior of the rostral plate to tip of the head (PRK), width between the widest head sections (LKT), length from the anterior to the tip of the abdomen (PAA), width between the widest abdominal somite (LAT), length of first somite abdominal segment (ASS), length of second somite abdominal segment (ASD), length of third somite abdominal segment (AST), length of fourth somite abdominal segment (ASE), length of fifth somite abdominal segment (ASL), length of sixth somite abdominal segment (ASN), length from the anterior to the tip of the telson (POO), and width between the widest telson sections (LOT). Fifty-six morphometric characters were obtained from 24 landmark points and were measured by the TNA method using tpsDig and PAST software (figure 3). The characters are formed following the formula of Strauss and Bookstein [11].

![Figure 2. Morphometric characters of mantis shrimp by standard method.](image)
2.3. Data analysis

2.3.1. Data transformation. All of the measurement data from both methods were transformed. The transformation refers to the following formula [12]:

$$M_{\text{trans}} = \frac{M}{SL}$$  \hspace{1cm} (1)

\(M_{\text{trans}}\) = Data transformation  
\(M\) = Original measurement (mm)  
\(SL\) = Total length (mm)

2.3.2. Morphometric character differences. The differences of morphometric character were analyzed using discriminant analysis with SPSS software.

3. Result

3.1. Identification of mantis shrimp

Morphological identification was conducted by observing the color, shape of the head, claws, and telson. Based on morphological identification, one type of mantis shrimp can be identified as *Harpiosquilla harpax*. Meanwhile, the other two types were only identified up to the genera, i.e *Miyakella* sp. and *Oratosquillina* sp. The differences and similarities of the three types of mantis shrimp can be seen in figure 4.

![Figure 3](image-url)
Figure 4. Head section of Harpiosquilla harpax (left), Miyakella sp. (middle), and Oratosquillina sp. (right).

H. harpax has a rostral plate with an anterior projection, while Miyakella sp. and Oratosquillina sp. has a rostral plate broader than long. The median carina of H. harpax is like a straight line across the center of the head. Meanwhile, the median carina of Miyakella sp. is divided in half with a dorsal pit in the middle, and the median carina of Oratosquillina sp. split in half and merge into the dorsal pit. Posterolateral of H. harpax formed the corner, while the posterolateral Miyakella sp. and Oratosquillina sp. evenly rounded (figure 5).

Figure 5. Posterolateral of Harpiosquilla harpax (left), Miyakella sp. (middle), and Oratosquillina sp. (right).

The difference in the raptorial claws is seen in the propodus and dactylus. The propodus of the raptorial claw of H. harpax have large and small erect spines, whereas Miyakella sp. and Oratosquillina sp. have blunt pectination (figure 6). There are eight teeth on the dactylus of H. harpax and six teeth on the dactylus of Miyakella sp. and Oratosquillina sp. The median carina in the telson of H. harpax is dark green and has a proximal dark spot and has six spines on the telson that are yellowish-green. The median carina in the telson Miyakella sp. is dark green and six spines on telson are bluish-green. Oratosquillina sp. has a median carina of the telson with yellowish-green and six spines on the telson with the same color (figure 7).
3.2. Morphometric character differences
Morphometric character differences are concluded from the significance value (p-value), if the significance value is less than 0.05 indicates that there are differences in the morphometric characters of the three types of mantis shrimp. There are 14 morphometric character differences (p-value <0.05) from 15 morphometric characters measured based on analysis using the standard method (table 1). Overall, the TNA method contained 47 morphometric character differences (p-value <0.05) from 56 morphometric characters measured (table 2).

3.3. Distribution of species groups
The distribution of species groups based on the discriminant function by the standard method form three species groups of mantis shrimp which are characterized by differences in distribution centers (centroids) (figure 8). Likewise, the distribution of species groups by the TNA method form three species groups (figure 9). There is an overlap in the distribution of species groups in the standard and TNA method, there are certain similarities in the characteristics of the three types of mantis shrimp.
### Table 1. Morphometric character differences of mantis shrimp in the standard method.

| No. | Morphometric characters | Wilks’ Lambda | p-value |
|-----|------------------------|---------------|---------|
| 1   | PTO                    | 0.815         | 0.000   |
| 2   | PTA                    | 0.905         | 0.000   |
| 3   | PRK                    | 0.762         | 0.000   |
| 4   | LKT                    | 0.673         | 0.000   |
| 5   | PTT                    | 0.560         | 0.000   |
| 6   | PAA                    | 0.908         | 0.000   |
| 7   | LAT                    | 0.789         | 0.000   |
| 8   | ASD                    | 0.940         | 0.000   |
| 9   | AST                    | 0.934         | 0.000   |
| 10  | ASE                    | 0.952         | 0.001   |
| 11  | ASL                    | 0.661         | 0.000   |
| 12  | ASN                    | 0.966         | 0.010   |
| 13  | POO                    | 0.735         | 0.000   |
| 14  | LOT                    | 0.682         | 0.000   |

