

First report of the parasitic crustacean rhizocephala on female Albunea symmysta from Indonesia

by Agus Nuryanto

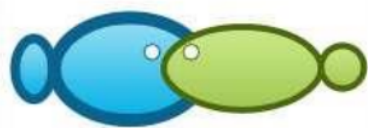
Submission date: 20-Mar-2023 05:05PM (UTC+0700)

Submission ID: 2041573699

File name: 42._Bhagawati_Bioflux_2021.pdf (964.66K)

Word count: 4696

Character count: 26250



First report of the parasitic crustacean rhizocephala on female *Albunea symmysta* from Indonesia

Dian Bhagawati, Agus Nuryanto, Aswi A. Rofiqoh

Faculty of Biology, Jenderal Soedirman University, Purwokerto, Central Java, Indonesia.
Corresponding author: D. Bhagawati, dian.bhagawati@unsoed.ac.id

Abstract. Several studies reported rhizocephala parasitism in mole crabs (*Albunea symmysta*). However, no report about which rhizocephala species infect mole crabs from Parangkusumo beach, Yogyakarta, Indonesia, has been found. This study aims to identify the rhizocephala species that infect mole crabs in the mentioned location. Rhizocephala were identified based on morphology, micro-anatomy, and cytochrome c oxidase 1 barcoding. The result showed that only female *Albunea symmysta* were infected by rhizocephala. Further examination of the parasitic rhizocephala proved that all characters were only reliable for genus level identification. All characters highly match with genus *Sacculina*. It is concluded that *A. symmysta* from Parangkusuma beach, Yogyakarta, Indonesia, was infected by *Sacculina* sp.

Key Words: gen CO1, identification, morphology.

Introduction. Rhizocephala is the most advanced parasitic metazoan. It can attack its host, mostly consisting of decapods, with a high attack rate (Brusca et al 2016). Several researchers (Høeg 1995; Høeg & Lützen 1995; Lafferty & Kuris 1996; O'Brien 1999; Thresher et al 2000; Waser et al 2016; Mouritsen et al 2018) reported that the attacks of rhizocephala have significant influences on its host population.

Studies on rhizocephala to identify members of the genus *Sacculina* based on anatomical characters and the external and internal cuticle peculiarities were carried out by Okada & Miyashita (1935) and Boshnaka (1953). The use of morphological characters in the taxonomic studies of rhizocephala by Høeg & Lützen (1985, 1996) and Øksnebjerg (2000) is exclusively related to externa. Spears et al (1994) have used molecular methods in the phylogenetic analysis of rhizocephala. The use of external histology in identifying rhizocephala has also been carried out by Yoshida et al (2011, 2015). Recently, several studies have combined various taxonomic characters to obtain more accurate results (Glenner et al 2003; Rybako & Høeg 2013; Lützen et al 2016; Kobayashi et al 2018).

Rhizocephala parasitism of crustaceans has been studied by Høeg et al (2019) to rearrange their relationships. Previous phylogenetic studies using molecular characters have been conducted and suggested a need for a fundamental revision of the rhizocephala. Those studies proved that rhizocephala widely vary in their development, host and control taxon, parasite morphology, and reproductive system. It was further explained that rhizocephala only consists of a few hundred species, generally with marine habitats, and significantly influence the host crustacean populations. The resulting phylogeny enabled the use of rhizocephala as a model for studying biological evolution in highly specialized and biologically thriving and diverse parasitic taxa (Glenner & Hebsgaard 2006; Glenner et al 2010, 2020; Lützen et al 2016; Høeg et al 2019).

Rhizocephala was reported to attack many crustacean species (Rees & Glenner 2014; Lützen et al 2018; Jensen et al 2019). For example, rhizocephala was found to infect *Upogebia* spp. (Lützen et al 2016), *Portunus sanguinolentus* (Raffi et al 2012; Yang et al 2014); mud crab *Scylla olivacea* (Kahar et al 2016); and the shrimp *Pandalina brevirostris* (Nagler et al 2017). Moreover, Elumalai et al (2014) reported that *Sacculina*

spp. infect several types of commercial marine crabs, like *P. sanguinolentus*, *Portunus hastatoides*, and *Charybdis feriatus*. However, according to Chan (2004), research on rhizocephala in the Asian region is still limited, including in Indonesia.

This research aimed to identify rhizocephala infecting female *Albunea symmysta* from the coast of Parangkusumo, in the Special Region of Yogyakarta, Indonesia, based on morphology, microanatomy, and barcode marker.

Material and Method

Study sites. *A. symmysta* specimens were collected from Parangkusumo beach, Yogyakarta, Indonesia. Study sites were located at 7°59'15"S to 8°1'58"S and 110°16'52"E to 110°20'37"E (Figure 1).

