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## Distributions of a halophilous and a riparian species of harvestmen along Sendai River, Tottori City, with the first records of harvestmen in Tottori Sand Dunes

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**Abstract** — Distributions of a maritime harvestman, *Psathyropus tenuipes* and a riparian harvestman *Paraumbogrella pumilio* were investigated along the Sendai River, Tottori City, Honshu, Japan. *Psathyropus tenuipes* was found from the mouth of the river to the site 4 km upstream where slight salinity (0.1 PPT) was detected in the river. On the other hand, no specimens were found from the upstream sites where no salinity was detected. This indicates that the species needs at least a slight salinity for its occurrence. *Paraumbogrella pumilio* was found at five sites from the dry riverbed near the Shobu floodgate to a site on the right bank of Sendai River just upstream of Yachiyo Bridge. Occurrence of this species seems to be related to presence of open ground covered with lower grasses on the banks. Recently, the both species were also found from the right bank of the river mouth of Sendai River that is also a part of Tottori Sand Dunes. These are the first records of harvestmen from Tottori Sand Dunes.

**Key words** — distribution, Opiliones, salinity, *Psathyropus tenuipes*, *Paraumbogrella pumilio*, Sendai River, Tottori Sand Dunes

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The Sendai River, 50 km long, is one of three first-class rivers flowing down in Tottori Prefecture (from west to east, Hino R., Tenjin R., Sendai R.), and flows through Tottori City and pours into Sea of Japan, making Tottori Sand Dunes at the right (eastern) bank of the river mouth (Fig. 1). The river has been paid much attention as an effective dispersal barrier for various species of harvestmen and millipedes (Shear et al. 1994; Tsurusaki et al. 1991; Gorlov & Tsurusaki 2000; Tsurusaki 2003a, 2007). On the other hand, riverbeds of the Sendai River provide habitats for a few species of harvestmen of Gagrellinae (Sclerosomatidae), such as *Psathyropus tenuipes* L. Koch 1878 (Tsurusaki unpublished data) and *Paraumbogrella pumilio* (Karsch 1881) (Tsurusaki 1993). *Psathyropus tenuipes* is a maritime species and its occurrence is strictly restricted to sea coasts in western part of Japan, though some inland populations have also been found in eastern and northern Japan (Tsurusaki & Ikeda 1987; Tsurusaki & Shimada 2004; Tsurusaki 2015). This species has been found also on the shorefront of some

rivers, such as Tamagawa, Arakawa, and Edogawa Rivers in Tokyo Prefecture (Tsurusaki & Fukaya 2014) or Ohashi River (Shimane Prefecture) and Lake Shinji with brackish water with a salinity around 1/10 of sea water in Shimane Prefecture (Tsurusaki 2008). On the other hand, *P. pumilio* is a harvestman which tends to be found in disturbed habitats, such as roadsides in agricultural land or riverbeds and banks of large rivers (Tsurusaki & Fukaya 2014, Tsurusaki 2015). This species has also been found under pebbles on the bare riverbed, which is likely to be easily submerged during floods, of the Sendai River (Tsurusaki 1993). To test a hypothesis that presence of the salinity is a prerequisite for the occurrence of *P. tenuipes* and to know the range of populations of *P. pumilio* in Sendai River, we made surveys for the occurrence of the two species along the Sendai River in 2006. In this paper, we report the results of the survey.

In addition, we also present recent records collected in 2019 of the two species on the right bank of the river mouth of Sendai River, which is the western border of the Tottori