### Table 2. Morphometric character differences of mantis shrimp in the TNA method.

| No. | Number of landmarks | Wilks’ Lambda | p-value | No. | Number of landmarks | Wilks’ Lambda | p-value |
|-----|---------------------|---------------|---------|-----|---------------------|---------------|---------|
| 1   | 1-2                 | 0.598         | 0.000   | 24  | 8-9                 | 0.971         | 0.020   |
| 2   | 3-24                | 0.800         | 0.000   | 25  | 9-18                | 0.762         | 0.000   |
| 3   | 1-3                 | 0.870         | 0.000   | 26  | 8-18                | 0.773         | 0.000   |
| 4   | 2-24                | 0.858         | 0.000   | 27  | 9-19                | 0.783         | 0.000   |
| 5   | 23-24               | 0.954         | 0.002   | 28  | 17-18               | 0.842         | 0.000   |
| 6   | 3-4                 | 0.943         | 0.000   | 29  | 9-10                | 0.904         | 0.000   |
| 7   | 4-23                | 0.767         | 0.000   | 30  | 10-17               | 0.718         | 0.000   |
| 8   | 3-23                | 0.804         | 0.000   | 31  | 9-17                | 0.743         | 0.000   |
| 9   | 4-24                | 0.821         | 0.000   | 32  | 10-18               | 0.741         | 0.000   |
| 10  | 5-22                | 0.631         | 0.000   | 33  | 16-17               | 0.908         | 0.000   |
| 11  | 4-22                | 0.951         | 0.001   | 34  | 10-11               | 0.909         | 0.000   |
| 12  | 5-23                | 0.925         | 0.000   | 35  | 11-16               | 0.881         | 0.000   |
| 13  | 6-21                | 0.631         | 0.000   | 36  | 10-15               | 0.800         | 0.000   |
| 14  | 5-21                | 0.681         | 0.000   | 37  | 11-17               | 0.807         | 0.000   |
| 15  | 7-20                | 0.698         | 0.000   | 38  | 15-16               | 0.722         | 0.000   |
| 16  | 6-20                | 0.709         | 0.000   | 39  | 11-12               | 0.719         | 0.000   |
| 17  | 7-21                | 0.696         | 0.000   | 40  | 12-15               | 0.861         | 0.000   |
| 18  | 19-20               | 0.968         | 0.013   | 41  | 11-15               | 0.813         | 0.000   |
| 19  | 7-8                 | 0.946         | 0.001   | 42  | 12-16               | 0.824         | 0.000   |
| 20  | 8-19                | 0.758         | 0.000   | 43  | 14-15               | 0.828         | 0.000   |
| 21  | 7-19                | 0.762         | 0.000   | 44  | 12-13               | 0.809         | 0.000   |
| 22  | 8-20                | 0.744         | 0.000   | 45  | 12-14               | 0.846         | 0.000   |
| 23  | 18-19               | 0.913         | 0.000   | 46  | 13-15               | 0.860         | 0.000   |
The similarity of the morphometric characters is expressed in the sharing component value. Sharing component values by standard methods are classified correctly in species of *H. harpax*, *Miyakella* sp.,
and *Oratosquillina* sp. amounted to 91.0%, 88.0%, and 69.4% (table 3). Sharing component values by TNA methods are classified correctly in species of *H. harpax*, *Miyakella* sp., and *Oratosquillina* sp. amounted to 85.0%, 90.0%, and 94.4% (table 4). The sharing component value in the standard method of *H. harpax* has a high sharing component value, while the TNA method is the opposite of the result of the standard method. *H. harpax* has a low sharing component value and *Oratosquillina* sp. has a high sharing component value.

### Table 3. The sharing component value of the distribution of species groups by the standard method.

| Total samples | Species          | Harpiosquilla harpax | Miyakella sp. | Oratosquillina sp. | Total |
|---------------|------------------|----------------------|---------------|--------------------|-------|
| 100           | *Harpiosquilla harpax* | 91.0%                | 2.0%          | 7.0%               | 100%  |
| 100           | *Miyakella* sp.   | 1.0%                 | 88.0%         | 11.0%              | 100%  |
| 72            | *Oratosquillina* sp. | 11.1%                | 19.4%         | 69.4%              | 100%  |

### Table 4. The sharing component value of the distribution of species groups by the TNA method.

| Total samples | Species          | Harpiosquilla harpax | Miyakella sp. | Oratosquillina sp. | Total |
|---------------|------------------|----------------------|---------------|--------------------|-------|
| 100           | *Harpiosquilla harpax* | 85.0%                | 14.0%         | 1.0%               | 100%  |
| 100           | *Miyakella* sp.   | 4.0%                 | 90.0%         | 6.0%               | 100%  |
| 72            | *Oratosquillina* sp. | 2.8%                 | 2.8%          | 94.4%              | 100%  |

### 3.4. The kinship of mantis shrimp

The kinship between the three types of mantis shrimp can be determined by the distance matrix by cluster analysis in the standard and TNA method. Based on the distance matrix in both method shows that *Miyakella* sp. and *Oratosquillina* sp. have a closer Euclidean range than the *H. harpax* (table 5 and 6). The dendrogram construction by both methods also shows that *Miyakella* sp. formed the same group with *Oratosquillina* sp., while the *H. harpax* formed their group (figure 10 and 11).

