FIRST RECORD OF TWO SPECIES OF HERMIT CRABS (DECAPODA, PAGURIDAE) FROM SOUTH KOREA, WITH REMARKS ON THE ASSOCIATED HYDROZOAN, HYDRISSA SODALIS

BY

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ABSTRACT

Two pagurid species, Pagurus quinquelineatus Komai, 2003 and Pagurus rectidactylus Komai, Saito & Myorin, 2015, are reported from South Korea. Pagurus nigrivittatus is most similar to these two species among the congeneric species known from South Korea. The additional morphological differences between P. quinquelineatus and P. rectidactylus are provided briefly. The most distinct feature of the South Korean P. rectidactylus compared to the original description is that an associated hydrozoan, Hydrissa sodalis (Stimpson, 1858) instead of Bouillonactinia misakiensis (Iwasa, 1934) is responsible for the carcinoecia. The association of H. sodalis with other hermit crabs in South Korea was investigated.

RESUMEN

Dos especies de pagúridos Pagurus quinquelineatus Komai, 2003 y Pagurus rectidactylus Komai, Saito & Myorin, 2015, son citados en Corea del Sur. Entre las especies del género citadas en Corea del Sur, Pagurus nigrivittatus es la más similar a estas dos especies. Se incluyen nuevas diferencias morfológicas entre P. quinquelineatus y P. rectidactylus. La diferencia más importante de los ejemplares coreanos de P. rectidactylus respecto a la descripción original es que una especie asociada de hidrozoo, Hydrissa sodalis (Stimpson, 1858) y no Bouillonactinia misakiensis (Iwasa, 1934) es la responsable de la carcinoecia. Se estudia la asociación de H. sodalis con otros cangrejos ermitaños de Corea del Sur.

INTRODUCTION

The genus Pagurus Fabricius, 1775 has been considered as the polyphyletic group in the family Paguridea Latreille, 1802 (McLaughlin et al., 2007; Mantelatto et al., 2009; Olguin & Mantelatto, 2013) and consists of 177 species worldwide

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To our knowledge this is the first report, as part of ongoing systematic studies on South Korean hermit crabs, of *P. quinquelineatus* Komai, 2003 and *P. rectidactylus* Komai, Saito & Myorin, 2015 from South Korean waters. Since the specimens of *P. rectidactylus* showed some differences from the original description, the species is diagnosed and illustrated briefly. The most distinct feature of *P. rectidactylus* from South Korea is that its associated hydrozoan is not *Bouillonactinia misakiensis* (Iwasa, 1934), as mentioned in the original description, but *Hydrissa sodalis* (Stimpson, 1858). Therefore, we further investigated the association of *H. sodalis* with other hermit crabs in South Korea.

**MATERIAL AND METHODS**

All specimens from the present study were preserved in 80% ethanol. All drawings were made with a dissecting microscope MZ8 (Leica, Wetzlar, Germany) equipped with a camera lucida. Photographs were taken with a Nikon D200 digital camera and processed with the focus stacking program Helicon Focus (Helicon Soft, Kharkov, Ukraine). Shield length (sl) was given to indicate size of the specimen, measured from the tip of the rostrum to the midpoint of the posterior margin of the shield, and was taken using a digital caliper (CD6CSX, Mitutoyo, Kawasaki, Japan) to the nearest 0.1 mm. The terminology used in this paper is that of McLaughlin et al. (2007). The specimens used in this study have been deposited in the Marine Arthropod Depository Bank, Seoul National University (MADBK) and National Institute of Biological Resources (NIBR) of South Korea.
The other specimens, from the Natural History Museum and Institute (Chiba, Japan), examined for the purpose of further comparative study, are as follows:


**SYSTEMATICS**

**Family PAGURIDAE** Latreille, 1802

**Genus Pagurus** Fabricius, 1775

**Pagurus quinquelineatus** Komai, 2003

(fig. 1)

*Korean name: Da-seot-jul-cham-jib-ge*

*Pagurus quinquelineatus* Komai, 2003: 149, figs. 20-23, 24B, 25A; Komai & Takeda 2006: 116; McLaughlin et al., 2010: 34 (list); Arima, 2014: 118.