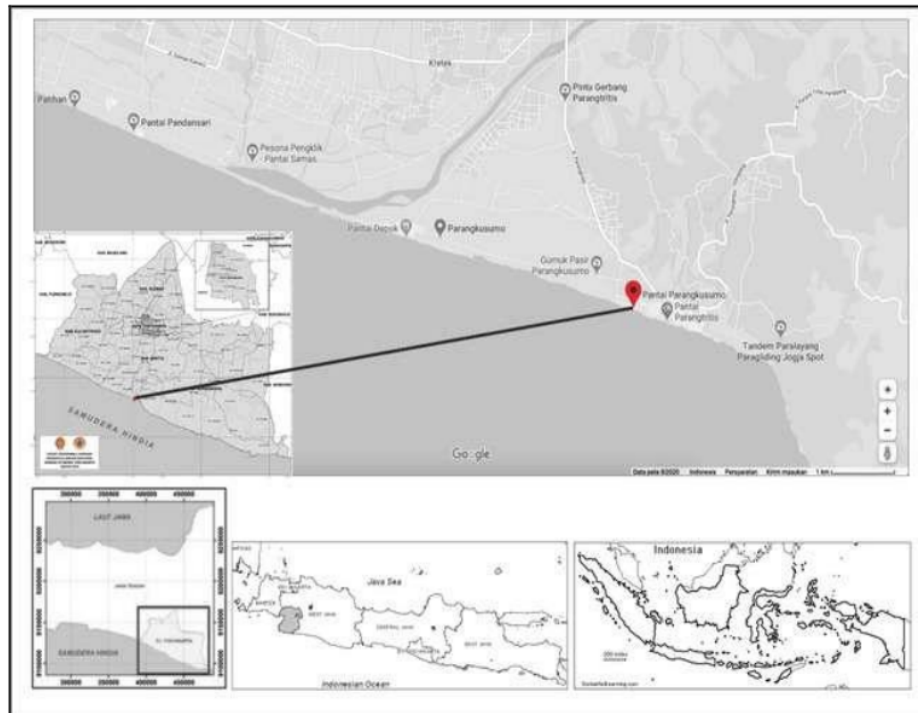


Figure 1. Study sites at Parangkusumo Beach Yogyakarta, Indonesia.

Mole crab samples were collected six times from May 2019 to March 2020. The specimens were directly, manually caught from a sloping sandy beach, on a 1 km distance along the coast. *A. symmysta* crabs were sorted according to their sex, which was determined based telson width. Females have a wider telson than males. Each female was carefully examined for the presence of parasites. The uninfected crabs were returned to the sampling site after being examined, while the infected specimens were preserved for further observation. Infection by rhizocephala was confirmed by the existence of an externa, which appears as a white sac on the host's stomach (Rees & Glenner 2014). The body of the rhizocephala was taken from the crab body using scissors and forceps, and preserved in 96% ethanol for DNA analysis. Most of the rhizocephala were preserved in 70% ethanol and 10% Neutral Buffered Formalin (NBF) solution for morphological and micro anatomic observations. The specific characteristics of the fixed and isolated externa were carefully observed under a microscope. Microanatomy examinations were carried out at the Histopathology Laboratory, Faculty of Veterinary

Medicine, Gadjah Mada University, Yogyakarta, while DNA analysis was carried out at PT Genetic Science, Indonesia.

Morphological observations. Mature or adult rizocephala live outside crab body (ectoparasite) and are called externa, while young and juveniles live inside the crab body (endoparasites). The general morphological appearance of two externa of rhizocephala that infected *A. symmysta* was examined. The parameters consisted of shape, length, and width, which were measured using a digital caliper. Other morphological characteristics were the shape and position of the mantel opening and the form of the stalk. The externa specimen was then prepared for microanatomy observations. The microanatomy preparations used paraffin and hematoxylin-eosin (HE) technique. Photomicrographs of the externa were examined under a microscope following Boschma (1933, 1953, 1955), Hoeg & Rybakov (1992), and Kobayashi et al (2018).

Molecular identification of rhizocephala. Two externa of adult rhizocephala were also subjected to molecular barcoding for taxonomic identification. The cytochrome c oxidase subunit 1 (COI) gene was used as a barcode marker. Molecular analysis was conducted at PT Genetika Science Indonesia, Jakarta. Genomic DNA of rhizocephala was extracted using Zymo Tissue and Insect DNA MiniPrep kit (Zymo Research, D6016) according to the company's protocol. The fragment of the COI was amplified using O1490 as forwards primer and HCO2198 as a reverse primer (Folmer et al 1994). The PCR amplification used KOD FX Neo (Toyobo, KFX - 201) ready mix. Amplification products were sequenced using the bi-directional sequencing technique.

Data analysis. The parasite general performance and micro-anatomy were analyzed descriptively. The COI sequences were edited manually in Bioedit 7.0.4.1. (Hall 1999). All sequences were aligned using ClustalW (Thompson et al 1994). The taxonomic status was determined based on the sample identity values compared to the sequences of conspecific references in the GenBank using the basic local alignment search tool (BLAST) method. Support to the BLAST result was obtained from phylogenetic analysis. Phylogenetic trees were reconstructed using a neighbor-joining algorithm with the Kimura-2 Parameter (K2P) evolution model in MEGA version 6.0 (Tamura et al 2013). The polarity of the phylogenetic tree was obtained from 1000 non-parametric pseudo-replicates. The parasite prevalence was also calculated using the formula of Kabata (1985).

Results and Discussion. Sixty-one specimens of mole crab were collected during the study. Sixty among 61 specimens of mole crab had more pleopods than the remaining individual, which indicated that most of the samples were female. Only one individual was an adult male. Further examination proved that ectoparasites were found on 7 out of the 60 female individuals. Thus, the prevalence was 11.48%.

Morphological assessment showed that the infected female crabs had a carapace length ranging from 2.71 to 3.23 cm (average of 2.92 ± 0.06 cm) and a width between 1.73 to 2.33 cm (average of 2.12 ± 0.08 cm). The careful observation proved that infected crabs did not carry eggs. It is assumed that ectoparasites might cause sterility of female mole crabs and that infected individuals could not produce eggs.

Ectoparasite attacks on mole crabs collected in Parangkusumo beach, Yogyakarta, could be recognized by the presence of externa attached to the host abdomen. A detailed and careful examination indicated that each crab was only infected by one individual ectoparasite and had a white color (Figure 2).

