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Description and distribution of *Crangonyx floridanus* (Crustacea: Amphipoda: Crangonyctidae) in Japan, an introduced freshwater amphipod from North America

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ABSTRACT The Japanese populations of *Crangonyx floridanus* Bousfield, 1963 are taxonomically diagnosed with illustration. Distributional analysis suggests that *C. floridanus* was introduced from North America in 1980's and now expanding the range from middle Honshu to western Japan.

KEY WORDS amphipod / *Crangonyx floridanus* / Japan / introduced species

Introduction

The first discovery of *Crangonyx florianus* in Japan was in 1989, from a pond in Chiba Prefecture (the animals were not identified to species at that time; see Tamura, 1990). The amphipods from the pond were forwarded to the third author in 1992, who immediately identified them as *C. floridanus*, an indigenous amphipod species in North America. This information was then spread to researchers mainly through personal communications, and thereafter in Japan, records of this species began to appear in literature of local faunal studies (e.g., Kanada, 2002; Morino, 2002) or reports from agencies for environmental studies (e.g., Tokyo Metropolitan Government, 1997-2003; Masaki, et al., 2003; Kanada and Fukushima, 2004). Most of these papers treated this species briefly or with short biological notes if any.

The genus *Crangonyx* contains 46 species that occur in epigean and/or hypogean waters, of which 42 species are distributed in North America, three in Europe and possibly one in Asia (Holsinger, 1986; Zhang and Holsinger, 2003). In contrast with the rich knowledge in North America on this group of animals (e.g., Zhang and Holsinger, 2003), a full account of this species has not been published yet in Japan. During perusal of pertinent literature and re-examination of the voucher specimens, not a few reports proved to include wrong information concerning species identification. At the same time, reliable information suggests that this species is currently explosively expanding the distribution in this country. In order to witness what is now happening with this peculiar species in Japan and cope with the invasion phenomenon if necessary, the taxonomic description that makes correct

identification easier and the biological information so far obtained will be given below.

Results and Discussion

Taxonomy

***Crangonyx floridanus* Bousfield, 1963**

(Japanese name: furorida mamizu yokoebi)

Figs. 1–4

Crangonyx floridanus Bousfield 1963: 2–9
Holsinger 1972: 34
Karaman 1978: 66–71
Material examined:

The following specimens were dissected and slide-mounted. Female (ovig., 8.0 mm) and 2 males (4.0, 4.2 mm) from Watarase Reservoir, Tochigi Pref., Apr. 19, 2001, K. Yaginuma coll.; female (7.0 mm) from Gongen-numa pond, Itakura-cho, Gumma Pref., Mar. 26, 1994, K. Sekine coll.; female (5.5 mm) from Sagami River, Atsugi, Kanagawa Pref., Sept. 3, 1996, N. Kobayashi coll.; female (ovig. 6.3 mm) and male (4.5 mm) from Furutone-numa Pond, Abiko, Chiba Pref., Jan. 30, 1992, H. Kusano coll. Representative samples from localities in Table 1 were also examined.

Description:

Females (5.5–8.0 mm) distinctly larger than males (4.0–4.5 mm). Head lateral lobe broadly rounded anteriorly. Eyes medium, oval to subreniform. In some specimens eyes without pigment and eye facets of posterior half degraded (Fig. 1B). Animals with faintly pigmented eyes also occurred. Pleonites and urosomites dorsally bare. Uropod 3 not extending beyond tip of uropod 2.

Antenna 1 more than 2 times as long as antenna 2. Peduncles of both antennae moderately setose. Antenna 1, peduncular articles 1 and 2 subequal in length, flagellum 19–21 articulate in female, 16–18 articulate in male, most articles with an aesthetascs respectively; accessory flagellum shorter than article 1, 2 articulate. Antenna 2, peduncular articles 4 and 5 subequal in length, 6–7 articulate in female; in male, peduncular articles 4 and 5 and proximal articles of flagellum with rod-shaped calceoli, flagellum 5–6 articulate.

Mandible palp article 3 with a few C-setae mid-ventrally and a few A-setae. Left mandible, incisor and lacinia 5 dentate. Maxilla 1 outer plate with 7 distal spines. Lower lip with inner lobe.