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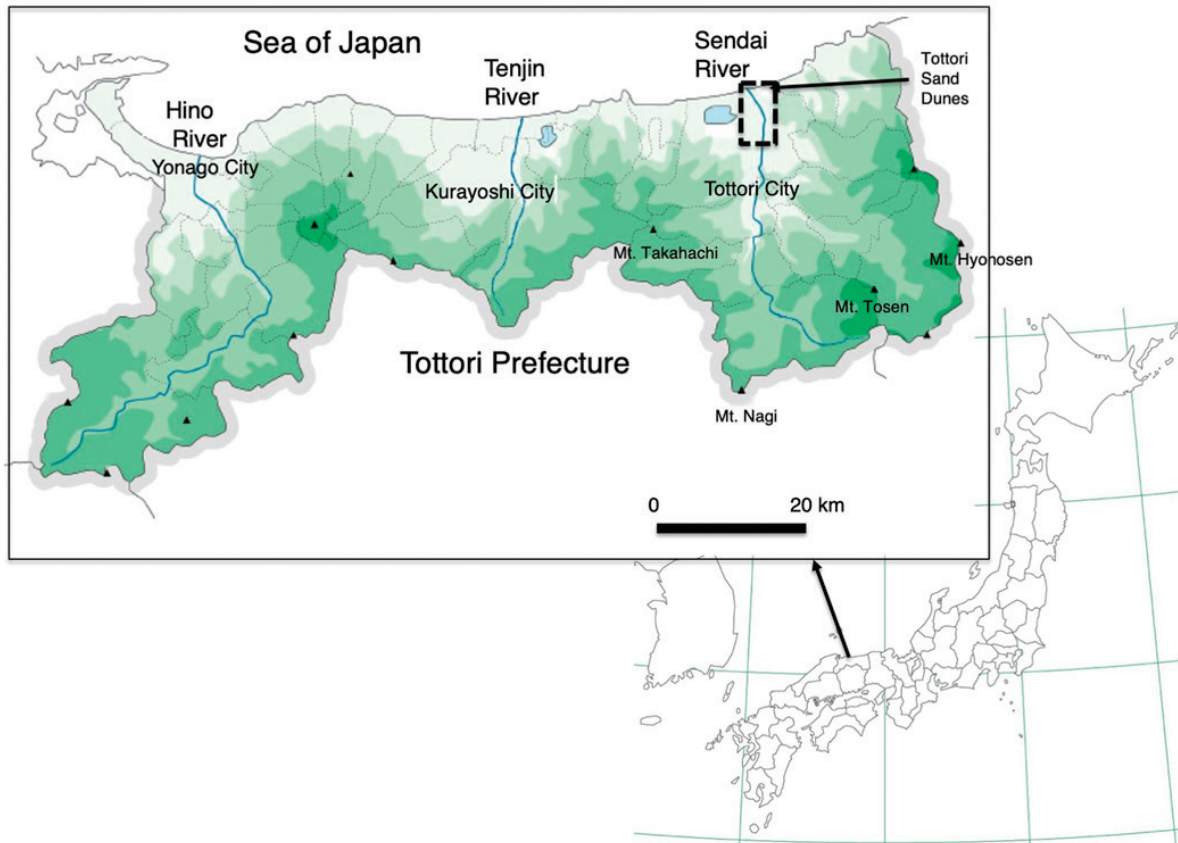


Fig. 1. Location of Sendai River (Tottori City, Tottori Prefecture). Area encircled by broken lines roughly corresponds to Figs. 3, 6–7.

Sand Dunes, which will be the first records of harvestmen to the fauna of Tottori Sand Dunes.

We believe this paper would contribute to some extent to the accumulation of ecological information for these species occurring in non-typical habitats for harvestmen.

### Materials and Methods

*Psathyropus tenuipes* (Fig. 2A) overwinters as eggs and becomes adulthood in late June to July (Tsurusaki 2003b). *Paraumbogrella pumilio* (Fig. 2B) overwinters as adults, and lays eggs in spring and adults of the species emerge in September (Tsurusaki 2003b). We searched for these harvestmen from July to October in 2006 along Sendai River by checking crevices of edge of water or ground covered with grasses for *P. tenuipes* (Fig. 5A, C–D) and under pebbles and logs on the ground or ground covered by grasses for *P. pumilio* (Figs. 5F–H).

We checked salinity along rivers using salinometer (YSI Model 30M/25 SCTmeter: YSI Nanotec, YSI Inc., Ohio, USA, Fig. 5B) on 19 December 2016 for 17 different sites (Fig. 3, Table 1). The unit of salinity used is “ppt” which ap-

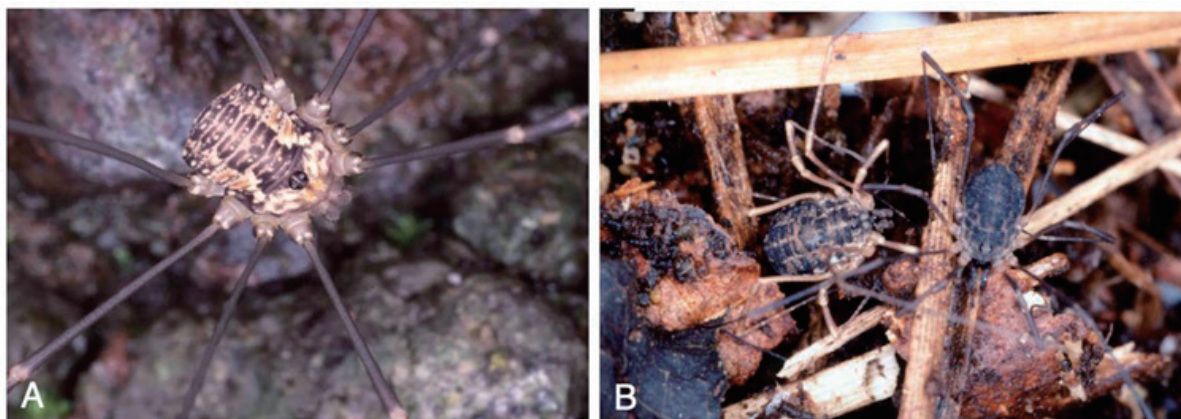
proximately equals to “psu” or “permil” (sea water is 35 ppt).

