

Research Article

Records of Chinese grass shrimp, *Palaemonetes sinensis* (Sollaud, 1911) from western Japan and simple differentiation method with native freshwater shrimp, *Palaemon paucidens* De Haan, 1844 using eye size and carapace color pattern

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Abstract

Chinese grass shrimp, *Palaemonetes sinensis* (Sollaud, 1911) were collected from inland waters of Nao-shima Island and Awa-shima Island, Seto Inland Sea, western Japan. The appearance of *P. sinensis* is thought to be due to the escape of imported shrimps used as sport fishing bait. *P. sinensis* looks conspicuously like the native freshwater shrimp, *Palaemon paucidens* De Haan, 1844. However, the two species have different eye sizes and differences in three diagonal stripes on the carapace. We provide a simple method using eye size and carapace color pattern to enable preliminary differentiation of the two species in the field.

Key words: palaemonid shrimp, sport fishing bait, species identification, Seto Inland Sea

Introduction

Chinese grass shrimp, *Palaemonetes sinensis* (Sollaud, 1911) (Figure 1A, B) is known from China, Myanmar, southeastern Siberia and Sakhalin (Holthuis 1950; Liu et al. 1990; Li et al. 2007; Cai and Dai 1999; Cai and Ng 2002; Labay and Barabanshikov 2009; Labay 2011). Before 1990, *P. sinensis* had not been reported from Japan (Liu et al. 1990). However, recently *P. sinensis* was discovered in an inland waterbody located in Shizuoka Prefecture, central Japan (Oonuki et al. 2010) (Figure 2).

P. sinensis has an abbreviated larval development for adaptation to freshwater life (Shen 1939). Therefore, it is difficult for larvae to disperse by the sea as found in amphidromous river shrimps. It is thought that the appearance of this species in Japan could have been caused by human-mediated introduction (Oonuki et al. 2010; Saito et al. 2011). Freshwater shrimp, *Palaemon paucidens*

De Haan, 1844 is distributed in Japan, Korea, China and Sakhalin (Hayashi 2000a) and this species is sold as bait for sport fishing in Japan. Although *P. paucidens* is a native species of Japan, it is imported from China and Korea to Japan for use as bait (Niwa 2010; Saito et al. 2011). *P. sinensis* is morphologically very similar to *P. paucidens* (Figure 1C), both species are identical in the structure of their thoracic legs (Labay and Barabanshikov 2009). Identification of the two species is difficult and imports of shrimps for use as bait inevitably include both species (Niwa 2010; Saito et al. 2011). The appearance of *P. sinensis* in Japan is thought to have been caused by the imported shrimps escaping or being released (Niwa 2010; Saito et al. 2011).

In the present paper, we report the occurrence of *P. sinensis* in two inland waters located in western Japan, and describe a simple method to distinguish *P. sinensis* from *P. paucidens*, enabling preliminary species differentiation in the field.