Gnathopods of female, propod palms fringed with many small spines, corner is defined by a few large spines laterally and a few tiny truncate spines medially, dactyl inner margin with a distal blade and a few setae; in male, propod palmar spines larger than those of female, dactyl smooth marginally. Gnathopod 1 in female, propod ca 1.2 times as long as carpus, palmar margin nearly transverse; in male, propod enlarged, 2.6 times as long as carpus. Gnathopod 2 in female, propod subequal to carpus in length, with several singly-

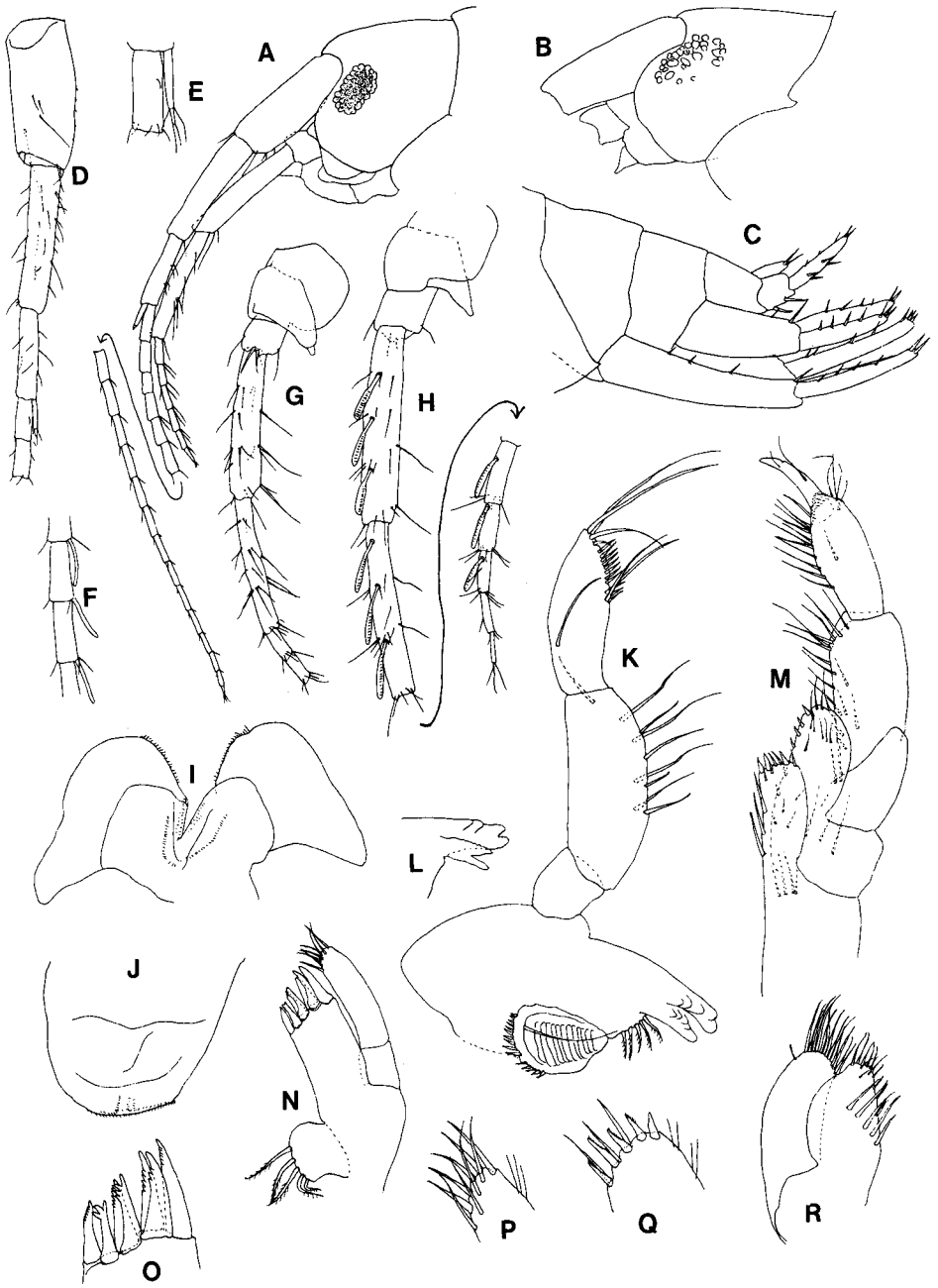

Fig. 1. *Crangonyx floridanus* Bousfield 1963. A, B, head part ; C, posterior part of body; D, peduncle of antenna 1; E, accessory flagellum of antenna 1; F, aesthetascs on antenna 1 flagellar article; G, peduncle of antenna 2; H, male antenna 2; I. lower lip; J, upper lip; K, left mandible; L, cutting edges of right mandible; M, maxilliped; N, maxilla 1; O, distal spines of maxilla 1 outer plate; P, distal spines of left maxilla 1 palp; Q, distal part of right maxilla 1 palp; R, maxilla 2. B: ovigerous female, 6.0 mm, from Setagaya, Tokyo. H: male, 4.0 mm; others: female, 8.0 mm, from Watarase Reservoir, Tochigi Prefecture.