### Results and Discussion

#### 1. *Psathyropus tenuipes* (Figs. 2A, 5A, C–D, 6, 8)

Occurrence of *P. tenuipes* along Sendai River and one of its tributaries, Fukuro River, is shown in Fig. 6. This species was widely found in the estuarine basin of Sendai and Fukuro Rivers. The most downstream habitat was the site near Shin-Hamasaka Bridge near the confluence of Sendai and Fukuro Rivers (No. 13 in Fig. 3, Fig. 5C) and the most upper stream habitat was the site called Sendaigawa Sports Square on the right bank of the upperstream side of Yachiyo Bridge (4.1 km from the river mouth, No. 4 in Fig. 3). Salinity of the water at the uppermost habitat was 0.1 ppt (Fig. 4, Table 1). The Jubako area (Nos. 15–17 in Fig. 3, Fig. 5D) which is also a part of the estuarine basin of Fukuro River whose salinity ranges from 2.6 to 3.2 was also inhabited by the species (Fig. 6).

No specimens of the species were found from the sites where no salinity was detected (Table 1), except for a site (No. 5 in Fig. 3) near Yachiyo Bridge, upper limit of the estu-



**Fig. 2.** A, *Psathyropus tenuipes*, male (Yatsukami Beach, Hamamura, Tottori City, 28 July 2003); B, *Paraumborrella pumilio*, a female (left) and a male (right). Karo, Tottori City (26 November 1991).

arine basin of the river. On the other hand, no specimens of *P. tenuipes* have been found from the most downstream part of Sendai River (Nos. 9 and 12 in Fig. 3). This is because, both banks along this area is heavily concrete-covered and have no soils or muds that provide oviposition site (Fig. 5E).

These results suggest that at least slight salinity is needed for the occurrence of this species, though why so is unclear. This species actively secretes slightly milky fluid that smells the faint odor of acetic acid from ozopores on the cephalothorax when disturbed (Fig. 8D arrowheads). It is difficult to conceive salinity is needed for the production of the defensive fluid. However, it has been known that the addition of small amount of sodium chloride to food enhances sourness (Hamajima 1976). Thus, salinity might increase defense of this species to enemies.

Records of harvestmen from sea shores or estuarine basin of rivers are extremely rare and Roth & Brown (1976) listed no examples for harvestmen in their review on marine arachnids and myriapods. Curtis & Machado (2007) enumerated a laniatorid *Baculiigerrus littoris* Soares 1979 (Escadabiidae), which mainly inhabits debris in intertidal zone as a single maritime species of harvestmen. *Psathyropus tenuipes* deserves to follow it though its habitat is not littoral zone but above littoral zone (see Tsurusaki & Shimada 2004 and Tsurusaki 2015 for the distribution map).

## 2. *Paraumbogrella pumilio* (Figs. 2B, 5F-H, 7)

Sites where *P. pumilio* was found along Sendai River and Fukuro River are shown in Fig. 7. Occurrence of the species was limited to a rather narrow range from the Sendaigawa Sports Square (No. 4 in Fig. 3) to the high river bed on the left bank near Shobu Watergate (No. 2 in Fig. 3, Fig. 5F) in the 2006 survey. The species was found on the ground densely covered by low grasses (Fig. 5F) or beneath pebbles or driftwoods (Fig. 5G). This species was also found under logs on concrete-covered bank of

left bank of the downstream part of Sendai River (No. 8) on 23 August 2019 by one of us, YO (Fig. 5H). On the other hand, this species has also been found in river beds of downstream part of Hino River (Tsurusaki and Kawato 2014), which is located in western part of Tottori Prefecture, although no specimens of the species have been available from riverbeds of Tenjin River of central part of the prefecture, in spite of rather extensive survey in the grasslands on the riverbeds. Furthermore, this species has been frequently recorded from riverbeds of major rivers in Japan (Tsurusaki & Fukaya 2014; Tsurusaki 2015). Thus, this species can be diagnosed as species with special ability of adaptation to riparian habitat.

Interestingly, a part of habitat of this species is on the riverbeds which are often submerged during times of flooding (Fig. 5G). Sendai River experiences flooding at least once or twice a year on average usually near the end of rainy season (June to early July) or during summer when typhoon arrives. Small size (body 2.5-3 mm long) of the body with relatively short legs of this species may serve to hide in small hollows of logs or pebbles during exposure to water.

