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Sexual dimorphism phenomenon of first record *Macrobrachium lar* (Fabricius, 1978) from the southern Sukabumi, West Java, Indonesia

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Abstract. *Rismawati R, Krisanti M, Farajallah A. 2024. Sexual dimorphism phenomenon of first record* Macrobrachium lar *(Fabricius, 1978) from the southern Sukabumi, West Java, Indonesia. Biodiversitas 25: 1929-1937. Macrobrachium lar* (Fabricius, 1798), commonly known as monkey river prawn, is a widely distributed amphidromous species found in various freshwater habitat, displaying adaptability to different salinities. This habitat diversity often leads to the emergence of cryptic species, particularly in freshwater shrimp. Notably, *M. lar* exhibits sexual dimorphism. The degree of sexual dimorphism can differ among decapod crustaceans. This study reports the first discovery of *M. lar* in Sukabumi, West Java, collected in January 2023 from a river tributary in the Cibitung Sub-district with insights into the sexual dimorphism phenomenon. We conducted species confirmation through molecular analyses. We use the Cytochrome Oxidase subunit 1 (COI) gene fragment for molecular analysis. Phylogenetic tree values revealed that the samples we found proved to be *M. lar*, forming a group with *M. lar* from the Indian-West Pacific region and *M. lar* from Pangandaran. However, they were distinct from the outgroups *M. idae* and *M. Lepidactyloides*. In this study, we only use the adult sample, which is already well-developed. Morphological analysis indicated that all morphological characters in males were larger than in females, with significant sexual dimorphism observed in the second pereiopod and its parts (ischium, merus, carpus, and palm). Although the body sizes of males and females are significantly different in a positive direction, the most distinguishing feature facilitating the identification of both as the same species is the pattern on the second pereiopod, which has irregular blotches of brownish coloration.

Keywords: COI gene, cryptic, freshwater shrimp, morphometric, Sunda land

INTRODUCTION

Macrobrachium lar (Fabricius, 1798), commonly known as the monkey river prawn, was first discovered and described in 1798 in India by J.C Fabricius (Cai and Ng 2001). It stands out as one of the largest prawn species distributed across the tropical Indo-Pacific high islands (Chace and Bruce 1993). As one of the most widespread amphidromous prawn species that need estuary to spawn, *M. lar* is considered a "Least Concern" species in conservation priority (GBIF 2024). However, *M. lar* exhibits specific habitat preferences in natural conditions. In contrast to other *Macrobrachium* species, *M. lar* prefers a solitary existence, establishing distinctive home ranges. Its adaptability extends to diverse environments, including surface freshwater streams, rivers, estuaries, and coastal ponds (Short 2004; Susilo et al. 2020). The adaptability of *M. lar* to various salinities, from freshwater environments to estuaries, depends on its life stages (Ghazi and Hassan 2021). In addition, due to its substantial size and rapid growth rates, this species shows promising potential for aquaculture endeavors (Lal et al. 2014), while on tropical islands, *M. lar* is part of the traditional diet (Castelin et al. 2013).

The morphological variation of *M. lar* is influenced by factors such as geographical location, environment, springs, flow direction, and vegetation conditions along the rivers (Fadli et al. 2018; Jurniati et al. 2021). Generally, *M. lar* exhibits distinct features from other freshwater shrimp species, including a rostrum with a straight or slightly sinuous dorsal margin and a sub-cylindrical chela of the major second pereiopod with one large tooth on each finger (Wowor et al. 2004). This characteristic is clearly visible in males but not in females because *M. lar* has high morphological variation between the sexes, known as sexual dimorphism. In the Palaemonidae, many species show sexual dimorphism with smaller males (Correa and Thiel 2003). However, some species sometimes show the opposite because the degree of sexual dimorphism, which refers to differences in body structure between males and females, can vary among decapod crustaceans (Hernáez and João 2018). Therefore, sexual dimorphism presents a challenge in identifying species within the genus *Macrobachium* (Makombu et al. 2019). The sexual growth dimorphism in body size and weaponry observed in crustaceans is likely linked to physiological advantages, with significant implications for their reproductive processes, strategies, and mating behavior (Bauer et al. 2014; Rasch and Bauer 2016).

Sexual dimorphism has been studied in several species of shrimp, such as in several snapping shrimp: *Alpheus angulosus*, *Alpheus heterochaelis* and *Alpheus colombiensis* (Hughes et al. 2014; Azofeifa-Solano et al. 2020), *Neocaridina davidi* (Sganga et al. 2016) and *M. potiuna* (De Melo and Masunari 2017). However, exploring sexual dimorphism in *M. lar* remains limited, with previous

studies lacking associations with potential advantages. Recent research on *M. lar* has focused on population genetics (Castelin et al. 2013), food and feeding habits (Sethi et al. 2013), larval development (Lal et al. 2014), reproductive biology (Sethi et al. 2014), and reports of new records of *M. lar* (Ghazi and Hassan 2021). Therefore, discovering *M. lar* in Sukabumi, particularly in its southern region, enhances our understanding of the species' distribution and ecology. In this study, we comprehensively examine morphological traits of *M. lar* specimens from Sukabumi, West Java. Additionally, we confirm the species identity through molecular analysis using the COI marker.