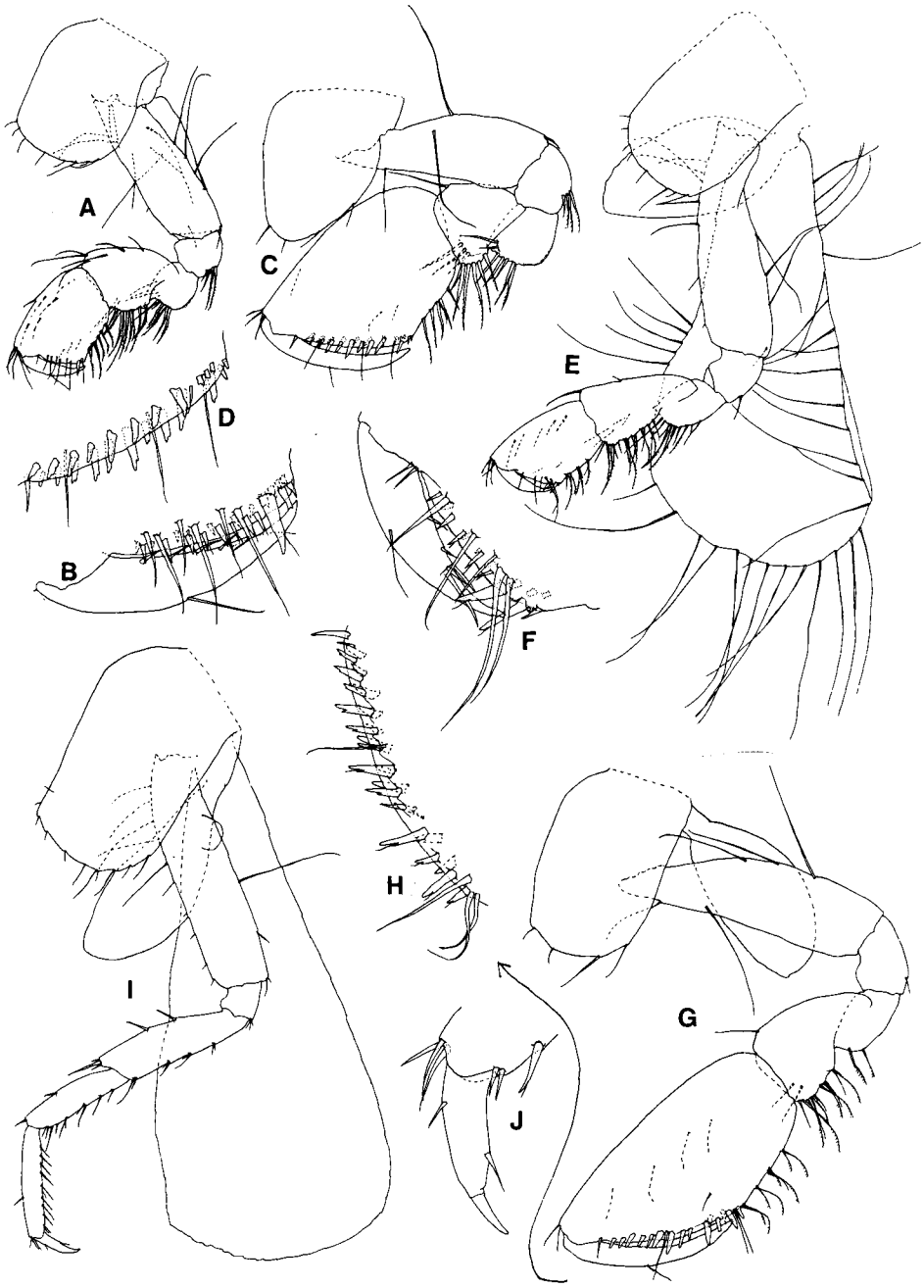

Fig. 2. *Crangonyx floridanus* Bousfield 1963. A, female gnathopod 1; B, propod palm and dactyl of female gnathopod 1; C, male gnathopod 1; D, propod palm of male gnathopod 1 (medial surface); E, female gnathopod 2; F, propod palm and dactyl of female gnathopod 2; G, male gnathopod 2; H, propod palm of male gnathopod 2; I, pereopod 3; J, dactyl of pereopod 3. C, D, G & H: male, 4.0 mm, others: female, 8.0 mm, from Watarase Reservoir, Tochigi Prefecture.