## 3. Records of *P. tenuipes* and *P. pumilio* in Tottori Sand Dunes

Fujita (1936) reported a species of harvestmen, which can be identified as *Paraumbogrella pumilio* by the photo presented, from *Pinus thunbergii* forest on Sanrihama Sand Dunes, Sakai City, Fukui Prefecture. This species has been also found from a windbreak forest consisted of *Pinus thunbergii* on the Karo coastal dunes (the dunes were formerly a part of Tottori Sand Dunes) which extends to the west from river mouth of Sendai River (Tsurusaki 1993). However, no specimens of harvestmen, including *P. pumilio* or *P. tenuipes*, have so far been unavailable from Tottori Sand Dunes including peripheral *Pinus thunbergii* forest, in spite of frequent searches made for these harvestmen.

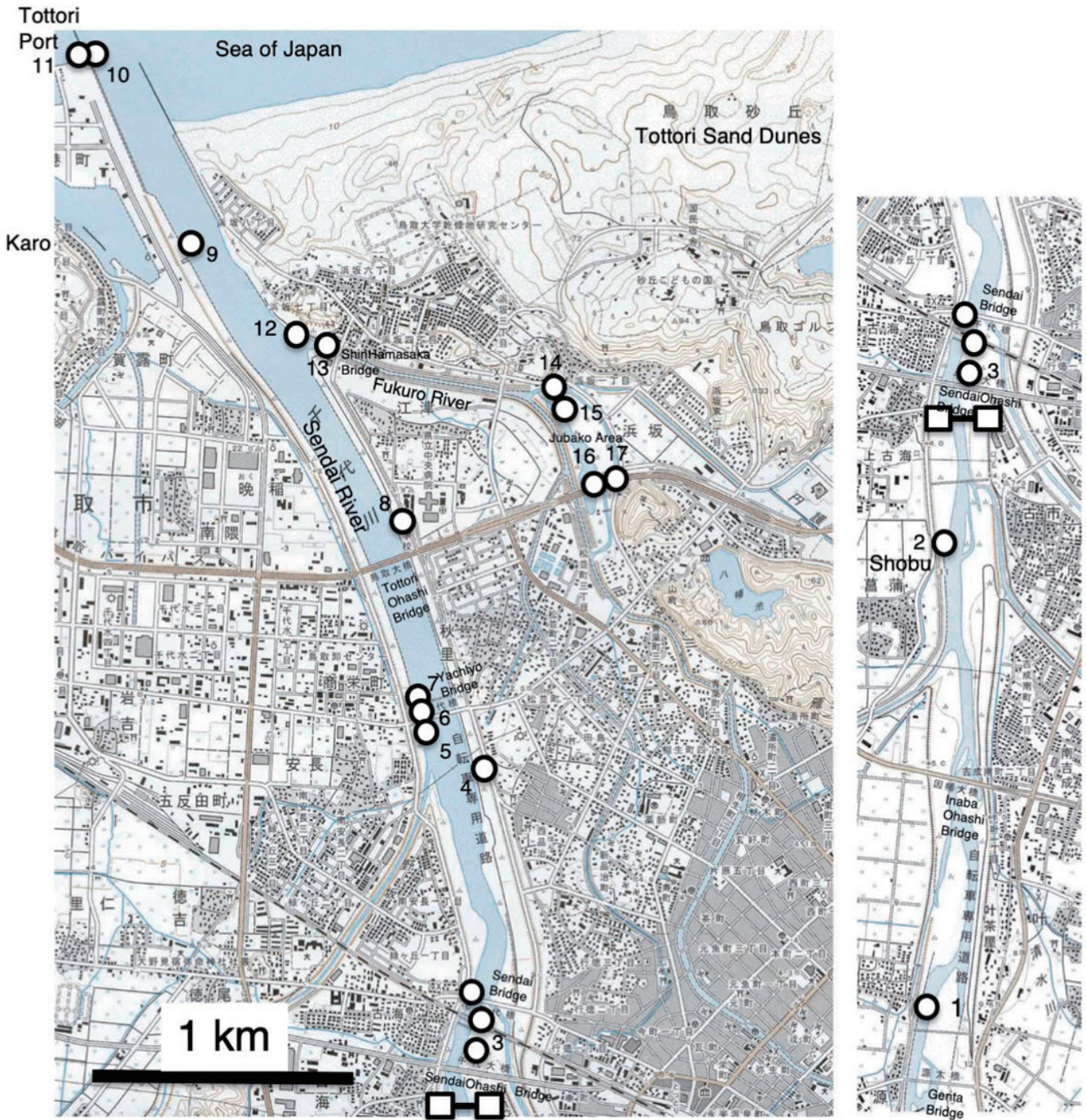


Fig. 3. Sites where salinity were measured (Open circles.). Site numbers correspond to those in Table 1. Maps used are 1:25,000 maps “Tottori Hokubu (NI-53-19-15-2)” and “Tottori Nanbu (NI-53-19-16-1)” issued in 2005 from the Geographical Survey Institute, Japan. Open squares with a bar marks a joint line between the left and right maps.