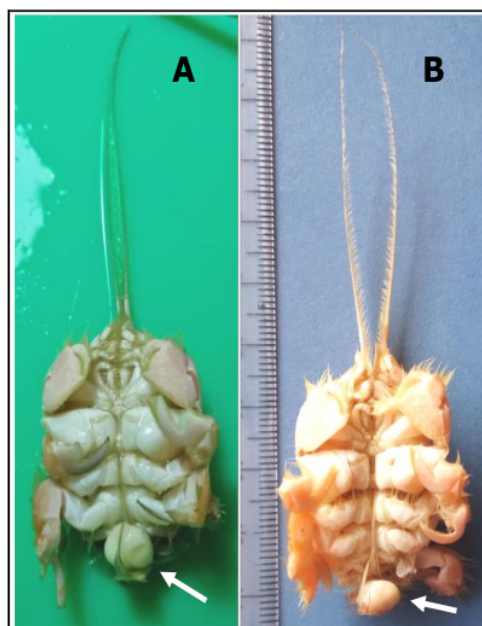


Figure 2. Externa of an adult ectoparasite on female mole crab (*Albunea symmysta*) indicated by arrow; A - fresh specimen of mole crab; B - preserved specimen of mole crab.

The outer cuticle surface of adult ectoparasites was smooth. The parasites were stalked, short tube-shaped, with a ring at the base. The externa of young ectoparasites was more rounded than that of the juveniles (Figure 3) and that of adults (Figure 4).

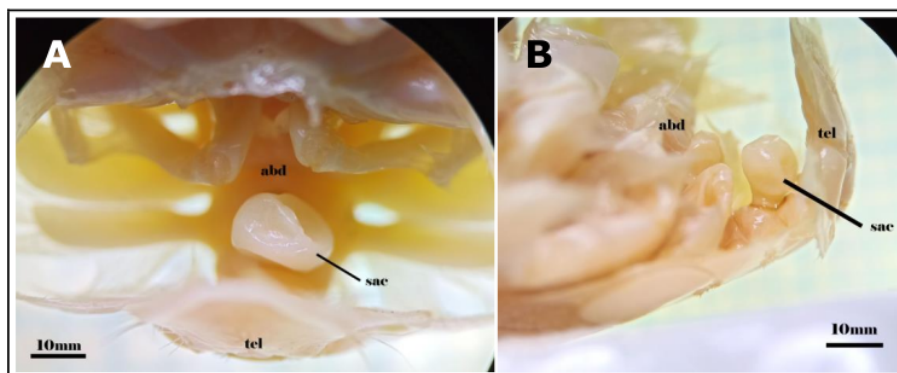


Figure 3. Externa of juvenile ectoparasites infecting female mole crabs (*Albunea symmysta*); A - dorsal view of mole crab with ectoparasite; B - lateral view of mole crab with ectoparasite; abd - abdomen; sac - saccus; tel - telson.

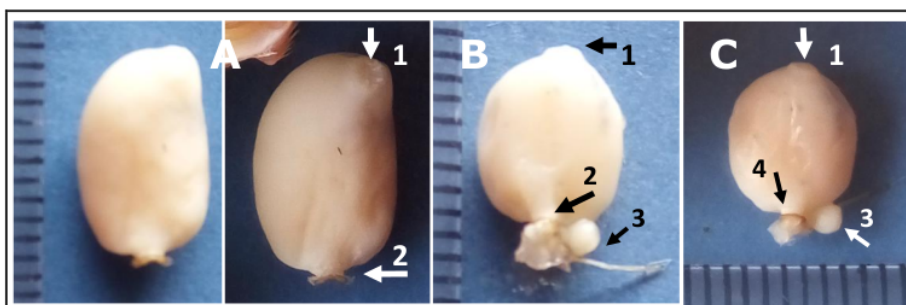


Figure 4. Externa of adult ectoparasite infecting mole crab (*Albunea symmysta*); A - asymmetry externa; B - ventral view of symmetry externa; C - dorsal view of symmetry externa; 1 - mantle aperture opening; 2 - stalk; 3 - root; 4 - ring on stalk. Bar scale: A=1 mm, B=1 mm, C= 1 mm.

The morphometric measurements showed that the externa of the observed ectoparasite had variable sizes (Table 1). Cross-section of the externa is presented in Figure 5.

Table 1

The size of externa of ectoparasites infecting *Albunea symmysta*

Individual	Length (mm)	Width (mm)	Thickness (mm)	Description
1	11	6.5	3.1	White, oval, smooth external surface, asymmetrical, circular of opening aperture mantle, visible ring on the stalk
2	8.5	6.8	3.6	White, oval, smooth outer surface, symmetrical, circular of opening aperture mantle, visible circle on the stalk
3	8.5	6,4	3.6	White, oval, smooth external surface, symmetrical, circular of opening aperture mantle, visible ring on the stalk
4	7.3	5.5	3.8	White, oval, smooth outer surface, symmetrical, circular of opening aperture mantle, visible circle on the stalk
5	7.0	5.3	3.8	White, oval, smooth external surface, symmetrical, circular of opening aperture mantle, visible ring on the stalk
6	6.1	5.0	4.0	White, rounded, smooth outer surface, symmetrical, circular of opening aperture mantle, visible ring on the stalk
7	5.2	4.8	4.3	White, rounded, smooth external surface, symmetrical, circular of opening aperture mantle, visible circle on the stalk

Basic local alignment search tool (BLAST) of the cytochrome c oxidase subunit 1 (COI) of the ectoparasite infecting mole crabs from Parangkusumo beach, Yogyakarta, showed a sequence identity of the P2 sample of 80.98% with *Sacculina* sp. sac 3 (KM087534), with the query cover of 87%. The P3 sample had a sequence identity of 80.80%, and the query covers 87% of *Sacculina* sp. sac 3 (KM087534).