Furthermore, this study focuses solely on investigating sexual dimorphism through morphological analyses of *M. lar* specimens. By meticulously examining the physical characteristics and structural differences between male and female individuals, we aim to uncover patterns and variations associated with sexual dimorphism within the species. Through detailed measurements and observations of morphological traits, we seek to elucidate the extent of sexual dimorphism in *M. lar* and its potential implications for reproductive strategies. However, it is important to recognize that sexual dimorphism is a complex phenomenon influenced by various factors beyond morphology, including behavior, genetics, and ecology. While our research provides significant insights into the morphological aspects, it represents just one facet of a multidimensional concept. Further investigations incorporating additional dimensions such as behavioral studies, genetic analyses, and ecological assessments are necessary to understand this phenomenon comprehensively. Nonetheless, the insights gained from our morphological analyses contribute significantly to the existing knowledge base and provide a foundation for future research endeavors in this field. Additionally, the findings offer essential information for conservation efforts to preserve *M. lar* populations and their habitats.

MATERIALS AND METHODS

Study area

This study is exploratory, utilizing a purposive sampling method based on information from local people regarding shrimp's presence. Samples were collected from a river in Cibitung Sub-district (7°15'37.1"S 106°41'29.2"E), Sukabumi District, West Java, in January 2023. Geographically, the southern region of West Java, including Sukabumi District, is directly bordered by the Indian Ocean. GPS coordinates were recorded at the collection site and were visually illustrated on a geographical map using QGIS v3.36.

Procedures

Sample collection

Samples were collected using the road sampling method along the river upstream from the starting point. The sampling points were selected based on the researcher's convenience in taking samples while considering the habitat conditions that usually support shrimp presence (i.e., riparian vegetation). Samples were captured by hand net and temporarily preserved in 70% ethanol in the field (Ng 2016) before being replaced with 96% ethanol for long-term preservation in the laboratory. We only collected adult individuals with well-developed morphology for identification. Additionally, we only selected individuals with complete body parts for morphological measurements. The specimens were deposited in the Animal Physiology and Behavior Laboratory at the Department of Biology, IPB University for identification. In addition, we also collected habitat data such as water temperature and pH, riverine substrate, and vegetation around the riverine area. Water temperature and pH were measured using a Multifunction 5in1 Digital Water Quality Tester, while substrate and riparian vegetation data were visually observed.

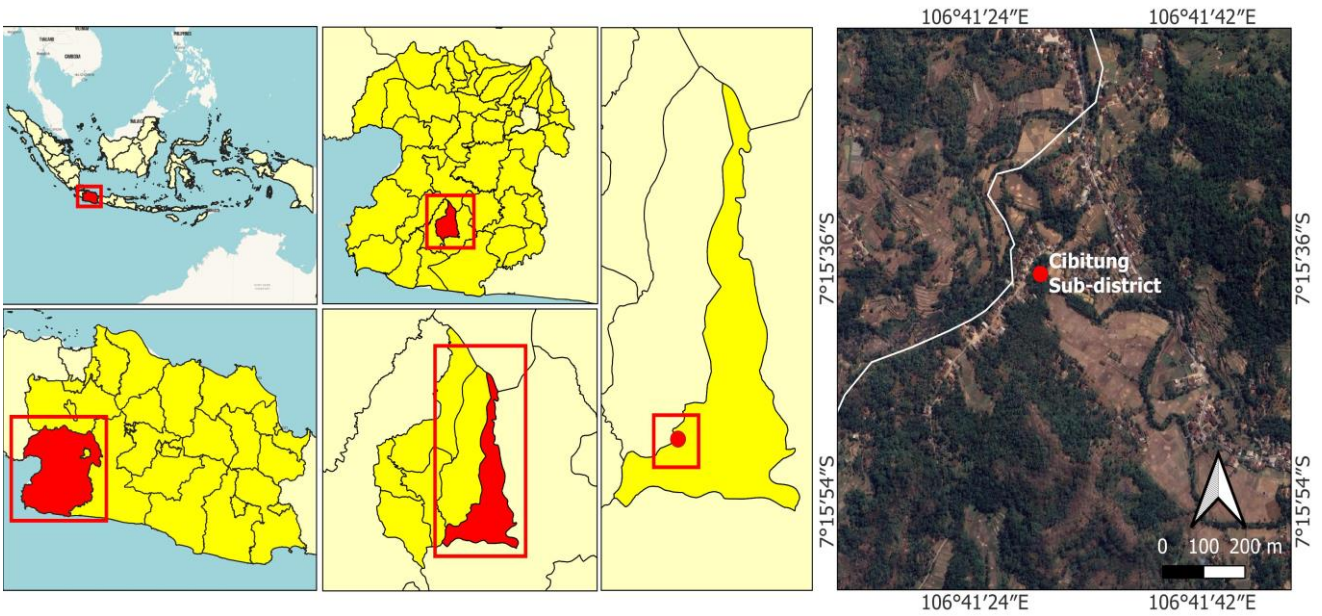

Figure 1. Geographical representation of sampling site in Cibitung Sub-district, Sukabumi District, West Java, Indonesia