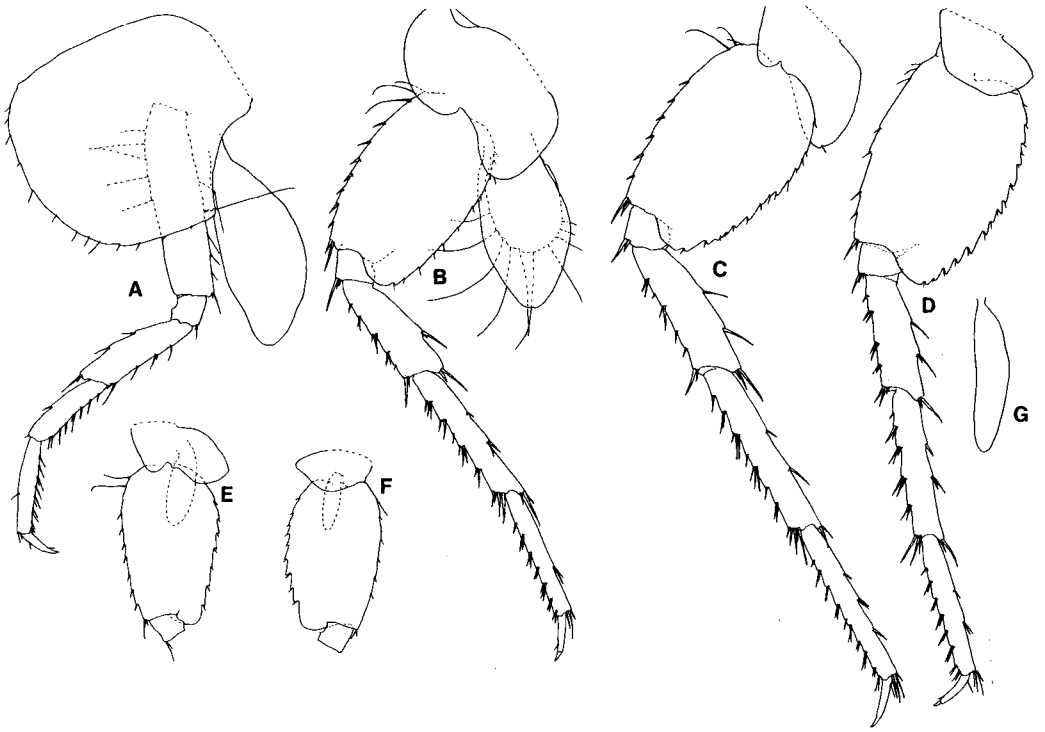

Fig. 3. *Crangonyx floridanus* Bousfield 1963. A, pereopod 4; B, pereopod 5; C, pereopod 6; D, pereopod 7; E, basis of male pereopod 6; F, basis of male pereopod 7; G, sternal gill of pleonite 1. E, F: male, 4.0 mm; others: female, 8.0 mm, from Watarase Reservoir, Tochigi Prefecture.

inserted setae on medial surface; in male, propod ca 2 times as long as carpus, slightly expanded distally, palmar margin oblique. Pereopods 3–7 slender and elongate, pereopod 4 longer than pereopod 3, pereopod 6 longest, posterior margin of bases of pereopods 6 and 7 sharply serrated. Coxal gills on pereopods 2–7, subovate (but that on 7 attached between coxa and basis). Single, small median sternal gills present on pereonites 2 and 3, paired lateral sternal gills on pereonites 6 and 7, and paired, rod-shaped sternal gills on pleonite 1 of female. Brood plates of pereopods 2–4 very large, with many setae, brood plate of pereopod 5 small. Abdominal side plates sharply pointed posteriorly, especially in plates 1 and 2. Pleopods well developed, with 2 (rarely 3) retinaculae. Clothes-pin spines present.

Uropods 1 and 2, rami with spines on lateral and medial margins. Uropod 2 in male, outer ramus equipped with comb spines distolaterally. Uropod 3, peduncle with a few strong spines, outer ramus 1 articulate, ca 1.5 times as long as peduncle, with 3–5 clusters of spines on both margins, inner ramus scale-like, 0.2–0.3 times as long as outer ramus.

Telson shorter than broad, apically incised to 0.4 times of length, apically with 2 – 6 spines, lateral margin with penicillate setae.