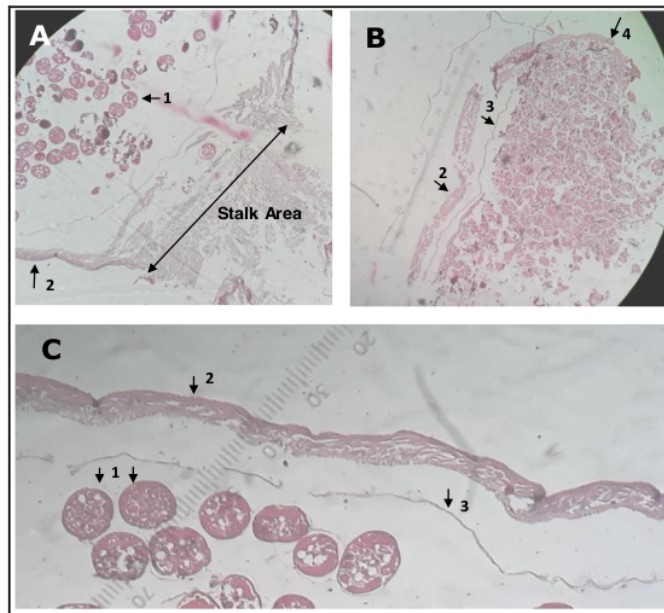


Figure 5. Cross-sections of externa of adult ectoparasite infecting mole crab (*Albunea symmysta*). 5A - cross-section of stalk areas; 4B and C - cross-section of a saccus; 1 - ovary; 2 - external mantle; 3 - internal mantle; 4 - visceral mass. Bar scales are in μm (original).

The phylogenetic tree showed that ectoparasite samples and reference species formed a monophyletic clade. The neighbor-joining (NJ) tree of the ectoparasite of mole crabs is illustrated in Figure 6.

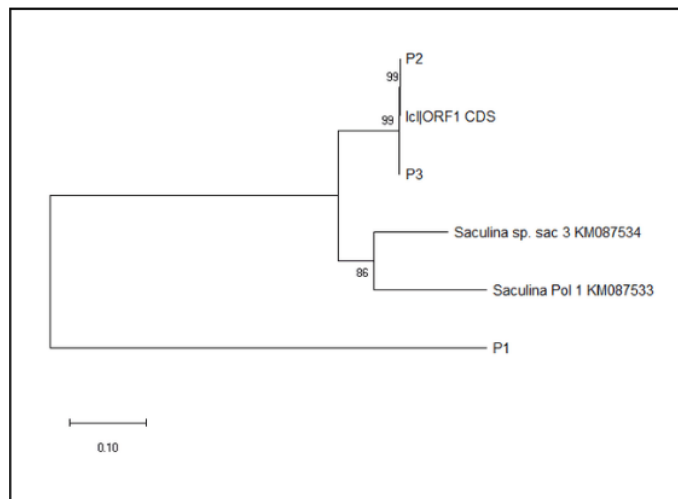


Figure 6. Neighbor joining tree of ectoparasites of mole crabs (*Albunea symmysta*).

Morphological identification of mole crabs and effect of infection. The characters of mole crab collected in Parangkusumo beach, Yogyakarta, are similar to those of *A. symmysta* previously reported by Bhagawati et al (2016) and Boyko & Harvey (1999).

Therefore, it can be determined that mole crab samples from Parangkusumo beach belong to *A. symmysta*. The rhizocephalan *Sacculina carcini* (Thompson, 1836) is a cosmopolitan parasite of many crabs species (Boschma 1972).

A detailed examination of infected *A. symmysta* from Parangkusumo beach showed reproductive disturbances. Infected individuals were unable to produce eggs. The condition is understandable because the energy that should be used for egg development is utilized by the parasite (Day 1935; Foxon 1940; Lützen 1985; Mouritsen & Jensen 2006). Previous studies proved that rhizocephala infection could alter host organisms in several ways. It has been reported that rhizocephala infection affects host behavior, energy requirement, reproductive traits, and survival (Sousa 1991; Moore 2002; Mouritsen & Poulin 2002; Lafferty & Kuris 2009; Larsen et al 2013).

Several mole crab species were found during the sampling (unpublished data). However, it was also found that only *A. symmysta* was infected by rhizocephala among mole crabs living in Parangkusumo beach, Yogyakarta. This indicated that there are hosts specific for *Sacculina* sp. It could be that *A. symmysta* has a broader carapace and telson compared to other mole crabs, such as *Hippa* spp. and *Emerita* spp. Moreover, *A. symmysta* also has a larger abdominal cavity, which makes them able to support parasite growth and develop and form saccus externa outside the host body (Boyko & Harvey 1999). The large telson of *A. symmysta* provides a protection for rhizocephala to complete their life cycle. The finding of rhizocephala in *A. symmysta* collected from Parangkusumo Beach, Yogyakarta, in this research is similar to the report of Hartnoll (1967).

Morphological and anatomical identification of the ectoparasites of mole crabs.

Morphological observations showed that the ectoparasite had white externa, was oval and rounded, with a smooth surface. It had a short, tubular stalk, and the base of the stalk had a ring. The stalk was attached to the sternum between the host's abdominal joints. The position of the opening of the mantle aperture was opposite to the base of the stalk. The opening of the mantle aperture on the adult externa is visible in a circular shape. In this study, the sac (symmetry and asymmetry) form was described based on comparing the size of the sac on the right and left of the opening mantle aperture (Figure 3). The observed characters were similar to the characters of rhizocephala described by Boschma (1933, 1953, 1955), Hoeg & Rybakov (1992), and Kobayashi et al (2018).