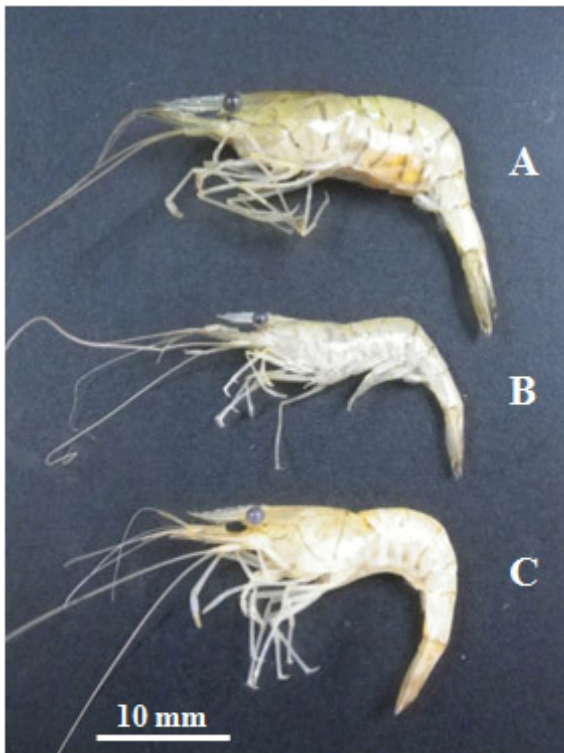


Figure 1. Lateral view of *Palaemonetes sinensis* (A and B) and *Palaemon paucidens* (C). Inland waters where specimens were collected were located in Nao-shima Island (A and C) and Awa-shima Island (B). Photographed by T. Imai.

Materials and methods

Sampling areas and methods

Nao-shima Island and Awa-shima Island are located in the Seto Inland Sea, which is the body of water separating Honshu, Shikoku and Kyushu, three of the main islands of Japan (Figure 2). The total area of Nao-shima Island and Awa-shima Island are 14.22 km² and 8.13 km², respectively.

We surveyed a total of 11 ponds in Nao-shima Island, November 2011 and June 2012. In Awa-shima Island, two ponds were surveyed, October 2012 (Figure 2; for details see supplementary Table S1). Freshwater decapod shrimps were sampled using D-shaped hand net (mesh size 2.5 mm; frame width 33 cm; handle length 60 cm). Collected shrimps were immediately preserved in 10% formalin.

An additional collection for taking photographs of shrimp and measurements of body parts were conducted July 2013 in Nao-shima Island. Collected shrimp were transported alive to the laboratory.

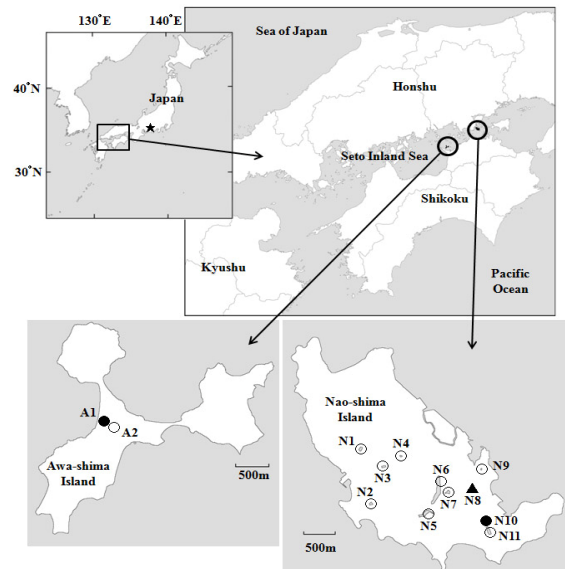


Figure 2. Location of Nao-shima Island and Awa-shima Island, Seto Inland Sea, Japan. Solid star shows the site of the previous study (Oonuki et al. 2010) where *Palaemonetes sinensis* were collected. White and black circles and black triangle represent inland waters where shrimp collection was attempted. Black circles represent sites where *P. sinensis* were collected. Black triangle represents additional collection site of *Palaemon paucidens*. For details see supplementary Table S1.

Identification and measurement

Fixed samples were used for species identification. The native freshwater decapods were identified according to Suzuki and Sato (1994) and Hayashi (1999, 2000a, b, 2007). Non-native freshwater carideans were identified using the identification guides by Chace and Bruce (1993), Jayachandran (2001) and Li et al. (2007). The presence or absence of a mandibular palp is a key characteristic to divide the genera *Palaemon* and *Palaemonetes*. We examined the sampled palaemonid shrimps for the presence or absence of a palp on the mandibles.

We photographed the carapace color pattern of *P. sinensis* and *P. paucidens* using live samples. After photography, carapace length (CL, from orbital edge to posterior margin of carapace), eye length (EL) and diameter of cornea (DC) were measured from the dorsal side (Figure 3). From the lateral side, rostrum length (RL, from tip of the rostrum to orbital edge) was measured, and the numbers of teeth were counted at three positions of the dorsal side (on carapace behind the orbit, teeth on the tip of the rostrum and less than 10% from the tip of rostrum) and on the ventral side.