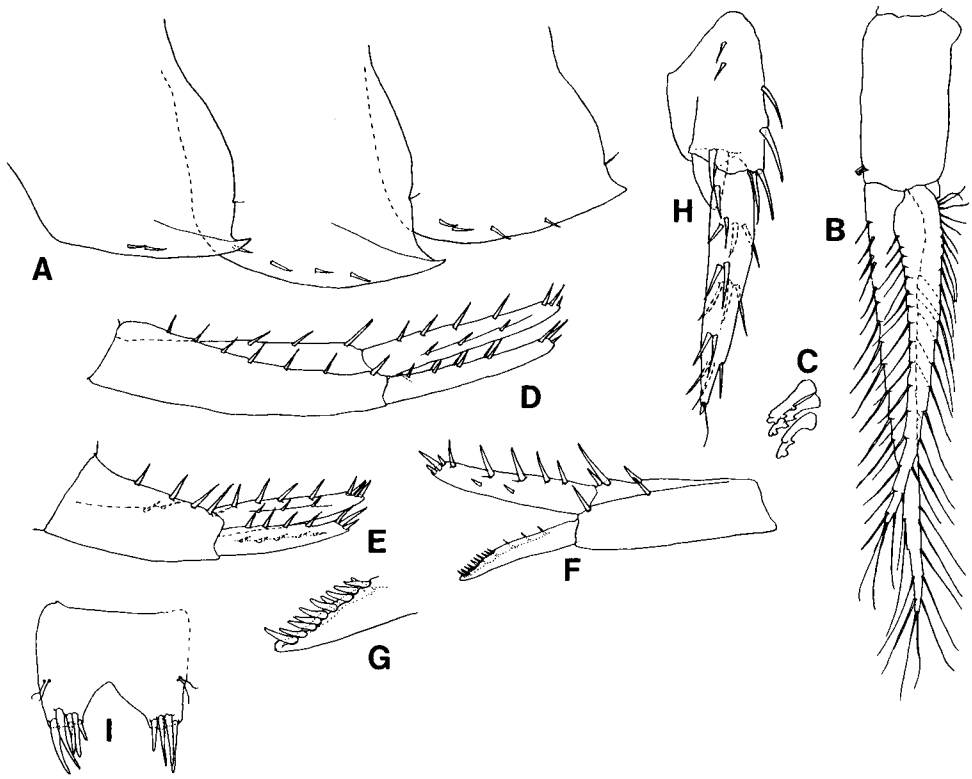

Fig. 4. *Crangonyx floridanus* Bousfield 1963. A, abdominal side plates; B, pleopod 1; C, coupling spines; D, uropod 1; E, female uropod 2; F, male uropod 2; G. comb spines of male uropod 2; H, uropod 3; I, telson. F, G: male, 4.0 mm; others: female, 8.0 mm, from Watarase Reservoir, Tochigi Prefecture.

Remarks:

The description presented above is different from the original one given by Bousfield (1963) in the number and distribution of sternal gills. First, Bousfield (1963) did not mention the median sternal gills on pereonites 2 and 3. Second, he referred to both pairs of gills on pereonite 7 as sternal gills, stating "Sternal gills....two pairs on segment 7." However, as noted in the description above, pereonite 7 bears one pair of lateral sternal gills and pereopod 7 bears a small, subovate "coxal-like" gill attached to the membrane between the coxa and basis.

The present species is clearly distinguished by the given description from all other Japanese epigean and hypogean freshwater amphipods. In order to make separation of *Crangonyx floridanus* from ecologically or morphologically similar genera or species easier, selected whole-body characters are shown below for respective taxa.

Jesogammarus and *Gammarus* species are distinguished from *C. floridanus* by the deep inferior antennal sinus, multi(>3)-articulated accessory flagellum of antenna 1,

dorsally spinose and setose urosomites, and the uropod 3 extending much beyond the tip of uropod 2.

Sternomoera species are distinguished by the inferior antennal sinus, many (>26)-articulated flagellum of antenna 2, and the uropod 3 with well-developed inner ramus and extending beyond the tip of uropod 2.

Pseudocrangonyctidae, including *Pseudocrangonyx* and *Eocrangonyx*, is distinguished by the inferior antennal sinus, dorsally setose and/or spinose pleonites and urosomites, slender bases of peropods 5–7, the uropod 3 lacking inner ramus and extending beyond the tip of uropod 2.

Noeoniphargus (Eoniphargus) kojimai is differentiated from *C. floridanus* by 4-articulated accessory flagellum of antenna 1, 20-articulated flagellum of antenna 2, the slender propod of gnathopod 2, and the uropod 3 subequal to the uropod 1 in length.

Distribution and range expansion

The localities of *Crangonyx floridanus* in Japan are depicted in Figs. 5 (Kanto District) and 6 (Japan) and the detailed data of the samples are summarized in Table 1 for each main river system. *C. floridanus* shows disjunct distribution; it is distributed in the Pacific side of middle Honshu (= Kanto District) and in western tip of Kyushu (Fig. 6). In Kanto District, they occur mainly on or along the large river systems, namely, Tone, Arakawa, Tama, Tsurumi, Sagami Rivers (Fig. 5). The animals inhabit lower to middle

