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DIAGNOSIS, SYSTEMATICS, AND NOTES ON *GRANDIDIERELLA JAPONICA* (AMPHIPODA: GAMMARIDEA) AND ITS INTRODUCTION TO THE PACIFIC COAST OF THE UNITED STATES

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Abstract: The introduction of *Grandidierella japonica* Stephensen, 1938 (Corophiidae) from Japan to Tomales Bay, Bolinas Lagoon and San Francisco Bay, California, is recorded for the first time. A diagnosis and a list of associate species are given. The possible synonymy of the genera *Grandidierella* and *Neomicrodeutopus* is indicated. This species probably arrived with oyster spat transplants from Japan.

Early in 1971, the authors discovered an amphipod from San Francisco Bay, California, that could not be readily identified. James T. Carlton of the California Academy of Sciences, San Francisco, pointed out a description of a Japanese species, *Grandidierella japonica* Stephensen, 1938 (Corophiidae), that proved to match the amphipod in question. *Grandidierella japonica* has previously been recorded only from Japan. This is the first record of this genus and species on the Pacific Coast of the United States.

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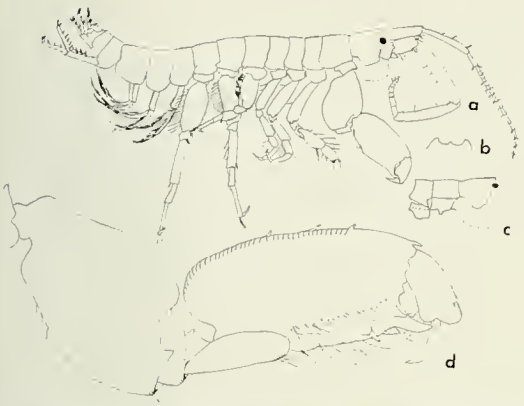

Figure 1. Male *Grandidierella japonica*: a, body; b, rostrum; c, medioventral spine on pereonite 1; d, medial view of gnathopod 1.

Figure 2. Female: a, rostrum; b, body; c, urosome.

Grandidierella japonica Stephensen, 1938
Figures 1–4

Diagnosis: Because Stephensen's description of *Grandidierella japonica* is incomplete and lacks certain critical details, a more thorough diagnosis is presented here.

Body (Figs. 1a, 3b): slightly cylindrical; urosomite segments separate, with no dorsal depression; no elongation of urosomite 1 (Fig. 3c). Mature males possessing a medio-ventral spine on first pereonite (Fig. 1c).

Head: one-fourth longer than pereonite 1, cuboidal; lateral lobes rounded, projecting slightly beyond a short acute rostrum (Figs. 1b, 3a). Eyes large and dark.

Antenna 1: greater than one-half body length, with 20 articles total; flagellum with 17 articles. Accessory flagellum consisting of one minute article with short distal hairs. Article 1 of peduncle with ventral spines.

Antenna 2: from three-fourths length to longer than antenna 1; article 2 barely visible from lateral view; spines on articles 3, 4, and 5; male antenna stout.

Mouthparts: form subquadrate bundle. Mandible (Fig. 4) with large triterative molar; incisors and lacina mobila toothed. Mandibular palp tri-articulate, article 2 longest, article 3 slightly longer than article 1, setation heaviest medio-distally on article 3.

Maxillipeds: generalized, inner plates of normal size, with distal setation; outer plates twice the length of inner plates with heaviest setation on medial sides. Maxilliped palp, four-articulate; article 2 twice length of articles 1 and 3; terminal palp claw-like; when extended, palp twice length of outer plate.

Male gnathopod 1 (Fig. 1d): massive, carpochelate; articles 2 and 5 greatly enlarged; article 2, length one and one half times width, broad and ovate, subequal in length to article 5, medial side concave, anterior edge sharp; article 3 small; article 4 elongate; article 5 length twice its width with three distal posterior teeth, one tooth enlarged, forming a thumb, anterior edge with short transverse grooves and four anterior spines; article 6 subquadrangular, one-third length of article 5.