Comparison between regression lines was carried out using an analysis of covariance.

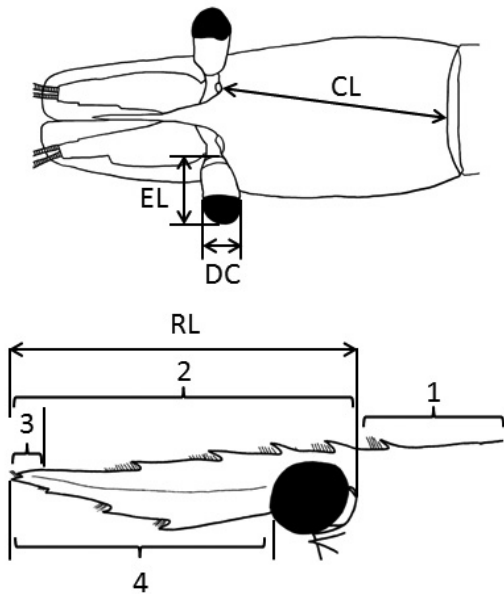


Figure 3. Diagrammatic representation of freshwater shrimps of carapace length (CL), eye length (EL), diameter of cornea (DC), and rostrum length (RL) measured, and rostrum teeth number of dorsal side (1: on the carapace behind the orbit, 2: on the rostrum before the orbit, 3: less than 10% from the tip of rostrum) and ventral side (4) counted in this study.

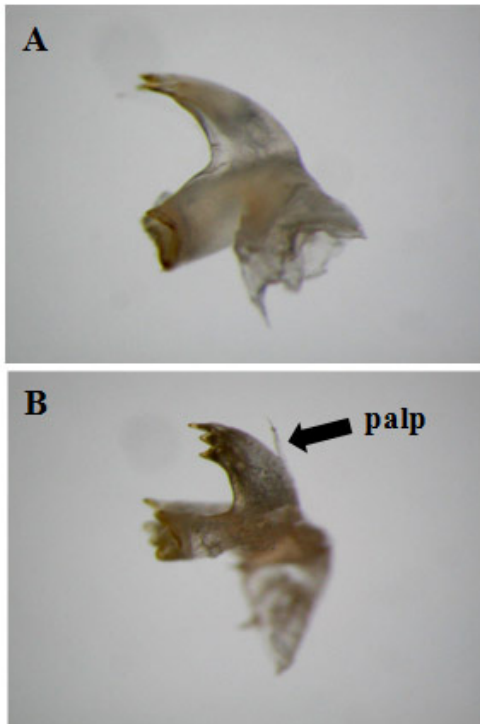


Figure 4. Mandible. *Palaemonetes sinensis* (A) and *Palaemon paucidens* (B), collected at Nao-shima Island. Photographed by T. Imai.



Figure 5. Photographs of inland waters, where *Palaemonetes sinensis* were collected. Located in Nao-shima Island, 17 June 2012 (A) and 25 December 2013 (B). Located in Awa-shima Island, 28 October 2012 (C). Photographed by T. Imai.



Figure 6. Lateral view of carapace. *Palaemonetes sinensis* (A) and *Palaemon paucidens* (C), collected in Nao-shima Island. Carapace color pattern shown as three lines (B, D). Photographed by T. Imai.