Molecular identification

The total DNA was isolated from abdominal muscle tissue using the Genomic DNA Mini Kit (Tissue) provided by Geneaid (www.geneaid.com), following the manufacturer's protocols. The mitochondrial COI gene fragment of *M. lar* was amplified using forward primer AF286 (5'-TCTACAAAYCATAAAGAYATYGG3') and reverse primer AF287 (3'-GTGGCRGANGTRAARTA RGCTCG 5'). Thermal cycling began with pre-denaturation at 94°C for 1 minute, followed by denaturation at 94°C for 1 minute, annealing at 54°C for 3 minutes, extension at 72°C for 1 minute, and a final extension holding at 72°C for 2 minutes, with a total of 35 cycles. The PCR products were separated by electrophoresis on 1.0% agarose gels. Commercial companies conducted primer synthesis and DNA sequencing.

Morphological identification

The morphology of *M. lar* was identified following Wowor et al. (2004) and Chace and Bruce (1993); we also differentiated the sex of the samples by observing the presence of appendix masculine on the endopod of the second pleopod for males and the absence of attachments for females (Wowor et al. 2004; Bauer et al. 2014; de Miranda Grilli et al. 2014; Imai et al. 2018) (Figure 2).

Morphometric characters were measured consisting of morphometric and meristic measurements of morphological characters including Total Length (TL, the distance between the tip of the rostrum and the distal tip of the telson with the shrimp extended), Carapace Length (CL, the distance between the posterior margin of the orbit and the midpoint of the posterior margin of the carapace), Abdomen Length (AL, the distance between the anterior and posterior edges of the abdomen), Rostrum length (R, the distance from the base of the epigastric teeth to the tip rostrum), Head length (H, distance from the tip of the rostrum to the posterior midpoint), Carapace Height (CH, distance from the dorsal and ventral tips of the carapace), Pereiopod length (L1 and L2, distance between the proximal edge of the ischium and the distal tip of the propodus), Length of the ischium (I1 and I2, distance from the proximal end to the distal end of the ischium), Length of the merus (M1 and M2, distance between the proximal and distal edges of the merus), Length of the carpus (C1 and C2, distance from the proximal end to the distal end of the carpus), Length of the palm (P1 and P2, the distance between the proximal and distal edges of the palm), the Length of the Dactylus (D1 and D2, the distance between the proximal and distal edges of the dactylus), the number of teeth on the rostrum (Konan et al. 2008) and Abdominal Width (AW, the distance between the left and right anterior edges of the abdomen) (Nogueira and Almeida 2023). All measurements were carried out using a digital caliper (0-150 mm).

Data analysis

The morphological measurement results between males and females of *M. lar* were then visualized and analyzed using the Mann-Whitney U test, which is appropriate for non-normally distributed data (Wall Emerson 2023). Statistical analysis was carried out using RStudio software for descriptive statistics and comparative analysis (R Core Team 2021). For the molecular data, we reconstructed a phylogenetic tree to examine the relationship of *M. lar* that we obtained with reference samples, *M. lar*, and outgroup sequences, which are considered sister species for comparison: *M. lepidactyloides* and *M. idae*. These sequences were deposited in the National Centre for Biotechnology Information (NCBI) database (Table 1) using the Maximum Likelihood (ML) method. We also analyzed pairwise genetic distances calculated using the 2-parameter Kimura model with a partial deletion option. All data were analyzed using Molecular Evolutionary Genetics Analysis (MEGA) 11 software (Tamura et al. 2021). The sequence of *M. lar* from Sukabumi was compared with sequences from Pangandaran (our unpublished data) and sequences from the database (Table 1).