Female gnathopod 1 (Fig. 5a): reduced, articles 4 and 5 possessing posterior hairs with pinnate barbs; article 6 with three posterior spines; article 7, serrated claw forming acute angle with article 6.

Male gnathopod 2 (Fig. 5c): subchelate, smaller than gnathopod 1, article 2 twice length of article 5; articles 4, 5, and 6 possessing posterior hairs with pinnate barbs, serrated subchelate claw forms transverse angle with article 6; sexual dimorphism apparent, male with elongate article 2 (Fig. 5c). Pereopods 1–5 as described by Stephensen, 1938 (as pereiopods 3–7), coxae reduced, 1–4 subquadrate.

Female gnathopod 2 (Fig. 5b): similar to male gnathopod 2 but with shortened article 2.

Uropod 1 and 2 biramous; uropod 3 uniramous; numerous spines on all uropods; uropod 1 projecting posteriorly slightly beyond uropod 2 and 3, prominent distal peduncular process on uropod 1, urosomite 1 with two spines on antero-lateral surface (Fig. 3c).

Figure 3. Right mandible and mandibular palp.

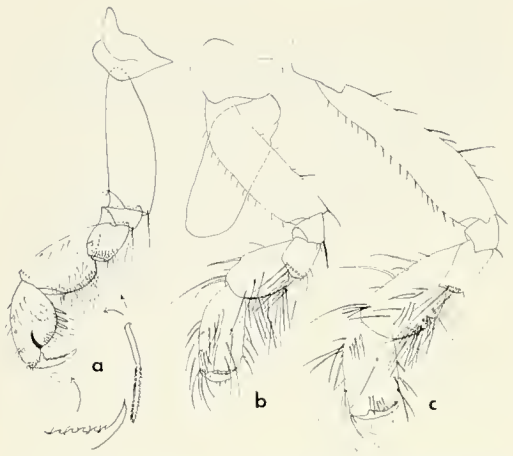

Figure 4. a, female gnathopod 1; b, female gnathopod 2; c, male gnathopod 2.

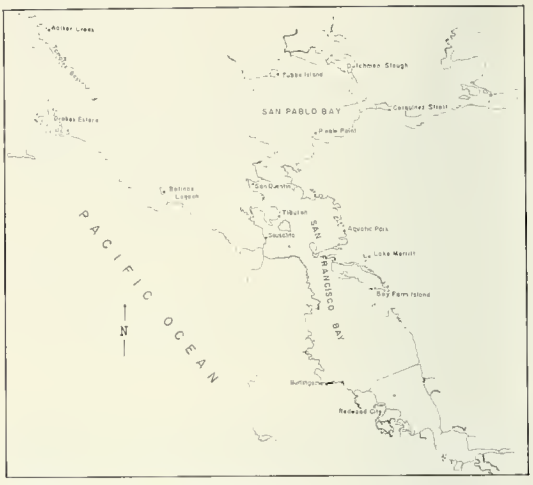

Figure 5. Collecting sites in San Francisco and Tomales Bay areas, California.

Telson small, button-like, with pronounced medial groove.

Largest male examined 22 mm in length, largest female 13 mm; cuticle mottled gray to gray brown, color retained in 70 percent isopropyl alcohol, flesh becoming apaque.

Material examined: Specimens have been deposited in the California Academy of Sciences, Department of Invertebrate Zoology, Type Series, no. 585 (Male, Fig. 1a) and no. 586 (Female, Fig. 3b). Additional material has been deposited at the Academy and at the National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Remarks: *Grandidierella japonica* builds U-shaped tubes in muddy bottoms in which one male and one female often are found together. Males have been observed wandering about in tide pools at low tide.

Males observed in aquaria were noted to scrape the grooves on article 5 of gnathopod 1 rapidly against the sharp anterior edge of article 2. It has been suggested that these grooves function as "stridulating organs" (Stephensen, 1938).