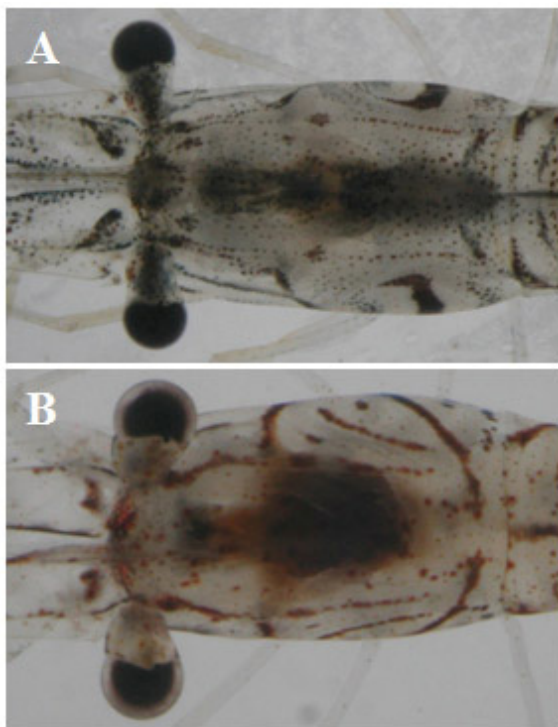


Figure 7. Dorsal view of carapace. *Palaemonetes sinensis* (A) and *Palaemon paucidens* (B), collected in Nao-shima Island. Photographed by T. Imai.

Results

The specimens identified as *P. sinensis* had mandibles without a palp (Figure 4A), and other characters that agree well with the previously published descriptions (Sollaud 1911; Kemp 1918; Holthuis 1950; Liu et al. 1990; Bruce 1994; Li et al. 2007). *P. paucidens* have mandibles with a palp (Figure 4B). Three species of freshwater shrimps, *Neocaridina denticulata* (De Haan, 1844) (11 inland waters), *P. paucidens* (four ponds) and *P. sinensis* (only one pond, Figure 5A), and the crayfish *Procambarus clarkii* (Girard, 1852) (only one pond) were recognized from Nao-shima Island (see supplementary Table S1). Ovipigerous females of *P. sinensis* were collected in June and July. However, the habitat of the Nao-shima Island population of *P. sinensis* was changed due to habitat improvement (Figure 5B). After the habitat improvement, we were unable to catch shrimps or any other organisms in the pond. In Awa-shima Island, only *P. sinensis* was collected in one pond (Figure 5C).

Both *P. sinensis* and *P. paucidens* have a unique pattern on the carapace that consists of a line between two diagonal stripes. The former species has three diagonal stripes, and the posterior one is hook-shaped (Figure 6A, B). The latter species has a line which lengthens in the cardiac region from the hepatic region between two diagonal lines (Figure 6C, D). These characteristics can be observed from the dorsal view (Figure 7).

The eye of *P. sinensis* is more slender than *P. paucidens* (Figure 7), with values of the length/diameter of cornea of *P. sinensis* (1.47–1.96) being higher than those of *P. paucidens* (1.18–1.55) (Figure 8). A significant difference between the two lines was found only in their elevations ($P < 0.05$).

Two individuals for *P. sinensis* and one individual for *P. paucidens* were excluded from the rostrum teeth count, because of a part of rostrum had broken off. Rostrum teeth formula (rostral teeth on carapace behind the orbit + upper rostral teeth/lower rostral teeth) of *P. sinensis* was similar to *P. paucidens*, and these were 0-2 + 3-6/0-2 and 1-2 + 4-6/0-2, respectively. There was no tooth on the dorsal side of less than 10% from the tip of rostrum (Figure 3-3) in the investigated total of 29 specimens of *P. sinensis* (Figure 9). On the other hand, a tooth on the tip of the rostrum in *P. paucidens* was present in 22 out of 33 specimens.

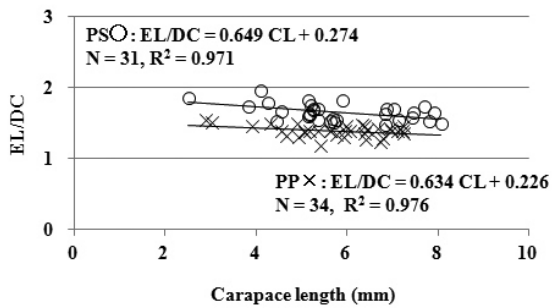


Figure 8. Relationship of eye length/diameter of cornea (EL/DC) and carapace length (CL) in *Palaemonetes sinensis* (PS) and *Palaemon paucidens* (PP), collected in Nao-shima Island.

