

Notes on the distribution of *Caridina sulawesi*, an endemic freshwater shrimp from Sulawesi, Indonesia

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Abstract. *Caridina sulawesi* Cai and Ng, 2009, an endemic freshwater shrimp, has been described based on the type locality in Maros, South Sulawesi. Surprisingly, this species was reported from two rivers in Central Sulawesi. Here, we provided the data about ecological aspects and the recent distribution of the species on Sulawesi Island. The specimens were collected using a hand net in 2018 and 2019, from a small natural spring in Bobo and two creeks in Napu. Water temperature varied between 17 to 22°C. Our finding shows *C. sulawesi* inhabited almost all freshwater habitat exclude lake system, with high variation in elevation and water temperatures.

1 Introduction

Genus *Caridina* H. Milne Edwards, is the most widespread freshwater shrimp from family Atyidae. This genus contains more than 300 valid species and occurs from the Africa to Indo-Pacific region [1]. The members of this genus have at least two life strategies, *i.e.*, prolonged type –required saline water for larval development, and abbreviated type –larval fully developed in freshwater [2]. In the tropical islands, such as Sulawesi, the latter type, called as landlocked type, can be found both on habitat lacustrine (lakes) and riverine (rivers or streams) [3,4].

The endemic shrimp genus *Caridina* from Sulawesi and small islands around comprise of 34 species. Many studies only focussed in the ancient lakes (*e.g.* Poso Lake and Malili Lake System), therefore it double raise the number of lacustrine species in those areas [5]. A total of 14 riverine species has been documented on this Island. Although the research on freshwater riverine endemic shrimp genus *Caridina* in Sulawesi was started about some centuries ago, intensive studies have begun in recent decades. The taxonomic issues of riverine endemic *Caridina* have been discussed by several authors [4-7], but the comprehensive data about their ecology and distribution is very lacked. One of riverine endemic shrimp that has a unique distribution pattern in the island is *Caridina sulawesi*.

Caridina sulawesi Cai and Ng, 2009 firstly been described based on type specimen from Sungai Beru, Kappang, in Maros, South Sulawesi [7]. Previously, the

distribution of this species has only known restricted in several locations in the southern and southeast arm of Sulawesi [4,7].

Surprisingly, this species was reported from two rivers in Central Sulawesi namely Poboya (PN) and Toranda (TR) [8,9]. The recent study revealed of *C. sulawesi* in a small natural spring in Bobo and two creeks in Napu, Central Sulawesi. Here, we provided the data about ecological aspects and the recent distribution of the species on Sulawesi Island.

2 Materials and methods

There is a natural spring which is located on the cacao plantation in Bobo village, Sigi. It is located about 30 km from Palu, the capital city of Central Sulawesi, Indonesia. Two other sites of creeks were located in Watumaeta and Watutau Village, Lembah Napu, Poso and flow towards the south joining with Lariang River. All sites are close to the border of Lore Lindu National Park (LLNP) (Fig. 1), the largest conservation area in Central Sulawesi. This area comprises sub-mountain to mountain zone, with altitude ranged from 250 to 2340 m above sea level [10]. The sampling from Bobo natural spring was conducted during a field course of Department Biology, Tadulako University in 2018 while the samples taken from the two other sites, Watumaeta and Watutau, were conducted during fieldwork by Zoological Community of Celebes (ZCC) in 2019.

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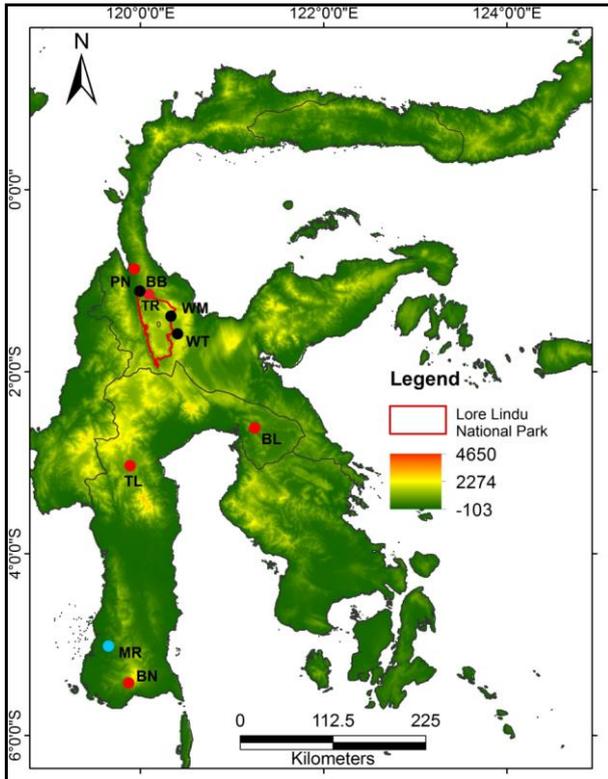


Fig. 1. Study sites and distribution of *Caridina sulawesi* on Sulawesi Island, Indonesia. Black dot shows the study sites close to the border of TNLL; red dot shows the distribution based on previous studies by several authors; blue dot shows type locality of the species, in Sungai Beru Kappang, Maros. (PN=Poboya; TR=Toranda; BL=Balambano; TL=Tilanga; BN=Bantaeng; MR=Maros; BB=Bobo; WM=Watumaeta; WT=Watutau). The color of the map displays altitudinal differences (m asl) in each site.