The analysis using a micro-anatomical cross-sectional photomicrograph of the rhizocephala externa (Figure 4) in the stalk area (Figure 4A), showed an ovary, and an external mantle with a surface without burrs. Figure 4B-C presents a cross-sectional photomicrograph of the sac, showing the internal mantle and the visceral mass. The micro-anatomical feature was similar to the anatomy of *Sacculina* from the family Sacculinidae, which has been described by Boschma (1933, 1953, 1955), Hoeg & Rybakov (1992), and Kobayashi et al (2018). Therefore, in this report, the ectoparasite of mole crabs from Parangkusumo beach, Yogyakarta, was identified as *Sacculina*.

Molecular identification of ectoparasites. Ectoparasite samples could only be identified at the genus level, since they only had 80.98% identity to *Sacculina* sp. With this identity value, the ectoparasite could only be identified as *Sacculina* sp., because the identity was less than 95%. According to Lin et al (2015), specimens could be referred to as a single species if they have a minimum sequence identity of 95% to the reference species available in database. Moreover, it has been widely used that the barcoding gap for species determination in molecular identification was 5% (Candek & Kuntner 2015).

The monophyly indicated that they belong to a single genus (Figure 6). The lengths of the tree branches indicate they can only be identified up to the genus level. According to Xu et al (2015), specimens are considered a single taxon if they form a monophyletic group.

Conclusions. According to the morphological characteristics, the ectoparasite isolated from *A. symmysta* from Parangkusumo beach, Yogyakarta, Indonesia, belongs to

rhizocephala. Microanatomy and molecular identification placed the ectoparasite into the *Sacculina* genus.

11

Acknowledgements. The author would like to thank the leadership of Jenderal Soedirman University, who approved the submission of fees for this research, as well as to the Chairperson of the Research and Community Service Institute, who had facilitated the implementation of this research (Contract number: T/387/UN23.18/PT.01.03/2020).

6

Conflict of Interest. The authors declare that there is no conflict of interest.

References

- Bhagawati D., Anggoro S., Zainuri M., Sya'rani L., 2016 Ethnotaxonomical study of mole crab (Crustacea: Hippoidea) on coastal community of Cilacap. *Biosaintifika* 8(2):222-230.
- Boschma H., 1933 On *Sacculina gordonii*, a new species of the genus, parasitic on *Atergatis floridus*. *Bulletin of the Raffles Museum* 8:36-45.
- Boschma H., 1953 The rhizocephala of the Pacific. *Zoologische Mededelingen* 32(17):185-201.
- Boschma H., 1955 Rhizocephala from New Guinea. II Peltogastridae. *Zoologische Mededelingen* 32:185-201.
- Boschma, H., 1972 On the occurrence of *Carcinus maenas* (Linnaeus) and its parasite *Sacculina carcini* Thompson in Burma, with notes on the transport of crabs to new localities. *Zoologische Mededelingen* 47(11):145-155.
- Boyko C. B., Harvey A. W., 1999 Crustacea Decapoda: Albuneidae and Hippidae of the tropical Indo-West Pacific region. *Résultats des Campagnes MUSORSTOM, Mémoires du Muséum National d'Histoire Naturelle*, Crosnier A. (ed), 20(180):379-406.
- Brusca R. C., Moore W., Shuster S. M., 2016 *Invertebrates*. Oxford University Press. Oxford, 1128 p.
- Čandek K., Kuntner M., 2015 DNA barcoding gap: reliable species identification over morphological and geographical scales. *Molecular Ecology Resources* 15(2):268-277.
- Chan K. K. B., 2004 First record of the parasitic barnacle *Sacculina scabra* Boschma, 1931 (Crustacea: Cirripedia: Rhizocephala) infecting the shallow water swimming crab *Charybdis truncate*. *The Raffles Bulletin of Zoology* 52:449-453.
- Day J. H., 1935 Memoirs: The life-history of *Sacculina*. *Journal of Cell Science* 2(308):549-583.
- Elumalai V., Viswanathan C., Pravinkumar M., Raffi S. M., 2014 Infestation of parasitic barnacle *Sacculina* spp. in commercial marine crabs. *Journal of Parasitic Diseases* 38(3):337-339.
- Folmer O., Black M., Hoeh W., Lutz R., Vrijenhoek R., 1994 DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology* 3(5):294-299.
- Foxon G. E. H., 1940 Notes on the life history of *Sacculina carcini* Thompson. *Journal of the Marine Biological Association of the United Kingdom* 24(1):253-264.
- Glenner H., Hebsgaard M. B., 2006 Phylogeny and evolution of life-history strategies of the parasitic barnacles (Crustacea, Cirripedia, Rhizocephala). *Molecular Phylogenetics and Evolution* 41(3):528-538.
- Glenner H., Høeg J. T., Rees D. J., Schubart C. D., 2020 A new molecular phylogeny-based taxonomy of parasitic barnacles (Crustacea: Cirripedia: Rhizocephala). *Zoological Journal of the Linnean Society* 190:632-653.
- Glenner H., Høeg J. T., Stenderup J., Rybakov A. V., 2010 The monophyletic origin of a remarkable sexual system in akentrogonid rhizocephalan parasites: a molecular and larval structural study. *Experimental Parasitology* 125(1):3-12.
- Glenner H., Lützen J., Takahashi T., 2003 Molecular and morphological evidence for a monophyletic clade of asexually reproducing rhizocephala: *Polyascus*, new genus (Cirripedia). *Journal of Crustacean Biology* 23(3):548-557.