### Table 5. Euclidean distance from cluster analysis by standard method.

| Species                | Harpiosquilla harpax | Miyakella sp. | Oratosquillina sp. |
|------------------------|----------------------|---------------|--------------------|
| *Harpiosquilla harpax* | 0                    | 0.054         | 0.046              |
| *Miyakella* sp.        | 0.054                | 0             | 0.021              |
| *Oratosquillina* sp.   | 0.046                | 0.021         | 0                  |

### Table 6. Euclidean distance from cluster analysis by TNA method.

| Species                | Harpiosquilla harpax | Miyakella sp. | Oratosquillina sp. |
|------------------------|----------------------|---------------|--------------------|
| *Harpiosquilla harpax* | 0                    | 0.108         | 0.056              |
| *Miyakella* sp.        | 0.108                | 0             | 0.061              |
| *Oratosquillina* sp.   | 0.056                | 0.061         | 0                  |
4. Discussion
Morphology identification of mantis shrimp to validate species and classification based on morphological characteristics. *H. harpax* belongs in the family Harpiosquillidae with morphological characteristics having large T-shaped eyes and a rostral plate with an anterior projection [10]. The species also have propodus with large and small erect spines, large claws, and have dactylus with eight teeth. The large claws are an adaptation form of *H. harpax* to catch prey [13]. Other morphological characteristics are abdomen and telson colors which the abdomen has light brownish gray with dorsal spots. the telson has spines with green color. and the median carina with a proximal dark spot [9].

*Miyakella* sp. and *Oratosquillina* sp. are members of the family Squillidae. Morphologically, these two types have almost the same characteristics. i.e., having large T-shaped eyes. but the eye size of *Oratosquillina* sp. bigger than *Miyakella* sp., the rostral plate in these two genera is broader than long, propodus with blunt pectination, dactylus with six teeth used as a weapon to search prey [10]. Besides, the median carina of the head of *Miyakella* sp. has formed two branches that are fused to the posterior and there is a dorsal pit in the middle, while the *Oratosquillina* has a median carina that divides anteriorly into a dorsal pit in the midline of the head [9].

Morphometric character differences based on the discriminant analysis by the standard and the TNA method were 14 and 47 characters. Differences in morphometric characters can be caused by different species and variations in sample size and gender [6]. The size and age of the shrimp affect differences in morphometric characters because they change continuously with growth [14]. Biota from the same habitat or environment can have different morphological characters. It depends on environmental conditions and adaptation factors. Differences in morphometric characters can also be caused by adaptation processes of physiology, morphology, and behavior to their environment [15].

The similarity of characters between groups of mantis shrimp population is stated in the sharing component value. *H. harpax* has a high sharing component value. which means that the species have a high similarity of morphometric characters in their population. *Oratosquillina* sp. has a low sharing component value. which means that the morphometric character of *Oratosquillina* sp. more diverse in population. Meanwhile. the sharing component value in the TNA method is the opposite of the results from the standard method. A population with a low sharing component value has high internal diversity [16].
The mixing value between populations by the standard method is 1.0% - 19.4% and the TNA method is 1.0% - 14.0%. The mixing value of mantis shrimp from the TNA method is lower which means that the accuracy of population grouping is higher than the standard method. The TNA method is very suitable to determine morphometric differences between species [17]. The advantages of the TNA method are to analyze more detail and specifically [18] and more systematically characters [11]. 

The results of the cluster analysis showed Miyakella sp. and Oratosquillina sp. form one group and have a closer Euclidean distance compared to H. harpax. The close Euclidean distance means that it has close kinship and otherwise [19]. This is because Miyakella sp. and Oratosquillina sp. belong to the same family and are characterized by almost the same morphological characters. The close kinship is caused by similarity in family or genus. The similarity in body shape, morphological characters, and behavior [19]. 

Morphometric studies emphasize the morphological characters of a species in an area. The mantis shrimp caught in the southern waters of Madura have different morphometric characters based on the results of the analysis in this study. This indicates that there are differences in the morphometric characters of the mantis shrimp group. Thus, forming two species groups. The species group formed describes the characteristics of the mantis shrimp population and is the response to its environment. The results of this study can be used as basic information and consideration in the management of mantis shrimp such as stock studies. Species distribution, and management of other mantis shrimp in the southern waters of Madura in the future.

5. Conclusions 
Three types of mantis shrimp are dominant in the southern waters of Madura. i.e., Harpiosquilla harpax. Miyakella sp., and Oratosquillina sp. The three types of mantis shrimp have different morphometric characters and differentiate each population group. Miyakella sp. and Oratosquillina sp. have a close relationship compared to Harpiosquilla harpax. Besides, the distribution mantis shrimp populations in the south of Madura formed two species of kindship groups.

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