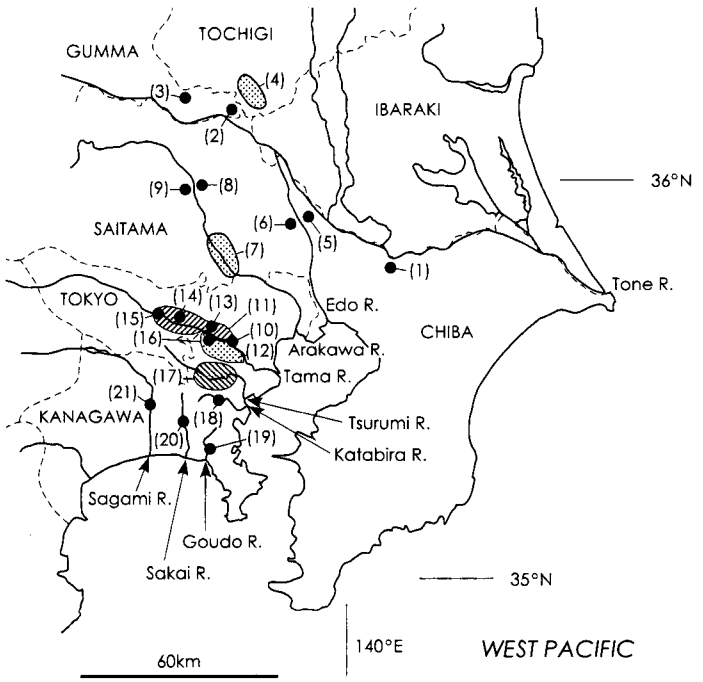

Fig. 5. Geographic distribution of *Crangonyx floridanus* in Kanto District, Japan. Numerals in parentheses correspond to localities in Table 1.

Table 1. Locality of *Crangonys floridanus* recorded from Japan.

River system	date	locality (numerals in map s)	Collector or source
Tone R.	16.Nov.89, 20.Jan.92	Furutone-numa Pond, Abiko, Chiba Pref. (1)	Tamura (1990)
	30.Jan.92	Furutone-numa Pond, Abiko, Chiba Pref. (1)	Kusano, H.
	26.Mar.94	Gongen-numa Pond, Itakura, Gumma Pref. (2)	Sekine, K.
	3.Oct.94	Tenjin-ike Pond, Itakura, Gumma Pref. (2)	Sekine, K.
	2.Jan.99	Nakano-numa Pond, Oura, Gumma Pref. (3)	Sekine, K.
	Apr. to Jun., 2001	many ponds around Watarase Reservoir, Tochigi Pref. (4)	Yaginuma, K.
Edo R.	6.Feb.03	tributary, Mitsubori, Noda, Chiba Pref. (5)	Yaginuma, K.
	7.Feb.03	tributary, Seto, Noda, Chiba Pref. (5)	Yaginuma, K.
	3.Sep.03	spring pond, Matsubushi, Saitama Pref. (6)	Furuya, A.
Arakawa R.	7.Jan.91	tributaries, Ohmiya, Saitama Pref. (7)	Kanada, S.
	25.Sep.01	"Biotope Pond", Toda, Saitama Pref. (7)	Yaginuma, K.
	1.Oct.01	small pond along the river, Saitama, Saitama Pref. (7)	Yaginuma, K.
	30.Apr, 29.May, 24.Jun.2003	tributary, Kitamoto, Saitama Pref. (8)	Yaginuma, K.
	29.May.03	tributary, Yoshimi, Saitama Pref. (9)	Yaginuma, K.
Tama R.	from 1997 on	Futago-bashi, Ohta, Tokyo (10)	Kanada (2002)
	from 1997 on	many sites along the river system, Tokyo (11)	Tokyo Metropolitan Government (1997-2003)
	from 1999 on	many sites along the river system, Kawasaki, Kanagawa Pref. (12)	Masaki et al. (2004)
	3.Mar.00	Setagaya, Tokyo (13)	Iikura, Y.
	22.May.00	springbrook, Joyama Park, Kunitachi, Tokyo (14)	Ishida, A.
	24.Mar.01	springbrook, Joyama Park, Kunitachi, Tokyo (14)	Ueda, T.
	7.Jan.02	Tama-oohashi, Akishima, Tokyo (15)	Shinoda, S.
	29.Nov.02	Fuda, Kawasaki, Kanagawa Pref. (16)	Ishiwata, S.
	2.Sep.03	Sudare-numa Pond, Setagaya, Tokyo (13)	Shinoda, S.
	25.Apr.03	Nogawa R., Seijo, Setagaya, Tokyo (13)	Imada, Y.
Tsurumi R.	from 1999 on	many sites along the river system, Kawasaki, Kanagawa Pref. (17)	Masaki et al. (2004)
	27.Nov.02	Hontani R., Aoto, Yokohama, Kanagawa Pref. (17)	Sunouchi, N.
	2002-2003	many sites along the river system, Yokohama, Kanagawa Pref. (17)	Kanada & Fukushima (2004)
Katabira R.	30.Jan.03	Tsurumai-bashi, Yokohama, Kanagawa Pref. (18)	Kanada & Fukushima (2004)
Goudo R.	2.Dec.02	Koshigoe-tsu, Kamakura, Kanagawa Pref. (19)	Sunouchi, N.
Sakai R.	12.Aug.02	Takakama-bashi, Yokohama, Kanagawa Pref. (20)	Kanada & Fukushima (2004)
	4.Sep.02	Meguro-bashi, Yokohama, Kanagawa Pref. (20)	Kanada & Fukushima (2004)
Sagami R.	24.Mar.96	Atsugi, Kanagawa Pref. (21)	Shinoda, S.
	3.Sep.96	Sagami-ooseki, Atsugi, Kanagawa Pref. (21)	Kobayashi, N.
	29.Jan.02	tributary, Ebina, Kanagawa Pref.(21)	Ishiwata, S.
Ooi R.	4.Aug, 16.Oct.2003	tributary, Ooigawa-cho, Shizuoka Pref. (22)	Yaginuma, K.
Yasaku R.	12.Mar.02	Kohda R., Kohta, Aichi Pref. (23)	anonymous
Fukue R.	11.Nov.03	Fukue, Nagasaki Pref. (24)	anonymous