Table 1. Locality and GenBank accession numbers of specimens used in phylogenetic analyses

Taxa	Sample ID	Accession number	Location	Reference
Macrobrachium lar	22a	PP702365	Sukabumi	This study
	30a	PP702366		
	30b	PP702367		
	P1	-	Pangandaran	
	L1	GU205064.1	Indian West Pacific	Zimmerman G. et al. (2009)
	L2	GU205065.1		
	L11	GU205066.1		
	L21	GU205067.1		
	L31	GU205068.1		
	BIC-0223	MN526224.1	Bali	Hernawati et al. (2020)
	BIC-0221	MN526225.1		
	BIC-0225	MN526226.1		
	BIC-0224	MN526227.1		
	BIC-0222	MN526228.1		
Macrobrachium lepidactyloides	BIC-0270	MN526230.1	Bali	Hernawati et al. (2020)
Macrobrachium idae	MACR018	FM958070.1	Tioman	Wowor et al. (2009)

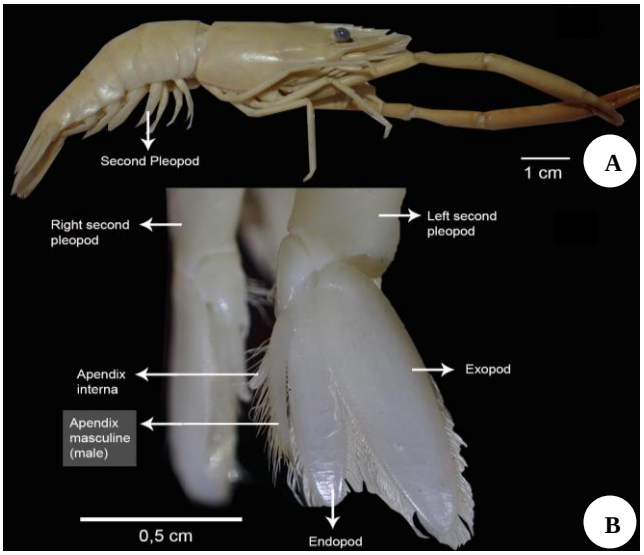

Figure 2. The appendix masculine is positioned on the A. Male's second pleopod to determine the gender of freshwater shrimp; B. The appendix masculine is located near the appendix internal and endopod

RESULTS AND DISCUSSION

We discovered ten adult individuals of *M. lar*, with six males with carapace lengths ranging from 25.6-38.2 mm and four ovigerous females with carapace lengths between 20.7-43.1 mm. Additionally, we sequenced three individuals of *M. lar*.

Genetic distance and phylogenetic

We identified all freshwater shrimp samples from Sukabumi as *M. lar* by comparing the genetic distances with *M. lar* Pangandaran and reference sequences from GenBank, including *M. lar* from the Indian-West Pacific Ocean, and *M. lar* from Bali, as well as the outgroup *M. lepidactyloides* and *M. idae* which are sister species of *M. lar*. The genetic distance values ranged from 0 to 0.274 (Table 2). *Macrobrachium lar* from Bali exhibited higher genetic distance values than *M. lar* from other locations used in this study. The genetic distance values of *M. lar* from Bali were even closer to those of *M. idae* (0.092-0.103).

The phylogenetic relationship of *M. lar* species, analyzed using the Maximum Likelihood (ML) method and depicted in Figure 2, reveals four lineages. The first group consists of the West Java sample and the reference from the Indian-West Pacific, the second group consists of the West Java samples and Pangandaran sample, the third group only consists of samples from the Indian-West Pacific, while the fourth group consists of sample from Bali and outgroup *M. idae*. As indicated by the phylogenetic tree, all samples of *M. lar* from Sukabumi are separated from the sister species *M. lepidactyloides* and *M. idae* (Figure 3).

Morphology of *Macrobrachium lar* (Fabricius, 1978)

Identification

The rostrum is short and moderately deep, with its maximum depth slightly exceeding the dorsoventral diameter of the eye. Its dorsal margin is sinuous and anteriorly upturned, with dentate features along its entire length. The teeth tend to be more closely spaced at mid-length. The rostral formula consists of 1+7/2-6 teeth, with 1-2 teeth being completely postorbital. These teeth reach the distal end of the third segment of the antennular peduncle. The post-antennular carapace margin is rounded. The scaphocerite is stout, with a length slightly less than three times its maximum width (Figure 4A). The major second pereiopod is long and sub-cylindrical, equal in shape, and may be similar or dissimilar in size between the right and left sides. All segments are covered with spines. The carpus is slightly shorter than or equal to the merus in females, while in males, the carpus is clearly shorter than the merus and also shorter than the palm, a distinction not as pronounced in females (Figure 4C and Figure 4D). The carpus has a conical shape. The ischium is moderately short. In males, the fingers gape, each bearing one large tooth, with an elongated and arched dactylus (Figure 4B and Figure 4C). The inter-uropodal sclerite exhibits a strongly developed pre-anal carina. Additionally, the distolateral process on the uropodal exopod features a spiniform seta mesially. The distal margin of the telson bears a pair of large spiniform setae.

Living colour

The rostrum is olive-grey to olive brown, and some are black (Figure 5). The body color is deep olive-brown, almost black to olive grey or blue-grey without spots or blotches. The abdominal condyles are light cream to orange, with the posterior abdomen often darker than the anterior and the tergum darker than the pleura. The first chelipeds and ambulatory legs are blue-grey to dark brown. The second chelipeds are olive to dark brown, sometimes marbled with irregular brown, olive, or blue-grey blotches, with fingers dark reddish-brown and a pink mark on the chela at the base of the dactylus. This pattern can serve as one of the distinguishing features of *M. lar* from other species.