Material examined.— One ♀ (sl 2.2 mm), Uljin-gun, Gyeongsangbuk-do, South Korea, 16 m, by scuba diving, 30 Oct. 2009, MADBK 160742_001; 1 ♀ (sl 2.7 mm), Tonggumi, Ulleung-gun, Gyeongsangbuk-do, South Korea, 15 m, by scuba diving, 13 Nov. 2013, Coll., Jung J., NIBRIV0000325763.

Colour.— In ethanol, each ambulatory leg with 3 stripes on lateral surface of dactylus, 5 stripes on propodus, and 4 stripes on carpus.

Distribution.— Suruga Bay, southeastern and northwestern coast of mainland of Japan; Ulleung Island and Uljin-gun, South Korea (present); intertidal to subtidal.

Habitat.— Gastropod shell.

**Pagurus rectidactylus** Komai, Saito & Myorin, 2015

(figs. 2-4A)

*Korean name: Je-jib-jul-cham-jib-ge*

*Pagurus rectidactylus* Komai, Saito & Myorin, 2015: 225, figs. 1-5.

Material examined.— One ♂ (sl 3.5 mm), Dokdo, Ulleung-gun, Gyeongsangbuk-do, South Korea, by scuba diving, 3 Jun. 2015, coll. Park J., NIBRIV0000325762; 1 ♀ (sl 5.4 mm), Dokdo, Ulleung-gun, Gyeongsangbuk-do, South Korea, by scuba diving, 21 Sep. 2015, coll. Park J., MADBK 160748_001.

Diagnosis.— Shield (fig. 2A) as long as broad, with tuft of setae on dorsal surface and lateral margin. Rostrum broadly triangular, exceeding base of ocular
Fig. 1. *Pagurus quinquelineatus* Komai, 2003 (female, sl 2.7 mm, NIBRIV0000325763, left second ambulatory leg missing, chelipeds and right ambulatory legs broken). A, dorsal view; B, ventral view.
Fig. 2. *Pagurus rectidactylus* Komai, Saito & Myorin, 2015 (male, sl 5.4 mm, MADBK 160748_001). A, shield and cephalic appendages, dorsal view; B, right cheliped, dorsal view; C, left cheliped, dorsal view; D, left pereopod 2, lateral view; E, left pereopod 3, lateral view; F, dactylus of left pereopod 3, mesial view; G, telson, dorsal view. Scale bars = 2 mm.
acicles. Lateral projection obsolete. Posterior carapace almost membranous, with tufts of setae.

Ocular peduncle shorter than length of shield; dorsomesial margin with a row of tufts of setae. Ocular acicles subcircular, terminating in small submarginal spine, separated basally by about basal width of acicle. Antennular peduncle exceeding corneas by half of ultimate segment. Antennal peduncle exceeding corneas. Antennal flagellum reaching distal end of right cheliped.

Pereopods with numerous long tufts of setae. Right cheliped (fig. 2B) longer than left one. Chela of right cheliped two times as long as broad. Dactylus slightly shorter than palm; dorsal surface unarmed or row of tiny spines; dorsomesial margin with small tubercles; cutting edge with row of calcareous teeth, terminating in corneous claw. Palm as long as carpus and merus, dorsal surface slightly convex with 4-5 rows of small spines or tubercles; dorsomesial and dorsolateral margin with row of spines. Dorsal surface of carpus with 4 irregular rows of spines. Ventromesial and ventrolateral margin of merus with row of spines.

Chela of left cheliped (fig. 2C) 3 times as long as broad. Dactylus unarmored, longer than palm; cutting edge with row of corneous teeth, terminating in corneous claw. Palm half as long as carpus; dorsal surface slightly convex with 2 rows of spines nearby midline, mesial part with 3-4 small spines or tubercles; dorsolateral margin with row of spines. Carpus as long as merus, depressed laterally; dorsomesial and dorsolateral margins with rows of spines sparsely; lateral surface with few tubercles; ventrolateral margin with row of spines distally. Ventromesial and ventrolateral margin of merus with row of spines.

Ambulatory legs (fig. 2D-F) slender and long. Dactylus subequal to propodus, with distal corneous claw; dorsomesial surface with row of spines; ventral margin with 12-16 long spines. Ventral margin of propodus with row of 4-8 spines distally. Carpus with dorsodistal spine.