**Table 1.** Salinity measured on 19 December 2006 along Sendai River and occurrence of *P. tenuipes* and *P. pumilio*.

Site name	Site No.	Latitude / Longitude	Bank	Distance from river mouth (km)	Salinity ppt	Date collected in 2006*	Presence of <i>P. tenuipes</i>	Presence of <i>P. pumilio</i>
Genta Bridge	1	35.465911,134.210974	Left bank	8	0		—	—
Shobu Watergate	2	35.492665,134.212787	Left bank	5.5	0	18-Oct-06	—	2 ♂
Sendai Ohashi Bridge	3	35.497473,134.214000	Right bank	5	0	13-Aug-06	—	5 ♂ 10 ♀
Sendai Brid./ Sendai Ohashi Brid.		35.498182,134.213136	Left bank	5.1		11-Jul-06	—	2 ♂ 1 ♀
Sendaigawa Sports Square	4	35.512256,134.213693	Right bank	4.1	0.1	25-Oct-06	1 ♂	1 ♂
Yachiyo Bridge (100 m above weir)	5	35.512256,134.213693	Left bank	3.3	0	11-Jul-06	1juv.	—
Yachiyo Bridge (2m Below weir)	6	35.512921,134.211343	Left bank	3.2	0.4	11-Jul-06	1 ♀	—
Yachiyo Bridge (30mBelow weir)	7	35.513833,134.211063	Left bank	3.1	2.6		—	—
Site in front of Chuo Hospital	8	35.522344,134.209762	Right bank	2.3	3.4	25-Oct-06	1 ♂	—
Site in front of "Aqua"	9	35.514294,134.210858	Left bank	0.8	5.4	11-Jul-06	3juv.	(1 ♀ **)
Tottori Port (River mouth of Sendai R.	10	35.540055,134.194540	Left bank	-0.5	30		—	—
Tottori Port (inside harbor)	11	35.543550,134.192433	Right bank of harbor	-0.5	27.4		—	—
River mouth of Fukuro River	12	35.529792,134.205632	Right bank of Fukuro R.	1.2	1.1		—	—
Shinhamasaka Bridge	13	35.529812,134.206852	Right bank	1.4	4.1	25-Oct-06	1 ♂	—
Benten Bridge of Fukuro R.	14	35.527887,134.219004	Right bank of Fukuro R.	2.6	0.2		—	—
Fukuro Bridge (Benten Shrine)	15	35.527167,134.219205	R. bank of the catchment	2.6	0.9	10-Oct-06	2 ♀	—
Jubako (Fukuro River)	16	35.523126,134.219974	Central	3.2	1.8	11-Jul-06	1 ♂	—
Jubako (Catchment)	17	35.523412,134.220562	Central	3.1	1.9	11-Jul-06	3 ♂ 1 ♀	—
Hamasaka (Totori Sand Dunes) under logs		35.540461,134.199437	Right bank	0		5-Nov-19	—	1 ♀
Hamasaka (Totori Sand Dunes)		35.5395741,134.1979561	Right bank	0		5-Nov-19	1 ♂ 3 ♀	—
Site near "Aqua"	9	35.5370000,134.1961185	Left bank	0.8		23-Aug-19	—	1 ♀

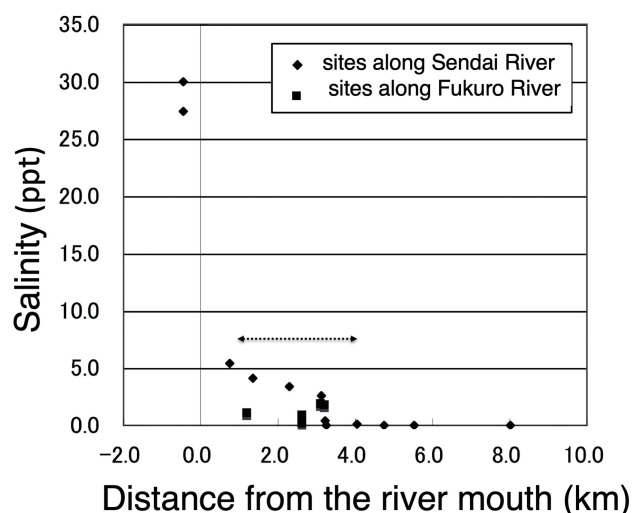
\*All the specimens collected in 2019 were collected by Y. Obae.

\*\* collected on 23August 2019 by Y. Obae.