Distribution

Macrobrachium lar has a broad distribution across the Indo-Pacific region, from eastern Africa to the Ryukyu Islands (Short 2004; Ghazi and Hassan 2021). While in Indonesia, these species can be found from Central Java and Yogyakarta (Holthuis 1950), Sumba and Ambon (Holthuis 1978), Halmahera (Cai and Ng 2001), Sulawesi (Dwiyanto et al. 2018; Rahayu and Annawaty 2019; Annawaty et al. 2022), West Papua (Fadli et al. 2018), and East Java (Susilo et al. 2020).

Habitat

Out of the 34 sampling points conducted in southern Sukabumi, *M. lar* was exclusively found in tributaries in Cibitung Sub-district, Sukabumi District, with no other freshwater shrimp species detected in the river. Found on a tributary with an elevation of 91 m, connected to a large river that flows directly into the sea. The water is murky, with moderate water flow. The water temperature is 28.5°C, and the water pH is 7.03. The substrate consists of mud and fallen plant litter. The vegetation around the creek is lush with bushes and trees (Figure 6).

Table 2. Pairwise genetic distances between *Macrobrachium lar* samples and references indicate that the sample from Sukabumi is *M. lar*, with a genetic distance of 0.00, while the genetic distance from the sister species *M. idae* is over 0.1 and *M. lepidactyloides* is over 0.25

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.	22a																
2.	30a	0.003															
3.	30b	0.019	0.015														
4.	P1	0.006	0.003	0.019													
5.	L1	0.068	0.064	0.054	0.068												
6.	L2	0.068	0.064	0.054	0.068	0.000											
7.	L11	0.019	0.015	0.000	0.019	0.054	0.054										
8.	L21	0.019	0.015	0.000	0.019	0.054	0.054	0.000									
9.	L31	0.019	0.015	0.000	0.019	0.054	0.054	0.000	0.000								
10.	BIC-0223	0.240	0.240	0.236	0.240	0.240	0.240	0.236	0.236	0.236							
11.	BIC-0221	0.240	0.240	0.236	0.240	0.240	0.240	0.236	0.236	0.236	0.009						
12.	BIC-0225	0.240	0.240	0.236	0.240	0.240	0.240	0.236	0.236	0.236	0.006	0.003					
13.	BIC-0224	0.240	0.240	0.236	0.240	0.240	0.240	0.236	0.236	0.236	0.006	0.003	0.000				
14.	BIC-0222	0.240	0.240	0.236	0.240	0.240	0.240	0.236	0.236	0.236	0.006	0.003	0.000	0.000			
15.	BIC-0270	0.190	0.190	0.182	0.190	0.194	0.194	0.182	0.182	0.092	0.103	0.099	0.099	0.099	0.099		
16.	MACR018	0.274	0.269	0.265	0.269	0.265	0.265	0.265	0.265	0.265	0.214	0.214	0.214	0.214	0.214	0.206	

*Specific name for sequences following Table 1

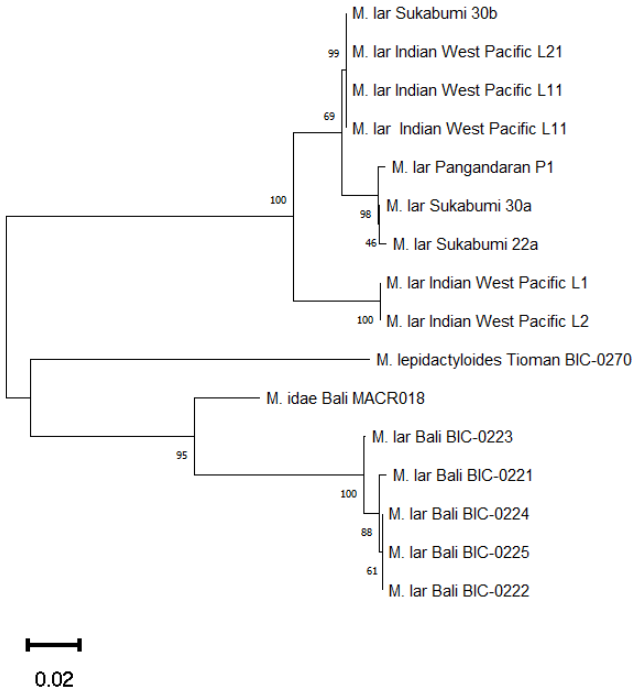

Figure 3. Maximum Likelihood (ML) tree of COI gene fragment of *Macrobrachium lar* and the outgroup *M. lepidactyloides* and *M. idae*. Four groups were formed, where *M. lar* Sukabumi joined the two groups *M. lar* Indian West Pacific and *M. lar* from Pangandaran

Morphological differentiation between male and female

Based on the Mann-Whitney U test analysis of all morphological characters compared between males and females, several characters have significant values as differentiators between males and females (Table 3). In contrast, the average results of morphological measurements between males and females can be seen in Figure 7.