- Hall T. A., 1999 BioEdit: A user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symposium Series 41:95-98.
- Hartnoll R. G., 1967 The effects of sacculinid parasites on two Jamaican crabs. Journal of the Linnean Society of London, Zoology 46(310):275-295.
- Høeg J. T., Lützen J., 1985 Crustacea Rhizocephala. Marine Invertebrates of Scandinavia, No. 6, Norwegian University Press, Oslo, 90 p.
- Høeg J. T., 1995 The biology and life cycle of the rhizocephala (cirripedia). Journal of Marine Biology Association United Kingdom 75:517-550.
- Høeg J. T., Lützen J., 1995 Life cycle and reproduction in the Cirripedia, Rhizocephala. Oceanography and Marine Biology: An Annual Review 33:427-485.
- Høeg J. T., Lützen J., 1996 [Rhizocephala]. In: Traite de Zoologie, Tome VII, Crustaces, Fascicule 2. Forest J. (ed), Masson, Paris, pp. 541-568. [In French].
- Høeg J. T., Rees D. J., Jensen P. C., Glenner H., 2019 Chapter 9. Unravelling the evolutions of the Rhizocephala – a case study for molecular based phylogeny in the parasitic Crustacea. In: Parasitic crustacea: state of knowledge and future trends. Smit N. J., Bruce N. K. L., Malherbe K. (eds), Springer, Berlin, pp. 387-419.
- Høeg J. T., Rybakov A. V., 1992 Revision of the Rhizocephala Akentrogonida (Crustacea: Cirripedia): with a list of all the species and a key to the identification of families. Journal of Crustacean Biology 12(4):600-609.
- Jensen R. A., Schneider M. R., Høeg J. T., Glenner H., Lützen J., 2019 Variation in juvenile stages and success of male acquisition in Danish and French populations of the parasitic barnacle *Sacculina carcini* (Cirripedia: Rhizocephala) parasitizing the shore crab *Carcinus maenas*. Marine Biology Research 15(2):191-203.
- Kabata Z., 1985 Parasites and diseases of fish cultured in the tropics. Taylor & Francis, London, 318 p.
- Kahar N. A. S., Sharif N. A. M., Ali M., Hussein S., Kian A. Y. S., 2016 Occurrence of parasitic barnacles Sacculinidae (Rhizocephala) infection on mud crab *Scylla olivacea* in Sabah, Malaysia. International Journal of Fisheries and Aquatic Studies 4(1):90-94.
- Kobayashi M., Wong Y. H., Oguro-Okano M., Dreyer N., Høeg J. T., Yoshida R., Okano K., 2018 Identification, characterization, and larval biology of a rhizocephalan barnacle, *Sacculina yatsui* Boschma, 1936, from northwestern Japan (Cirripedia: Sacculinidae). Journal of Crustacean Biology 38(3):329-340.
- Lafferty K. D., Kuris A. M., 2009 Parasitic castration: the evolution and ecology of body snatchers. Trends in Parasitology 25(12):564-572.
- Lafferty K. D., Kuris A. M., 1996 Biological control of marine pests. Ecology 77:1989-2000.
- Larsen M. H., Høeg J. T., Mouritsen K. M., 2013 Influence of infection by *Sacculina carcini* (Rhizocephala) on consumption rate and prey size selection of the European green crab *Carcinus maenas*. Journal of Experimental Marine Biology and Ecology 446:166-176.
- Lin H. C., Høeg J. T., Yusa Y., Chan B. K. K., 2015 The origins and evolution of dwarf males and habitat use in thoracican barnacles. Molecular Phylogenetics and Evolution 91:1-11.
- Lützen J., 1985 Rhizocephala (Crustacea: Cirripedia) from the deep sea. Galathea Reports 16:99-112.
- Lützen J., Itani G., Jespersen A., Hong J. S., Rees D., Glenner H., 2016 On a new species of parasitic barnacle (Crustacea: Rhizocephala), *Sacculina shiinoi* sp. nov., parasitizing Japanese mud shrimps *Upogebia* spp. (Decapoda: Thalassinidea: Upogebiidae), including a description of a novel morphological structure in the Rhizocephala. Zoological Science 33(2):204-213.
- Lützen J., Jensen K. H., Glenner H., 2018 Life history of *Sacculina carcini* Thompson, 1836 (Cirripedia: Rhizocephala: Sacculinidae) and the intermoult cycle of its host, the shore crab *Carcinus maenas* (Linnaeus, 1758) (Decapoda: Brachyura: Carcinidae). Journal of Crustacean Biology 38(4):413-419.
- Moore J., 2002 Parasites and the behavior of animals. Oxford University Press, London, 329 p.