Abdomen coiled rightward, with 3 unpaired pleopods in male and asymmetric uropods.

Terminal margin of telson (fig. 2G) slightly concave, terminal lobe divided by shallow and wide median cleft, each lobe armed with 6 spines.

Colour.— In ethanol, each ambulatory leg with 3 stripes on lateral surface of dactylus, 5 stripes on propodus, and 4 stripes on carpus (fig. 3).

Distribution.— Hiroshima Prefecture and Fukui Prefecture, Japan; Dokdo Island, South Korea (present); intertidal to shallow subtidal.

Habitat.— Carcinoecia formed by an associated hydrozoan, *H. sodalis* (fig. 4A).

**DISCUSSION**

*Pagurus quinquelineatus* and *P. rectidactylus* are reported from South Korean waters for the first time and the latter species is reported for the second time.
Fig. 3. Pagurus rectidactylus Komai, Saito & Myorin, 2015 (male, sl 5.4 mm, MADBK 160748_001, right cheliped broken). A, dorsal view; B, ventral view.
Fig. 4. *Hydrissa sodalis* (Stimpson, 1858) associated with Paguroidea species. A, *Pagurus rectidactylus* Komai, Saito & Myorin, 2015 (male, sl 5.4 mm, MADBK 160748_001); B, *Dardanus impressus* (De Haan, 1849) (male, sl 13.7 mm, EVOSYS 260504#004); C, *Pagurus simulans* Komai, 2000 (male, sl 5.9 mm, MADBK 160719_017).
in the world. Previously these two species were only recorded from the Honshu mainland of Japan. The distributional range of these two species now extends to the northwestern part (Uljin, Ulleung and Dokdo Islands, South Korea). The number of species belonging to genus *Pagurus* reported from South Korea has now reached 30.

*P. quinquelineatus* and *P. rectidactylus* are similar to *P. nigrivittatus*, previously reported from South Korea. These two species, however, can be distinguished from the latter species by various morphological characters, such as armature and number of stripes of ambulatory legs, as mentioned by Komai (2003). The morphological differences between *P. quinquelineatus* and *P. rectidactylus* were discussed in detail in the original description of the latter species (Komai et al., 2015). In addition, two more morphological differences between them were observed in this study. First, the antennular peduncle of *P. quinquelineatus* is shorter than that of *P. rectidactylus*. Second, the dorsal surface of the palm of the right cheliped is armed with 7 rows of spines in *P. quinquelineatus*, whereas there are 4-5 rows of spines in *P. rectidactylus*.

The present specimens of South Korean *P. rectidactylus* showed some differences from the original description (Komai et al., 2015). First, there are 12 spines on the ventral margin of the dactylus of the right second pereopods in the present specimens, whereas there are 15-20 spines in the original description. Second, the left chela in the present specimens has more spines and tubercles than in the specimen used for the original description. Third, the antennal acicles were missing in one specimen of South Korean *P. rectidactylus* (MADBK 160748_001), possibly due to injury or abnormality. The last and most distinct feature is that the associated hydrozoan forming carcinoecian of *P. rectidactylus* is *H. sodalis* in the present specimens, whereas it is *Bouillonactinia misakiensis* (Iwasa, 1934) in the original description.

Until now, *H. sodalis* has been known to be associated with *P. constans* (Stimpson, 1858; Goto, 1910; Williams & McDermott, 2004). However, the presence of *H. sodalis* in *P. rectidactylus* suggests that *H. sodalis* might have multiple hosts, like *Hydractinia echinata* (Fleming, 1828) does (Williams & McDermott, 2004). In order to determine whether *H. sodalis* is associated with other hermit crabs in South Korea, we examined 431 specimens belonging to 15 species, 4 genera, and 2 families of Paguroidea caught in the subtidal area from 1969 to 2016 (table I). The results showed that *H. sodalis* was associated with not only *P. constans* but also with *Dardanus impressus* (De Haan, 1849), *P. simulans*, *P. rectidactylus*, and 11 other species: *Dardanus arrosor* (Herbst, 1796), *Diogenes edwardsii* (De Haan, 1849), *D. penicillatus* Stimpson, 1858, *Elassochirus cavimanus* (Miers, 1879), *P.
TABLE I
Association of *Hydrissa sodalis* (Stimpson, 1858) with Paguroidea belonging to 15 species, 4 genera, and 2 families caught in subtidal area on the coast of South Korea from 1969 to 2016