Discussion

Molecular confirmation of Macrobrachium lar

The analysis of genetic differences and phylogenetic tree models reveals intriguing insights into the population of *M. lar* in Sukabumi. Although all samples belong to *M. lar*, the phylogenetic tree illustrates discernible groupings within the analyzed samples. *Macrobrachium lar* Sukabumi belongs to the *M. lar* group from the Indian West Pacific and *M. lar* from Pangandaran. In our analysis, we also included sequences of *M. lar* from Bali that are available in NCBI. However, these sequences were found to be separate from the sequences of *M. lar* from Sukabumi and *M. lar* from the Indian West Pacific, with a high genetic distance value (0.24), instead of grouping with *M. idae*, which we included as an outgroup of *M. lar*. Due to the presence of numerous cryptic species within the *Macrobrachium* genus, as highlighted in previous studies (Castelin et al. 2017; Siriwut et al. 2021), the data requires re-examination. Despite claims that *M. lar* lacks cryptic species, morphological identification may introduce biases, especially with phylogenetically close species like *M. rosenbergii*, *M. australiense*, *M. idae*, and *M. lepidactyloides* (Wowor et al. 2009). Cryptic speciation is a phenomenon within species groups with complex morphologies and overlapping distributions. The confusion in identifying freshwater shrimp is further compounded by diverse environmental conditions, leading to variations in phenotypes and morphometrics. Moreover, morphological differences between males and females can also lead to errors in species identification which could be the same species or actually different cryptic species. Although there is a high level of sexual dimorphism between male and female *M. lar* samples from Sukabumi, West Java, molecular confirmation has shown that they belong to the same species.