- Mouritsen K. N., Jensen T., 2006 The effect of *Sacculina carcini* infections on the fouling, burying behaviour and condition of the shore crab, *Carcinus maenas*. Marine Biology Research 2(4):270-275.
- Mouritsen K. N., Poulin R., 2002 Parasitism, community structure and biodiversity in intertidal ecosystems. Parasitology 124(7):101-117.
- Mouritsen K., Geyti S., Lützen J., Høeg J. T., Glenner H., 2018 Population dynamics and development of the rhizocephalan, *Sacculina carcini*, parasitic on the shore crab *Carcinus maenas*. Diseases of Marine Organisms 131:199-211.
- Nagler C., Hornig M. K., Haug J. T., Noever C., Høeg J. T., Glenner H., 2017 The bigger, the better? Volume measurements of parasites and hosts: parasitic barnacles (Cirripedia, Rhizocephala) and their decapod hosts. PLoS ONE 12:e0179958, 18 p.
- O'Brien J. J., 1999 Parasites and reproduction. In: Encyclopedia of Reproduction. Volumes 1-4. Knobil E., Niell J. (eds), Academic Press, Oxford, pp. 638-646.
- Okada Y. K., Miyashita Y., 1935 Sacculinization in *Eriocheir japonicus* de Haan, with remarks on the occurrence of complete sex-reversal in parasitized male crabs. Memoirs of the College of Science, Kyoto Imperial University, Series B 10:169-208.
- Øksnebjerg B. O., 2000 The rhizocephala (Crustacea: Cirripedia) of the Mediterranean and Black Seas: Taxonomy, biogeography, and ecology. Israel Journal of Zoology 46(1):1-102.
- Raffi S. M., Elumalai V., Selvam D., Suresh T. V., Pravinkumar M., Viswanathan C., Jaganathan K., 2012 Studies on the prevalence of *Sacculina* spp. infestation in *Portunus sanguinolentus* (Herbst, 1783) from Parangipettai coastal waters, Southeast Coast of India. Journal of Biodiversity & Endangered Species 1(1):1000101, 4 p.
- Rees D., Glenner H., 2014 Control region sequences indicate that multiple external represent multiple infections by *Sacculina carcini* (Cirripedia: Rhizocephala). Ecology and Evolution 4:3290-3297.
- Rybakov A. V., Høeg J. T., 2013 The taxonomic position of rhizocephalan crustaceans of the genus *Parthenopea* Kossman, 1874 (Cirripedia: Rhizocephala) with validation of a new family, Parthenopeidae fam. nov. Russian Journal of Marine Biology 39:357-362.
- Sousa W. P., 1991 Can models of soft-sediment community structure be complete without parasites? American Zoologist 31(6):821-830.
- Spears T., Abele L. G., Applegate M. A., 1994 Phylogenetic study of cirripedes and selected relatives (Thecostraca) based on 18S rDNA sequence analysis. Journal of Crustacean Biology 14:641-656.
- Tamura K., Stecher G., Peterson D., Filipski A., Kumar S., 2013 MEGA6: molecular evolutionary genetics analysis version 6.0. Molecular Biology and Evolution 30(12):2725-2729.
- Thompson J. G., Higgins D. G., Gibson T. J., 1994 CLUSTAL W: improving the sensitivity of progressive multiple sequence alignments through sequence weighting, position-specific gap penalties and weight matrix choice. Nucleic Acids Research 22:4673-4680.
- Thresher R. E., Werner M., Hoeg J. T., Svane I., Glenner H., Murphy N. E., Wittwer C., 2000 Developing options for managing marine pests: specificity trials on the parasitic castrator, *Sacculina carcini*, against the European crab, *Carcinus maenas*, and related species. Journal of Experimental Marine Biology and Ecology 254:37-51.
- Waser A. M., Goedknegt M. A., Dekker R., McSweeney N., Witte J. I., van der Meer J., Thielges D. W., 2016 Tidal elevation and parasitism: patterns of infection by the rhizocephalan parasite *Sacculina carcini* in shore crabs *Carcinus maenas*. Marine Ecology Progress Series 545:215-225.
- Xu X., Liu F., Chen J., Li D., Kuntner M., 2015 Integrative taxonomy of the primitively segmented spider genus *Ganthela* (Araneae: Mesothelae: Liphistiidae): DNA barcoding gap agrees with morphology. Zoological Journal of the Linnean Society 175(2):288-306.
- Yang C. Y., Li H. X., Li L., Yan Y., 2014 Occurrence and effects of the rhizocephalan parasite *Diplothyllacus sinensis* (Cirripedia: Rhizocephala: Thomsoniidae) in the

- swimming crab *Portunus sanguinolentus* (Decapoda: Portunidae) in Honghai Bay, South China Sea. *Journal of Crustacean Biology* 34(5):573-580.
- Yoshida R., Hirose M., Hirose E., 2015 *Peltogasterella sensuru* n. sp (Crustacea: Cirripedia: Rhizocephala) from off Okinawa Island (Ryukyu Archipelago, Japan) with remarks on its single brood externa. *Systematic Parasitology* 92:31-44.
- Yoshida R., Osawa M., Hirose M., Hirose E., 2011 A new genus and two new species of Peltogastridae (Crustacea: Cirripedia: Rhizocephala) parasitizing hermit crabs from Okinawa Island (Ryukyu Archipelago, Japan), and their DNA-barcodes. *Zoological Science* 28:853-862.

Received: 12 October 2020. Accepted: 04 January 2021. Published online: 28 May 2021.

Authors:

Dian Bhagawati, Faculty of Biology, University of Jenderal Soedirman, 63 Dr. Soeparno St., 53122 Purwokerto, Central Java, Indonesia, e-mail: dian.bhagawati@unsoed.ac.id

Agus Nuryanto, Faculty of Biology, University of Jenderal Soedirman, 63 Dr. Soeparno St., 53122 Purwokerto, Central Java, Indonesia, e-mail: agus.nuryanto.unsoed.ac.id

Aswi Andriasari Rofiqoh, Faculty of Biology, University of Jenderal Soedirman, 63 Dr. Soeparno St., 53122 Purwokerto, Central Java, Indonesia, e-mail: aswi.ar@unsoed.ac.id

This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

How to cite this article:

Bhagawati D., Nuryanto A., Rofiqoh A. A., 2021 First report of the parasitic crustacean rhizocephala on female *Albunea symmysta* from Indonesia. *AACL Bioflux* 14(3):1440-1450.