One of the authors, YO, found *P. pumilio* together with *P. tenuipes* under logs and debris on the beach or on ground surface of sandy beach on the right bank of Sendai River, which is also a part of Tottori Sand Dunes, during his night survey for the coastal insects in November 2019 (Table 1, Figs. 6-7, 8). These sites are at least 100 m apart from the nearest *Pinus thunbergii* forest (no harvestmen have been found from the forest). Thus, it is unlikely that these animals are the visitors just recently arrived from the neighboring forests. These findings suggest that these harvestmen can survive in sand dunes when pertinent shelters for harvestmen are available.

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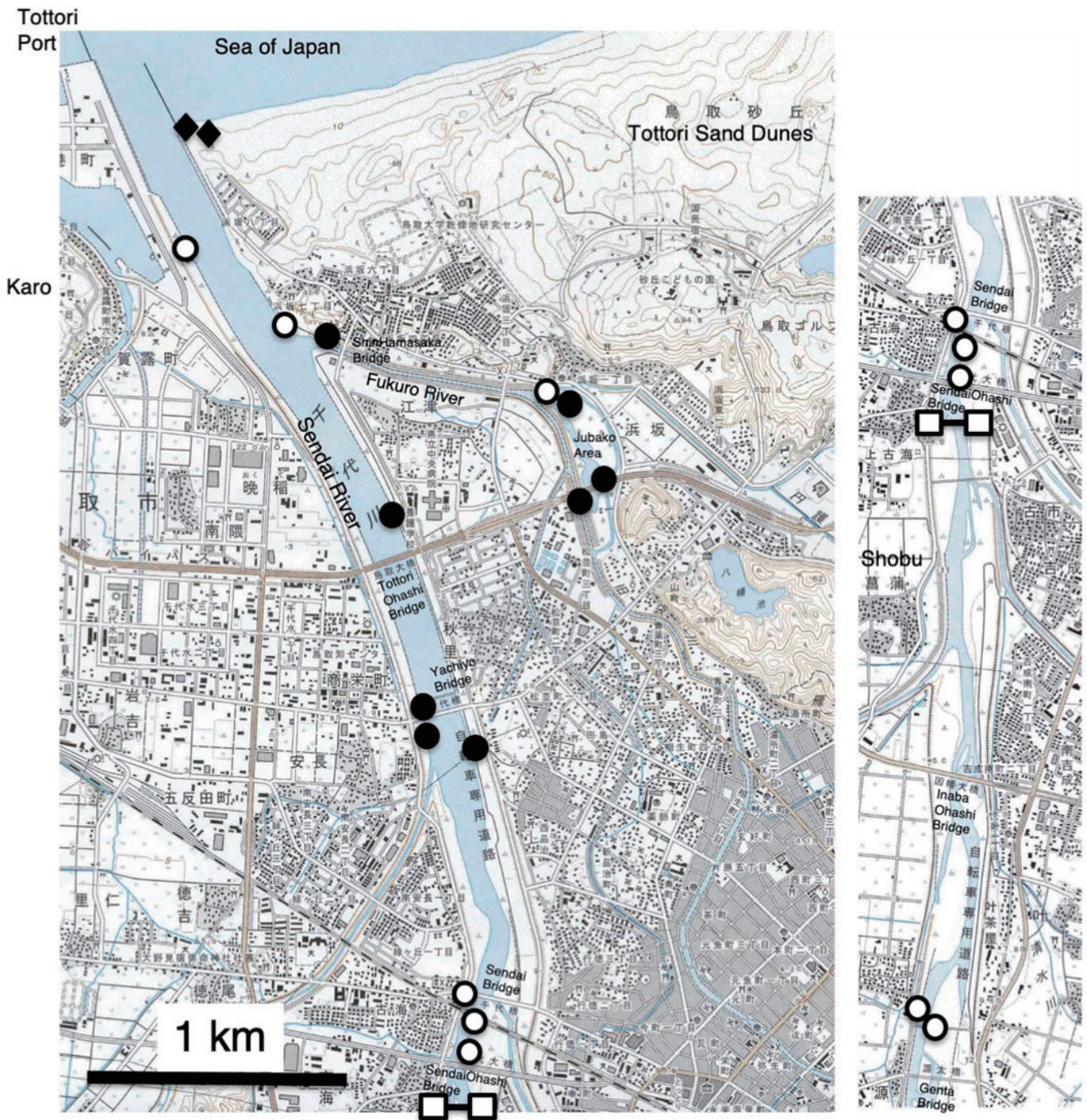
**Fig. 4.** Change of salinity along Sendai River. Dotted double headed arrow denotes the range where *Psathryopus tenuipes* was found. Maps used are 1:25,000 maps "Tottori Hokubu (NI-53-19-15-2)" and "Tottori Nanbu (NI-53-19-16-1)" issued in 2005 from the Geographical Survey Institute, Japan.