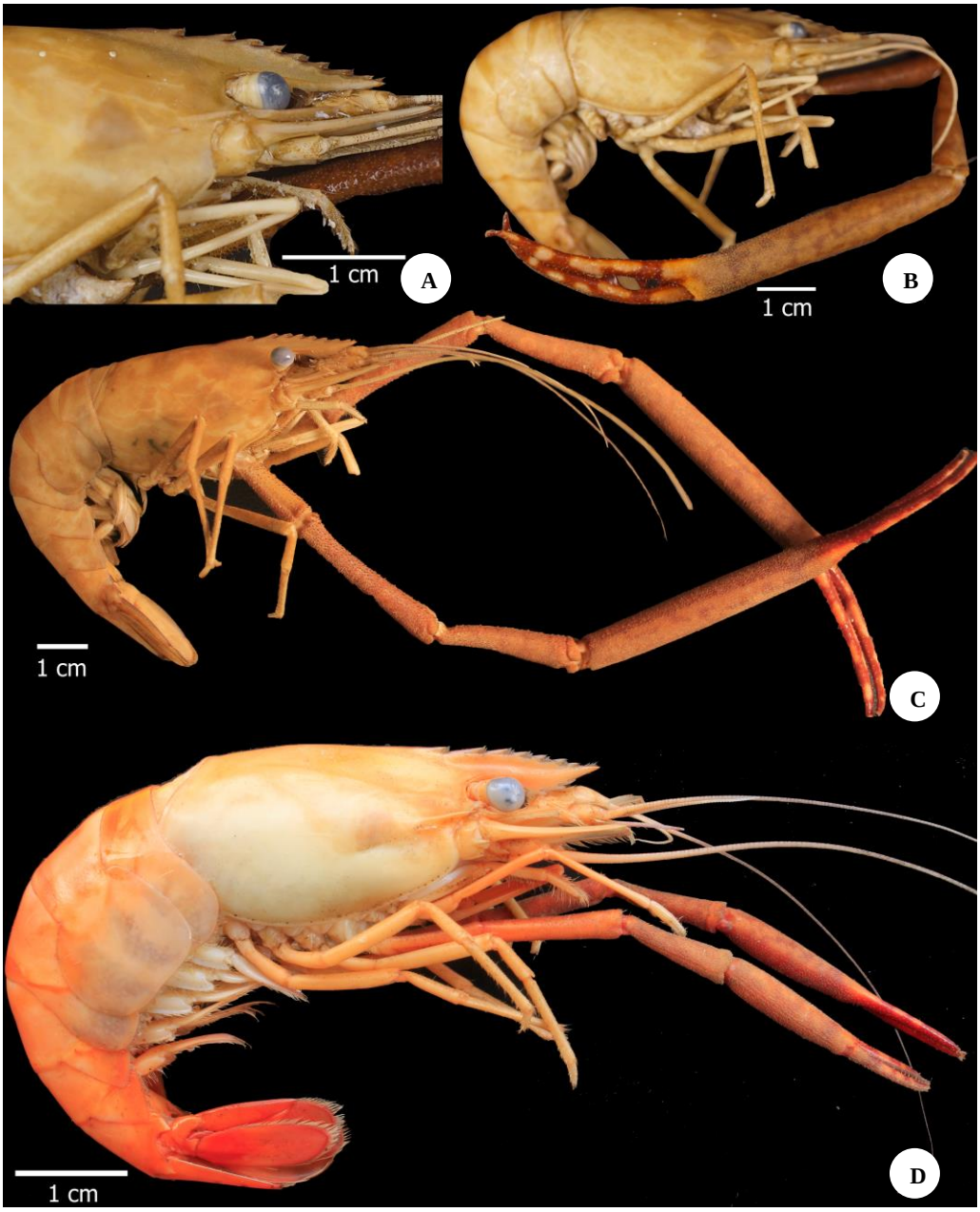

Figure 4. The morphology of *Macrobrachium lar* exhibits distinctive features: A. The head, characterized by a moderately short rostrum, not exceeding the scaphocerite and bearing 1-2 postorbital teeth; B. In males, the major second pereiopod showcases gaping fingers, each adorned with a large tooth, accompanied by an elongated and arched dactylus; C. Noticeable differences in segment length are observed in the major second pereiopod of male *M. lar*, while D. Ovigerous female *M. lar*, smaller in size than males, show less pronounced variations in segment length in their second pereiopods

Figure 5. The living color of male *Macrobrachium lar*, observed approximately an hour after sample collection, shows a deep olive-brown body color, ranging from nearly black to olive grey or blue-grey, without spots or blotches

Table 3. Mann-Whitney U test result for male and female morphological character, with measurements following Konan et al. (2008) and Nogueira and Almeida (2023). The second pereiopod (L1 and L2) and its components; carpus (C1 and C2), palm (P1 and P2), and dactylus (D1 and D2), show significant values distinguishing male and female *Macrobrachium lar*

Morphological characteristics	Wilcoxon rank sum test with continuity correction		Morphological characteristics	Wilcoxon rank sum test with continuity correction	
	W	p-value		W	p-value
TL	5	0.1082	I1	4.5	0.08825
CL	7	0.2193	I2	4.5	0.08825
R	4	0.0726	M1	5.5	0.1297
H	10	0.5083	M2	4.5	0.08825
CH	4	0.0726	C1	3	0.04672*
AL	5	0.1082	C2	3	0.04672*
AW	13	0.9247	P1	3	0.04722*
L1	3	0.04722 *	P2	3	0.04722*
L2	2.5	0.0372*	D1	3	0.04722*
			D2	3	0.04722*

*Note: Significance values are considered significant at the level α=0.05

Figure 6. Habitat of *Macrobrachium lar*. River tributary in Cibitung Sub-district, Sukabumi District, West Java, Indonesia. A. With moderate water current, and substrate consisting of mud and plant remnants; B. Dense riparian vegetation

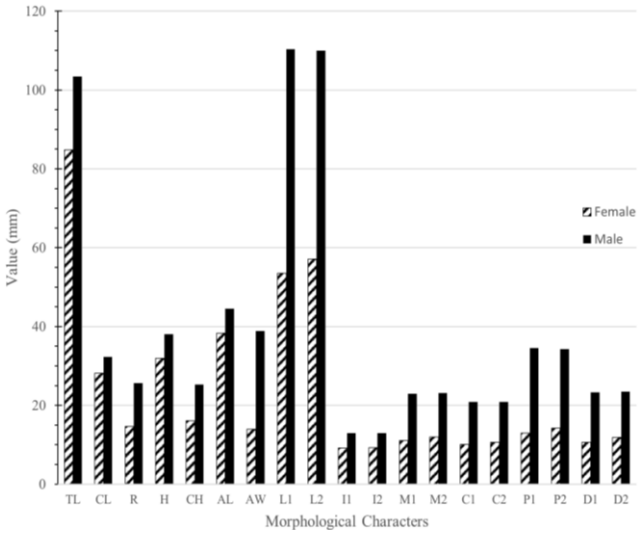

Figure 7. A morphological comparison between male and female *Macrobrachium lar* shows that male body size is significantly larger than females across all measured characteristics, particularly noticeable in the second pereiopod; L1 and L2, M1 and M2, C1 and C2, P1 and P2 and D1 and D2