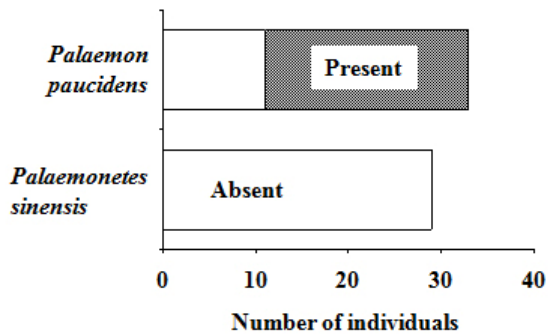


Figure 9. Presence or absence of teeth on less than 10% from the tip of rostrum of dorsal side in *Palaemonetes sinensis* and *Palaemon paucidens*, collected in Nao-shima Island.

Discussion

Before 1990, *P. sinensis* had not been reported from Japan (Liu et al. 1990). Afterwards, Oonuki et al. (2010) made the first discovery of this species and it was confirmed to reproduce in central Japan. Next our investigations also confirmed it in western Japan. We collected samples in June and July including ovigerous females. It is thought that this species has become established in the present survey area.

In western Japan, using freshwater shrimp as bait is a popular method of sport fishing. Both *P. paucidens* and *P. sinensis* are sold as Japanese trade name ‘Shirasa ebi’ (Niwa 2010; Saito et al. 2011). Both escape of the shrimp or its release by anglers are thought to be the potential cause of the occurrence of *P. sinensis* in waterbodies.

Therefore, it is possible that *P. sinensis* is also established in other place in western Japan. Further investigations are necessary to confirm the occurrence of this species in these areas.

The absence or presence of a mandibular palp is a valid character for differentiating the genera *Palaemonetes* and *Palaemon* (Chace and Bruce 1993; Jayachandran 2001; Li et al. 2007). Molar process structure of the mandible (Labay and Barabanshikov 2009; Labay 2011) or absence of a tooth on the tip of rostrum (Oonuki et al. 2010) have also been used to differentiate *P. sinensis* and *P. paucidens*. Disadvantages of these methods are: (1) identification at the sampling site is impossible; (2) potential damage of the identification character; and (3) identification by a non-specialist is difficult even if in the laboratory. Carapace color pattern used in this study is a known variation in *P. paucidens*, and all individuals examined in Shizuoka Prefecture, central Japan were confirmed to have the three diagonal stripes (Oonuki 2010). When shrimps were sampled from original habitat, they were maintained in black color tanks to maintain clearly their color pattern, because of it is known that caridean shrimps are able to change body color in relation to environmental conditions (Bauer 2004). If restricted to differentiation between *P. sinensis* and *P. paucidens* as in Japan, then eye size and carapace color pattern can be regarded as a simple effective method to distinguish the two species.

Apart from central Japan (Oonuki et al. 2010), *P. sinensis* was confirmed in western Japan in this study. Based on photographic evidence, this species also appears to occur in eastern Japan although confirmation is necessary. As both traders and fishermen are unaware that *P. sinensis* and *P. paucidens* potentially co-occur in “Shirasa ebi” there is a lack of awareness about the need to distinguish these species. By using the simple and easy distinction method shown here, data on the occurrence of this alien species *P. sinensis* in Japan can be achieved and thus enable awareness regarding problems relating to discharging it into natural inland waters.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Records of *Palaemonetes sinensis* and other freshwater decapods, collected in Nao-shima Island and Awa-shima Island.

This material is available as part of online article from:

http://www.reabic.net/journals/bir/2014/Supplements/BIR_2014_Imai_Oonuki_Supplement.xls