**Fig. 5.** Habitats and collecting scenes of *Psathyropus tenuipes* (A-D) and *Paraumbogrella pumilio* (F-H). A, Left bank ca. 100 m downstream of Yachiyo Bridge, which can be seen back; B, A scene measuring salinity using a salinometer at a dam blocking backward flow of sea water, just below Yachiyo Bridge; C, Right bank of Fukuro River, site downstream of Shin-Hamasaka Bridge, where *P. tenuipes* was found on ground covered by grasses; D, Jubako area with Benten Shrine (Groove) along Fukuro River; E, Right bank of the most downstream part of Sendai River; F, High riverbed covered by grasses at left bank of Sendai River, near Shobu; G, River bed at right bank of Sendai River at the site between Sendai-Ohashi Bridge and Sendai Bridge (Sendai Railroad Bridge can be seen back in the photo); H, Left bank of the most downstream part of Sendai River. *P. pumilio* was found under a log arrowed on 23 August 2019.

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**Fig. 6.** Distribution of *Psathyropus tenuipes* along Sendai River. ● = Found, ○ = Not found. ◆ = Records made in 2019. □ - □ represents a juncture between right and left maps. Maps used are 1:25,000 maps “Tottori Hokubu (NI-53-19-15-2)” and “Tottori Nanbu (NI-53-19-16-1)” issued in 2005 from the Geographical Survey Institute, Japan.