Furthermore, the proximity of the Indian-West Pacific *M. lar* sample from Genbank to the Sukabumi sample can be attributed to the amphidromous nature of *M. lar*, facilitating its widespread distribution (Irving et al. 2017). Although all samples are *M. lar*, the observed genetic variations indicate the presence of genetically separate subpopulations or subspecies. The presence of *M. lar* Sukabumi in both groups suggests the possibility of migration between the *M. lar* populations in Sukabumi and those from the two regions. That is consistent with the amphidromous nature of *M. lar*, which tends to migrate for breeding, resulting in genetic interactions among geographically separated populations. Amphidromous life histories are characterized by extended planktonic development in salt or brackish water. Larva *M. lar* require oceanic salinities for successful development (Lal et al. 2014). For this reason, ovigerous females migrate into brackish water areas for spawning and sometimes for hatching before returning to freshwater habitats (Sudhakar et al. 2014). Additionally, all larvae of amphidromous species eventually return as juveniles to freshwater environments for growth and reproduction (Castelin et al. 2017). With this life cycle, larvae of *M. lar* may be carried by sea currents and develop in various locations. Larval movement between nearby estuaries ('estuary hopping') or limited dispersal in the open sea facilitates gene flow among different populations (Vogt 2013). Furthermore, the habitat where *M. lar* was discovered faces the Indian Ocean, suggesting a potential connection with *M. lar* Indian West Pacific, despite the unknown exact location.

Morphological confirmation and differentiation between male and female

Our samples were morphologically identified as *M. lar*, consistent with the descriptions provided in references. The characteristics of our samples are the right and left second pereiopods exhibit variations in size and feature brown to light brown spots. Notably, there are distinct differences in body sizes between males and females, particularly evident in the second pereiopod (Figure 4C and Figure 4D). In this study, some males, *M. lar*, had a second pereiopod length that was twice the size of its body, with three large teeth on

its fingers. In contrast, the female's palm in the second pereiopod is shorter and less robust than the males', and the teeth on her fingers are not visible. Statistical analysis confirms significant differences in the second pereiopod and its components (ischium, merus, carpus, and palm) (see Table 3). The average measurements reveal that all morphological characters measured in males are larger than those in females. Additionally, a notable difference in abdominal width was observed, even though all the females measured were ovigerous. That contradicts findings in other studies, such as *Neocaridina davidi* and *Atyaephyra thyamisensis*, where ovigerous females exhibited greater abdominal segment values than males due to their involvement in spawning, attachment, and incubation of embryos beneath the abdomen (Sganga et al. 2016; Christodoulou and Anastasiadou 2017). Nevertheless, each variation in body parts plays a crucial role in accordance with the specific needs of their respective sexes.

Sexual dimorphism, the distinct differences in body size and weaponry between male and female crustaceans, is closely tied to their mating system (Bauer et al. 2014). In *M. lar*, males exhibit larger and stronger second pereiopods, complete with teeth on their fingers (see Figure 4 and Figure 7). This feature contributes to agonistic behavior observed in male *M. lar* during intrasexual interactions, as robust chelipeds are crucial for male shrimps, facilitating competition for scarce receptive females (Correa and Thiel 2003; Hernáez and João 2018; Nascimento et al. 2020). Apart from that, larger male size also benefits females because they are more likely to defend their territory (Azofeifa-Solano et al. 2020), this confirms Correa and Thiel's (2003) statement that larger and more robust males are positively correlated with mating success (Azofeifa-Solano et al. 2020). On other hand, sexual dimorphism also serves a purpose in *M. lar* females, who are smaller than males and lack weaponry. Due to the energy demands of chela growth in shrimp, there are different levels of energy allocation between male and female shrimp. Females allocate energy to embryo production and maintenance, compromising their growth and limiting the development of chelipeds (Sethi et al. 2014; Costa-souza et al. 2019). Moreover, *M. lar* is an amphidromous species, so females must also use their energy to migrate to estuary areas to ensure that their eggs are placed in a suitable environment for the development and survival of the larvae.

In conclusion, *Macrobrachium lar* in this study was first reported from Sukabumi, West Java, and confirmed through morphology and molecular data. Based on morphology, the study revealed sexual dimorphism in *M. lar*, with males displaying larger body and pereiopod sizes, while females have small bodies without weaponry. That occurs because of differences in energy allocation between sexes, where females prioritize gonadal development, embryo production, and maintenance (Hughes et al. 2014; Sethi et al. 2014; Costa-souza et al. 2019), also migrating to spawn (Hongjamrassilp et al. 2021). Even though sexual dimorphism occurred, based on the results of molecular analysis in the phylogenetic tree, our sample clusters with those from the Indian-West Pacific region, which means that all samples were confirmed to be *M. lar*. Furthermore, from the morphology, the easiest characteristic for distinguishing *M. lar* from other species, both males and females, is by observing the brownish pattern on the cheliped of the second pereiopod. The statistical outcomes of this study may vary if conducted on *M. lar* from populations elsewhere, as behavior, genetics, and ecology can influence the morphology of a species. Furthermore, the small sample size may also influence these results, considering we only used adult samples. Therefore, it is highly recommended for future studies to use a larger sample size.

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