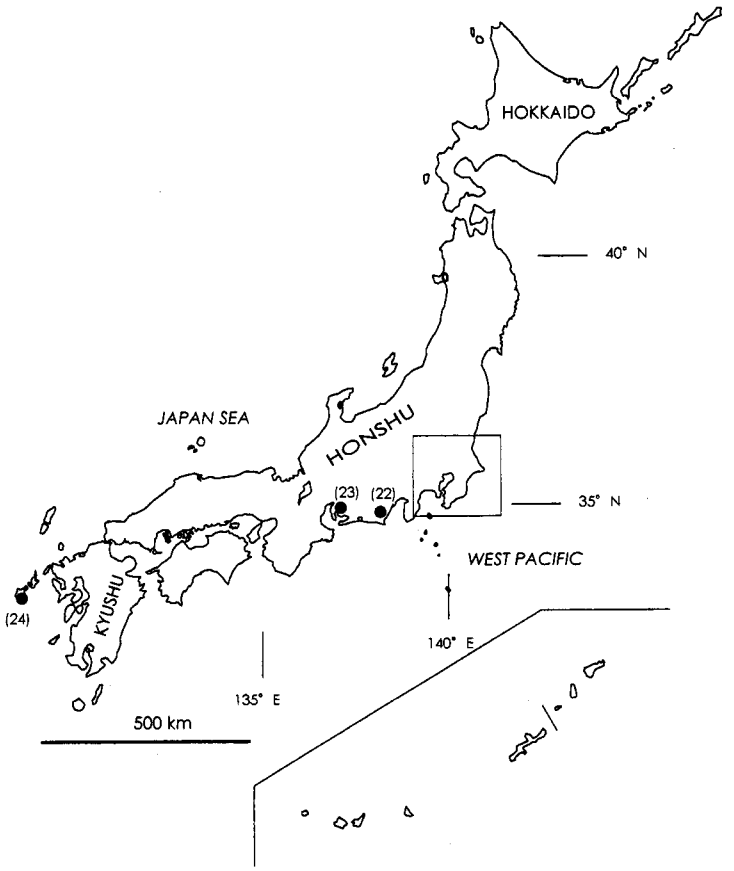

Fig. 6. Geographic distribution of *Crangonyx floridanus* in Japan, except Kanto District (square region). Numerals in parentheses correspond to localites in Table 1.

reach of the rivers and the habitats range from *Fragmites* zone, to temporal ponds adjacent to water bodies and springs. In general they tend to be found from artificial water systems, such as water reservoirs and so called Biotope Ponds. Middle reaches of rivers in Kanto District may also be inhabited by an anisogammarid species, *Jesogammarus spinopalpus* (Kusano, 2001). As regards the collections in Table 1, *J. spinopalpus* was collected with *C. floridanus* at Noda (5), Kitamoto (8) and Yoshimi (9). Thus species interaction could be operating at least between both amphipods in these sites.

As mentioned elsewhere, the first record of this amphipod species is in 1989 from Furutone-numa Pond (Tone R.), then in 1991 from Ohmiya (Arakawa R.) and then in 1996 from Atsugi (Sagami R.) and 1997 from Kawasaki (Tama R.). After that, this species seems to have expanded its range along respective river systems to upper reaches, the surrounding areas and very swiftly to the western part of Japan.

In North America, *Crangonyx floridanus* is also found in widely separated localities across the continent: eastern North America including Florida and Louisiana, and

western North America in Colorado, Oregon, and Sancramento/San Joaquin Delta in California (Zhang and Holsinger, 2003). The populations of western America are presumed to be introduced from eastern America, the possible native locality, by fish transport containers, or in the ballast water of ships (Zhang and Holsinger 2003). Toft et al. (2002) analysed the new occurrence of *C. floridanus* and 2 isopod crustaceans from the Sancramento/San Joanquin Delta, which were concluded to be introduced species, and discussed the mechanisms for introduction from eastern part of America to California. They suggested as possible dispersal mechanisms not only by ballast water, but also by coastwise cargo, ship fouling, fishing vessel traffic, and clinging to the roots of aquatic plants.