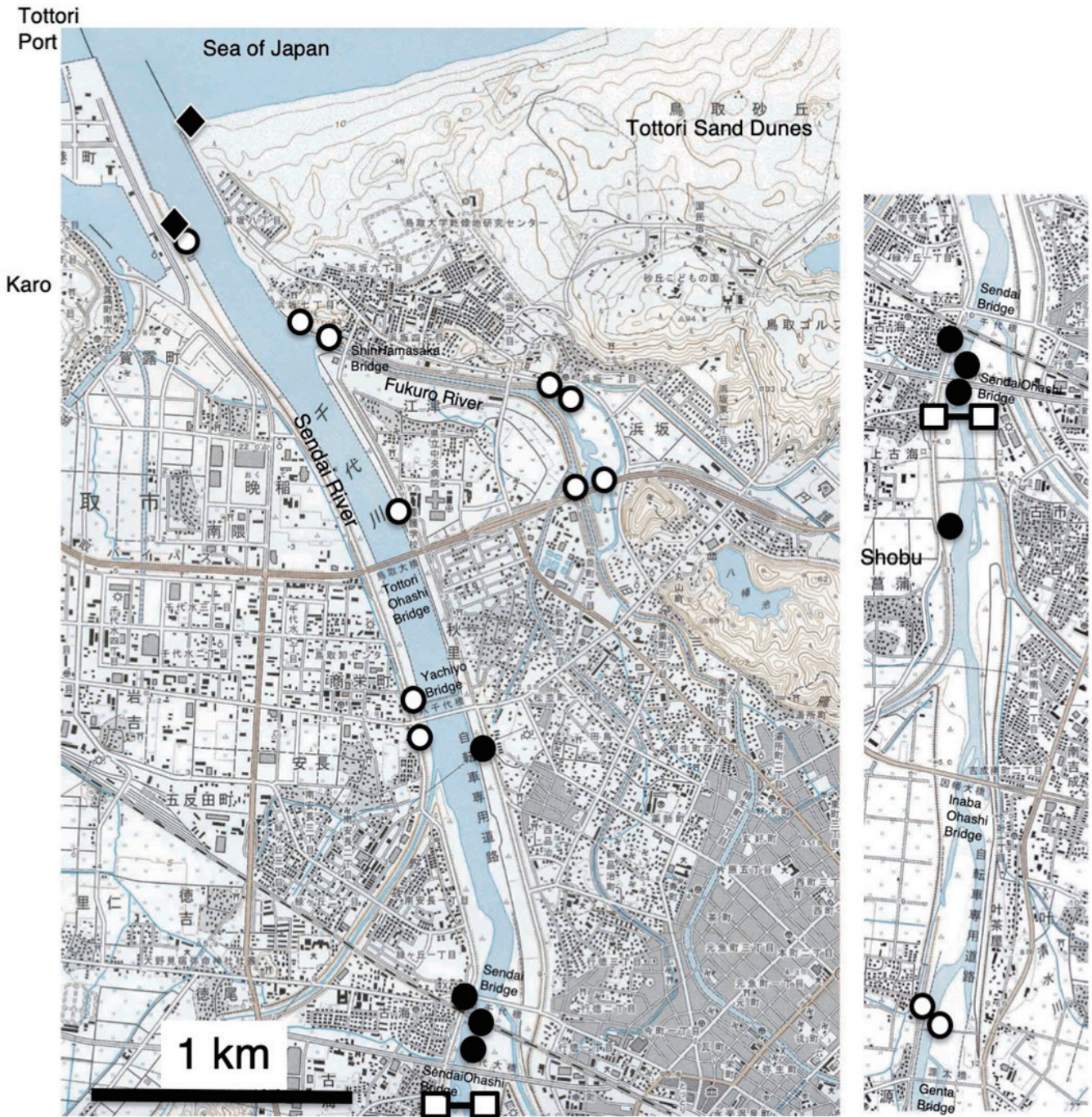
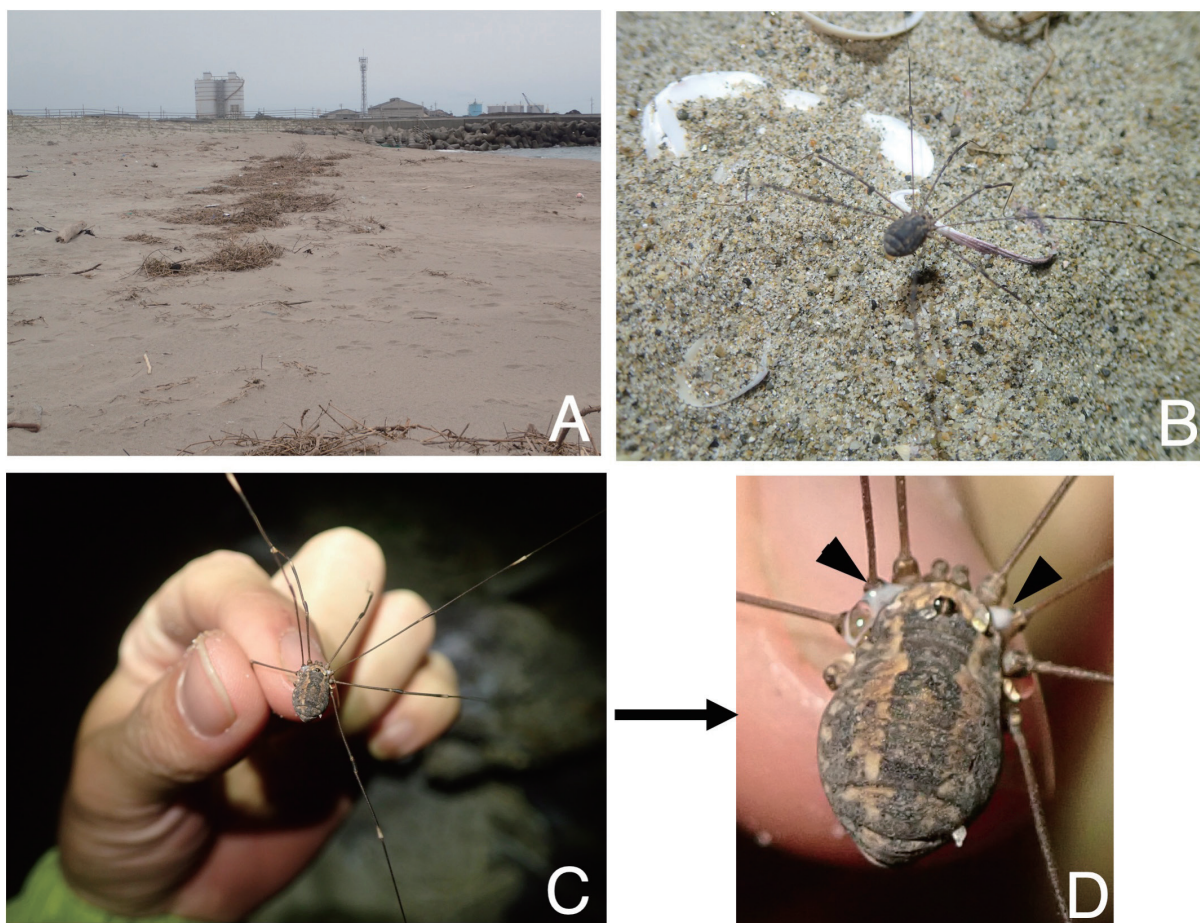


Fig. 7. Distribution of *Paraumbogrella pumilio* along Sendai River. ● = Found, ○ = Not found ◆ = Records made in 2019. □ - □ represents a juncture between right and left maps.



**Fig. 8.** Newly discovered habitat of *Psathyropus tenuipes* and *Paraumbogrella pumilio* at right bank of river mouth of Sendai River (westernmost border of Tottori Sand Dunes), Japan. A, Habitat photographed in daylight at the sites where both the species were found on 5 November 2019; B, A female walking at night (around 23:00) on the sandy ground photographed using flash light (5 November 2019); C, A female captured by hand under light of a LED headlamp (5 November 2019); D, Enlargement of the female in C, showing milky defensive fluid issued from a pair of ozopores (arrowheads), which is a typical habit of this species.

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