First report of the parasitic crustacean rhizocephala on female Albunea symmysta from Indonesia

ORIGINALITY REPORT

12%	%	12%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Abdelrahman S. Abouzied et al.. "Quality and Safety Determination of Blood Cockle (Tegillarca granosa) Meat, Alexandria, Egypt", Egyptian Journal of Aquatic Biology and Fisheries, 2022 Publication	3%
2	Jens T Høeg, Christoph Noever, David A Rees, Keith A Crandall, Henrik Glenner. "A new molecular phylogeny-based taxonomy of parasitic barnacles (Crustacea: Cirripedia: Rhizocephala)", Zoological Journal of the Linnean Society, 2019 Publication	3%
3	K. Preetha, R. Ravinesh, A. Bijukumar, K.V. Dhaneesh, S. George. "First record of Granulifusus poppei (Mollusca: Fasciolaridae) from Indian coast", Marine Biodiversity Records, 2014 Publication	<1%

4

Jørgen Lützen. " Growth, reproduction, and life span in Thompson (Cirripedia: Rhizocephala) in the Isefjord, Denmark ", Sarsia, 2011

Publication

<1 %

5

Park, J.M.. "Horizontal gene transfer of a plastid gene in the non-photosynthetic flowering plants Orobanche and Phelipanche (Orobanchaceae)", Molecular Phylogenetics and Evolution, 200706

Publication

<1 %

6

Yanping Yang, Ziyi Ke, Fengjiao Ma, Juanjuan Dong, Min Jiang, Peijie Li, Qing Zhu, Yinping Wang, Kai Liu, Fang Zhang. " Detection of immune - related enzyme activity, gene expression and metabolomic profiling in Chinese mitten crab parasitized by ", Aquaculture Research, 2022

Publication

<1 %

7

"ANATOMY OF ARCTUROSACCUS KUSSAKINI, NEW GENUS, NEW SPECIES (RHIZOCEPHALA: AKENTROGONIDA), FROM THE ULTRAABYSSAL ISOPOD ANTARCTURUS ZENKEWITCHI KUSSAKIN (ARCTURIDAE)", Journal of Crustacean Biology, 1992

Publication

<1 %

8

B Manurung, A Hasairin, A H Daulae. " Genetic analysis and molecular phylogeny of zigzag

<1 %

leafhopper (Motschulsky) using mitochondrial COI gene ", IOP Conference Series: Earth and Environmental Science, 2020

Publication

9

Daniela Hipolito Maggio. "Influence of cropping systems on insect predators diversity and their trophic relationships", Universidade de Sao Paulo, Agencia USP de Gestao da Informacao Academica (AGUIA), 2022

Publication

<1 %

10

Marta Pérez-Miguel, Pilar Drake, Jose A. Cuesta. "Experimental predatory behavior of the stone crab *Eriphia verrucosa* (Forskål, 1775) (Decapoda, Brachyura, Eriphiidae)", Nauplius, 2017

Publication

<1 %

11

"Treatise on Zoology - Anatomy, Taxonomy, Biology. The Crustacea, Volume 9 Part C (2 vols)", Brill, 2016

Publication

<1 %

12

Chang-Ping Yang, Dian-Rong Sun, Yong-Song Qiu, Yan Liu, Binbin Shan, Teng Li, Shengnan Liu. "The parasitic barnacle *Sacculina lata* Boschma, 1933 (Cirripedia, Rhizocephala, Sacculinidae) infecting the commercial swimming crab *Charybdis miles* (De Haan,

<1 %

1835) (Decapoda, Portunidae) in the Beibu Gulf, South China Sea", Crustaceana, 2018

Publication

13

Momoko Kobayashi, Yue Him Wong, Mieko Oguro-Okano, Niklas Dreyer, Jens T Høeg, Ryuta Yoshida, Keiju Okano. "Identification, characterization, and larval biology of a rhizocephalan barnacle, *Sacculina yatsui* Boschma, 1936, from northwestern Japan (Cirripedia: Sacculinidae)", Journal of Crustacean Biology, 2018

<1 %

Publication

14

Rapid Prototyping Journal, Volume 19, Issue 3 (2013-05-27)

<1 %

Publication

15

Khor Waiho, Henrik Glenner, Aleksei Mioliubov, Christoph Noever, Marina Hassan, Mhd Ikhwanuddin, Hanafiah Fazhan. "Rhizocephalans and their potential impact on crustacean aquaculture", Aquaculture, 2021

<1 %

Publication

16

Kohei Tsuchida, Mutsumi Nishida, Jørgen Lützen. "Sympatric Three-Species Infection by *Sacculina* Parasites (Cirripedia: Rhizocephala: Sacculinidae) of an Intertidal Grapsoid Crab", Journal of Crustacean Biology, 2006

<1 %

Publication

17

Mitsuteru Hiwatari, Masafumi Seki, Ryosuke Matsuno, Kenichi Yoshida et al. "Novel TENM3-ALK fusion is an alternate mechanism for ALK activation in neuroblastoma", *Oncogene*, 2022

Publication

<1 %

18

Pablo Jaciel Adame Soto, Elva Teresa Aréchiga Carvajal, Silvia Marina González Herrera, Martha Rocío Moreno Jiménez et al. "Characterization of mating type on aroma production and metabolic properties wild *Kluyveromyces marxianus* yeasts", *Research Square Platform LLC*, 2023

Publication

<1 %

19

R. Yoshida, M. Hirose, E. Hirose. "A new peltogastrid rhizocephalan parasitising a hermit crab from the Japanese coast: a second species of *Dipterosaccus* Van Kampen & Boschma, 1925 (Crustacea: Cirripedia)", *Systematic Parasitology*, 2013

Publication

<1 %

Exclude quotes On

Exclude matches < 5 words

Exclude bibliography On