The specimens were collected using a hand net and preserved in ethanol 96%. All of the materials used for identification and eggs measurement were kept in the Laboratory of Animal Biosystematic and Evolution, Department of Biology, Faculty of Sciences, Tadulako University, Palu, Indonesia. The eggs size of ovigerous females were measured from the longest and shortest axis [11] using a digital caliper (0.2 mm). Water temperature measurement was made using a mercury thermometer.

Table 1. Sampling sites and habitat descriptions of *Caridina sulawesi* in Central Sulawesi.

Locations	Number of individual	Habitat	Substrate	Microhabitat	Water Temp. (°C)	Elevation (m asl)
Bobo Village, Sigi Central Sulawesi	78	Natural spring	Silty sand	Leaf litter	22	752
Watumaeta Village, Poso, Central Sulawesi	4	Creek	Coarse sand	Leaf litter	18	1197
Watutau Village, Poso, Central Sulawesi	49	Creek	Silty sand	Macrophytes	17	1214

For habitat description, both substrate [12] and microhabitat were recorded at each site. Coordinates and altitude of all sites in this study were taken using GPS (Global Positioning System) Garmin eTrex 10 (Garmin Ltd.) and rest sites were acquired basis on the record of specimens localities in the studies by several authors [4,7-9]. The distribution map was prepared using ArcMap 10.3 based on Indonesia elevation data from DIVA-GIS (www.diva-gis.org).

3 Results and discussion

3.1 Morphology of *Caridina sulawesi*

Caridina sulawesi has a semi-transparent body-color with brown dots scattered on the cephalothorax to the abdomen (Fig. 2). This species, like other members of riverine species, has a less striking coloration compared to the lacustrine species in Lake Poso and Malili Lakes System. The body coloration of atyid shrimps, generally affected by their dwelling substrate (Daisy Wowor 2017 pers. comm.).



Fig. 2. Ovigerous female of *Caridina sulawesi* from Watutau Creeks, Central Sulawesi (not to scale). The figure show color pattern, morphology of rostrum and eggs of the species (Photo by D. Dwiyanto).

Morphologically, our materials are quite similar to the original description of *C. sulawesi* described by Cai and Ng 2009. The specimens have very short rostrum, reaching near to or reach end of basal segment of antennular peduncle. Rostrum unarmed or armed dorsally with 2-5 teeth. The first pereopod with carpus excavated anteriorly, about 1.6–1.8 times as long as wide. Second pereopod with slender carpus, about 5.5 times as long as wide and 1.3 times as long as chelae.

3.2 Ecology of *Caridina sulawesi*

In this study, *Caridina sulawesi* was found from both habitat in the surface water of natural spring and creeks (Table 1). Previous studies have shown this species only reported from river in both surface and subterranean water [4,7-9]. The highest number of individual was obtained in Bobo natural spring, and the lowest was recorded in creek of Watumaeta Village.

The different numbers of these individuals might be correlated with the different number of sampling in each site and substrates. This species was observed as sand substrate dwellers and prefer silty sand. Our finding is different from two other populations in Central Sulawesi, where they found this species in mossy and rocky substrates [8,9]. In contrast to lacustrine species, where the species composition is strongly affected by the type of substrates (hard or soft substrate) [5], riverine species of *Caridina* can be found in both soft and hard substrate. The microhabitat of *C. sulawesi* was common among piles of leaf litter and dead branches of *Theobroma cacao*, *Areca catechu* and *Dillenia cf. serrata* (Bobo and Watumaeta sites) and macrophytes in Watutau site. Leaf litter in the tropical stream ecosystem is one of the favorable microhabitats for many freshwater invertebrates [13] because it provides a significant potential food resources. For atyid shrimps, their cheliped equipped by setae which makes it easy to scavenge microbial on the leaf litter surface [14].

The water temperature from all sites varied between 17 to 22°C, and it correlated with the altitude of the sites (Table 1). Bobo natural spring has the the highest temperature with elevation only 752 m above sea level while creek in Watutau, Napu, has the lowest water temperature with highest elevation up to 1214 m above sea level. *Caridina sulawesi* has also been found in temperature 22 to 24°C [8]. In the Napu site, there are also two streams nearby Watutau creek with water temperature between 15.2 to 16°C. We found no shrimp in these sites even though we did much effort to find it, which might because this species could not tolerate the temperature below 17°C. Temperature is one of the physical factors confining the distribution of freshwater shrimp. For example, *C. kaili* in Lake Lindu, Central Sulawesi, was only found in the inlet which has a maximum temperature of 23°C and never been found in the temperature above it [15].