As has been pointed out by Toft et al. (2002) and Zhang and Holsinger (2003), it is of little doubt that the Japanese populations of *Crangonyx floridanus* have been introduced from North America. The fact that *C. floridanus* began to appear in late 1980's and expand its range very quickly in Japan is highly supportive to this conclusion. Present data suggest that the original population(s) may have been settled at Tokyo or Yokohama, where have historically developed large-scale importation ports. Carlton (1987) summarized the pattern of biological invasion by human activities in the Pacific Ocean and pointed out a major transoceanic dispersal route for marine and estuary organisms between the northeast Pacific and the northwest Pacific. According to Carlton (1989), two marine or brackish water amphipods, *Grandidierella japonica* and *Jassa marmorata,* were introduced from Japan into Coos Bay, North America by commercial oyster industry or by shipping (as fouling organisms or by ballast water). It seems less likely, however, that *Crangonyx floridanus* was also introduced by these means, since *C. floridanus* occurs in freshwater habitats in both North America and Japan. Instead, it is natural to hypothesize that the species has been transported accidentally with imported freshwater organisms, e.g., aquatic plants, as suggested by Toft et al. (2002). This hypothesis may also be applicable to disjunct range expansion from middle Honshu to western tip of Kyushu.

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References

Bousfield, E. L. 1963. New fresh-water amphipod crustaceans from Florida. *Nat. Hist. Pap. Natl. Mus. Canada* 18: 1–9.

Carlton, J. T. 1987. Patterns of transoceanic marine biological invasions in the Pacific Ocean. *Bull. Mar. Sci.* 4(2): 452–465.

Carlton, J. T. 1989. Man's role in changing the face of the ocean: Biological invasions and implications for conservation of near-shore environments. *Conserv. Biol.* 3(3): 265–273.

Holsinger, J. R. 1972. Biota of Freshwater Ecosystems, Identification Manual 5. The freshwater amphipod crustaceans (Gammaridae) of North America. U.S. Environmental Protection Agency.

Holsinger, J. R. 1986. Holarctic crangonyctid amphipods. In: Stygofauna Mundi (L. Botosaneanu ed.), pp. 535–549. Leiden - E. J. Brill / Dr. W. Backhuys.

Kanada, Sh. 2002. Short Notes: Crangonyctid amphipods from Tama River. Abstract in the 26th Meeting of Aquatic Insects Study, 6 p. (In Japanese)

Kanada, Sh. and S. Fukushima 2004. Benthic macro-invertebrate fauna of the streams and rivers in Yokohama City (No. 10, 2002–2003). The organisms of Rivers and Sea in Yokohama, Vol.10; River. *Report from the Environmental Protection Bureau of Yokohama City*, pp. 83–108. (In Japanese)

Karaman, G. S. 1978. Contribution to the knowledge of the Amphipoda 97. On three interesting species, *Crangonyx floridanus* Bous. 1963, *C. parvimanus* (Hol. 1903) and *Orchestia tiberiadis* Lor. 1883. *Glas. Republ. Zavoda Zast. Prirode – Prirodnjackog Muzrja Titograd*, 11: 65–73.

Kusano, H. 2001. Habitats of freshwater amphipods. *Kaiyo Monthly*, Special no. 16: 244–248. (In Japanese)

Masaki, K., A. Wakayama, and K. Yoshida 2003. Result of servey of distribution of freshwater amphipods in KAWASAKI (2002). *Annual Report of the Kawasaki Municipal Research Institute for Environmental Protection.* No. 30: 39–44. (In Japanese)

Morino, H. 2002. Natural History of Chiba Prefecture No. 6. Animals in Chiba Prefecture, I, Amphipoda, pp. 274–276, Chiba Historical Material Research Foundation. (In Japanese)

Tamura, T. 1990. Aquatic animals in the channels in lower November. *Nature of Furutone-numa* 4: 1–8. (In Japanese)

Toft, J. D., J. R. Cordell and W. C. Fields 2002. New records of crustaceans (Amphipoda, Isopoda) in the Sacramento/San Joaquin Delta, California, and application of criteria for introduced species. *J. Crust. Biol.* 22 (1): 190–200.

Tokyo Metropolitan Government 1997–2003. Report on biota of freshwater ecosystems in Tokyo. Bureau of Environmental Protection, Water Quality Protection Division. (In Japanese)

Zhang, J. and J. R. Holsinger 2003. Systematics of the freshwater amphipod genus *Crangonyx* (Crangonyctidae) in North America. *Mem. Virginia Mus. Nat. Hist.* 6: 1–274.