<table>
<thead>
<tr>
<th>Species name</th>
<th>The condition of occupied gastropod shell</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Totally covered hydrozoan</td>
<td>Partly covered hydrozoan</td>
</tr>
<tr>
<td><em>Dardanus arrosor</em> (Herbst, 1796)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><em>Dardanus impressus</em> (De Haan, 1849)</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td><em>Diogenes edwardsii</em> (De Haan, 1849)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><em>Diogenes penicillatus</em> Stimpson, 1858</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><em>Elassochirus cavimanus</em> (Miers, 1879)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><em>Pagurus brachiomastus</em> (Thallwitz, 1892)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><em>Pagurus constans</em> (Stimpson, 1858)</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td><em>Pagurus ochotensis</em> Brandt, 1851</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><em>Pagurus parvispina</em> Komai, 1997</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><em>Pagurus pectinatus</em> (Stimpson, 1858)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><em>Pagurus rathbuni</em> (Benedict, 1892)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><em>Pagurus rubrior</em> Komai, 2003</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><em>Pagurus rectidactylus</em> Komai, Saito &amp; Myorin, 2015</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>Pagurus simulans</em> Komai, 2000</td>
<td>29</td>
<td>51</td>
</tr>
<tr>
<td><em>Pagurus trigonocheirus</em> (Stimpson, 1858)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>59</strong></td>
<td><strong>65</strong></td>
</tr>
</tbody>
</table>

Numbers indicate the number of specimens.

*brachiomastus, P. ochotensis, P. parvispina, P. pectinatus, P. rathbuni, P. rubrior, and P. trigonocheirus.*

In the case of *P. constans*, its gastropod shell is small and fully covered by *H. sodalis*, as indicated in the previous study (Goto, 1910; Makarov, 1962), although there is a specimen living in the sponge (Komai, 1999). In *D. impressus* and *P. simulans*, 8 out of 13 (61.5%) and 80 out of 139 specimens (57.6%) are associated with *H. sodalis*, respectively. It is noteworthy that 7 out of 8 and 51 out of 80 specimens were found in the moderately large gastropod shell partly covered by *H. sodalis* (fig. 4B, C). This feature differs from the case of *P. constans* as mentioned above. In the case of two *P. rectidactylus* specimens, gastropod shell of one specimen (MADBK 160748_001) was fully covered by *H. sodalis* (fig. 4) but other specimen (NIBRIV0000325762) was partly covered. In *D. arrosor, P. brachiomastus, P. pectinatus and P. rubrior*, only one specimen was fully covered by *H. sodalis* (fig. 5A, B). In the case of *D. edwardsii, D. penicillatus, E. cavimanus, P. ochotensis, P. parvispina, P. rathbuni, and P. trigonocheirus*, only one specimen was partly covered by *H. sodalis* (fig. 5C-F). Present study on the association of *H. sodalis* with hermit crabs was based on the simple observation of preserved specimens of limited species. Additional data are necessary to
Fig. 5. *Hydrissa sodalis* (Stimpson, 1858) associated with Paguroidea species. A, *Dardanus arrosor* (Herbst, 1796) (female, sl 8.9 mm, EVOSYS 260502#011); B, *Pagurus brachiomastus* (Thallwitz, 1892) (male, sl 8.5 mm, EVOSYS 260706#069); C, *Diogenes penicillatus* Stimpson, 1858 (male, sl 4.1 mm, MADBK 160508_002); D, *Elassochirus cavimanus* (Miers, 1879) (male, sl 9.0 mm, MADBK 160701_007); E, *Pagurus parvispina* Komai, 1997 (male, sl 12.7 mm, MADBK 160744_001); F, *Pagurus trigonocheirus* (Stimpson, 1858) (male, sl 13.1 mm, MADBK 160720_007).

investigate several features such as host specificity and host availability concerning association of *H. sodalis* with hermit crabs.

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