3.3 Egg size of *Caridina sulawesi*

The egg size of *C. sulawesi* was greater than two other previous reports (Table 2). It was suggested that the reproductive biology of *C. sulawesi* belongs to the complete suppression larvae type [16], which spend their entire life in freshwater habitat. However, the eggs size of *C. sulawesi* are still smaller than *C. kaili* in Lake Lindu System (1.20-1.50 x 0.80-1.00 mm) [17] and *Lancaris singhalensis* Ortmann, from Sri Lanka (1.80 x 1.24 mm) with complete development larvae (as *Caridina singhalensis* [18]). Generally, the large egg sizes have shorter larval developmental stages, either two [18] or three stages [19].

Table 2. Eggs size variation of *Caridina sulawesi* interpopulation.

Locations	Eggs Size (mm)	Sources
Maros, Southern Sulawesi	0.90-1.00 x 0.55-0.65	Cai and Ng, 2009
Palu, Central Sulawesi	0.80-1.00 x 0.40-0.80	Mulyati <i>et al.</i> 2016
Bobo Village, Sigi Central Sulawesi	1.18-1.28 x 0.43-0.81	Present study
Watutawu Village, Poso, Central Sulawesi	1.10-1.24 x 0.75-0.83	Present study

3.4 Distribution of *Caridina sulawesi*

Caridina sulawesi was found in the three sites, *i.e.*, Bobo (BB), Watumaeta (WM) and WT (Watutau). This finding has expanded the distribution range of this species in Central Sulawesi which previously only reported in Toranda River, near Bobo site, and Pondo River, near Palu City [8,9]. Based on their type locality in Sungai Beru, Kappang, Maros (MR) (Fig. 1), *C. sulawesi* is the only member of endemic shrimp genus *Caridina* with wide distribution, from southern to the central part of Sulawesi. This species may be lived sympatrically with other riverine species, *i.e.*, *C. leclerci*, *C. longifrons*, *C. parvidentata*, and *C. pareparensis*, according to their locality in Maros (for detail please refer material examined in [6,7]) (Table 3).

In the eastern part, this species was found only in Balambano (BL), road from Malili to Sorowako (as Sungai Balambang in [7]). It has been questioned how could *C. sulawesi* distributed in this part. We hypothesized that the distribution of *C. sulawesi* might be affected by the geological process when Sulawesi Island formed in the past. Many taxa in Sulawesi Island have been distributed by dispersal events after Makassar strait formed which separated Sulawesi and Borneo islands [20]. However, some future studies, such as phylogeography analysis, are needed to show the biogeography pattern of this species.

Table 3. Distribution list of *Caridina* riverine species endemic to Sulawesi and small surround islands (based on [4]), *) Present study; (8,9).

Species	Distribution
1. <i>Caridina acutirostris</i> Schenkel 1902	Inlet of Lake Poso
2. <i>Caridina boehmei</i> Klotz & von Rintelen 2013	Tomori Area, Central Sulawesi
3. <i>Caridina butonensis</i> Klotz & von Rintelen 2013	Pulau Buton, near South-Eastern Sulawesi
4. <i>Caridina kaili</i> Annawaty & Wowor 2015	Inlet of Lake Lindu
5. <i>Caridina laroeha</i> Klotz & von Rintelen 2013	Laroeha Area, Central Sulawesi
6. <i>Caridina leclerci</i> Cai & Ng 2009	Maros, South Sulawesi
7. <i>Caridina longifrons</i> Cai & Ng 2007	Maros, South Sulawesi
8. <i>Caridina mahalona</i> Cai et al. 2009	River in Malili Lake System
9. <i>Caridina opaensis</i> Roux 1904	Aopa Area, South-Eastern Sulawesi
10. <i>Caridina pareparensis</i> De Man 1892	Several locations in South Sulawesi
11. <i>Caridina parvidentata</i> Roux 1904	Several locations in South Sulawesi
12. <i>Caridina sulawesi</i> Cai & Ng 2009	Several locations in South Sulawesi and Central Sulawesi*
13. <i>Caridina schenkeli</i> von Rintelen & Cai, 2009	Inlet of Lake Poso
14. <i>Caridina thomasi</i> von Rintelen et al. 2008	Peleng Island, near Luwuk Peninsula

Caridina sulawesi mainly distributed more in the inland water than nearby the estuary (Fig. 1). Their life strategy which supported by landlocked type showed that no longer requires brackish water or sea for larval development. However, they can be found in various altitudinal ranging from the lowland area to the mountain creeks.

4 Conclusion

Caridina sulawesi is an endemic shrimp inhabited in almost all freshwater habitat from a small natural spring to rivers, exclude lakes system. Based on their distribution, this species is commonly found in the inland water with high variation in elevation and water temperatures. *Caridina sulawesi* is widely distributed from southern to the central part of Sulawesi Island. The further study about phylogeography is needed to understand their biogeography on Sulawesi island, even though it may need more effort to find more samples.

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