Systematic discussion: Although originally placed in the genus *Grandidierella* by Stephensen, 1938, *Grandidierella japonica* cannot confidently be assigned to that genus or to the closely related genus, *Neomicrodeutopus*. Schellenberg, 1925, and Barnard, 1969; 1973, p. 14, distinguish the two genera by the length of mandibular palp article 1 (elongate in *Grandidierella*, short in *Neomicrodeutopus*). Since at least three species currently assigned to *Grandidierella* are now known to have a short palp article 1 (*G. dentimera* Myers, 1970, *G. japonica* Stephensen, 1938 and *G. perlata* Schellenberg, 1938), this character alternative appears to have no value in distinguishing the two genera (J. L. Barnard, April, 1973 *in litt.*). Barnard, 1973, has indicated the probable synonymy of *Grandidierella* and *Neomicrodeutopus*. Since the described species of both genera must be throughly reexamined to establish clear generic distinctions, if such exist, we consider it beyond the scope of the present paper to argue the correct generic placement of *G. japonica*.

Records: The following collection sites (Fig. 5) of *Grandidierella japonica* in central California are given with substratum, water depth, relative abundance, collection date and collector. The more common associated species are included where possible.

TOMALES BAY: Walker Creek delta, Marin Co: mud-sand, intertidal near Japanese oyster beds, abundant: 23:VII:1969: Coll. James Blake and Edmund Smith. Associates: polychaete, *Capitella* sp.; amphipods, *Ampelisca milleri*, *Ampithoe valida*, *Anisogammarus* sp. cf. *ramellus*, and *Corophium spinicorne*.

BOLINAS LAGOON: Marin Co: mud-sand, intertidal, moderately abundant: VIII: 1971: Coll. J. Chapman and J. F. Gustafson. Associates: polychaetes, *Capitella capitata* and *Streblospio benedicti*; amphipods, *Allorchestes angustus*, *Ampelisca milleri*, *Ampithoe valida*, *Corophium acherusicum* and *Corophium insidiosum*; isopod, *Gnorimosphaeroma lutea*; bivalves, *Cryptomya californica*, and *Gemma gemma*.

SAN FRANCISCO BAY: Carquinez Straits, Contra Costa Co: Construction site of barge loading facilities for brick works; mixed mud and brick fragments, 3 m, moderately abundant: 21:IX:1971: Coll. J. Chapman. Associates: polychaete, *Neanthes suc-*

cinea; barnacle, *Balanus improvisus*; amphipods, *Corophium acherusicum* and *Corophium spinicorne*.

Dutchman Slough, Solano Co: 100 m W Napa Val Fishing Resort; mud, intertidal, moderately abundant: 1966: Coll. Jean Chapman. Associates: amphipod, *Corophium spinicorne*; bivalve, *Macoma* sp.

Tubbs Island, Sonoma Co: northeast side, facing San Pablo Bay; mud, intertidal, moderately abundant: 19:III:1972: Coll. J. Chapman. Associates: polychaetes, *Neanthes succinea* and *Heteromastus filiformis*; bivalves, *Macoma balthica* and *Macoma nasuta*.

Pinole Point, Contra Costa Co: mud, 3 m, abundant: 20:II:1971: Coll. J. F. Gustafson. Associates: polychaete, *Glycinde* sp.; amphipods, *Ampelisca milleri* and *Corophium* sp.; bivalves *Gemma gemma*, *Macoma nasuta*, and *Mya arenaria*.

San Quentin, Marin Co: 100 m south of prison; mud-shell, intertidal, abundant: 28:II:1971: Coll. J. F. Gustafson. Associates: polychaete, *Glycinde* sp.; amphipods, *Ampelisca milleri* and *Corophium insidiosum*; bivalve, *Macoma nasuta*.

Tiburon, Marin Co: east cove on Tiburon Point; mud-sand, 2 m, moderately abundant: 28:II:1971: Coll. J. F. Gustafson. Associates: polychaete, *Glycinde* sp.; amphipods *Ampelisca milleri* and *Corophium insidiosum*; bivalve, *Macoma nasuta*.

Sausalito, Marin Co: from Ondine's Restaurant to sewage treatment plant; mud-sand, 2–6 m, scarce: 2:II:1971: Coll. J. F. Gustafson. Associates: polychaetes, *Glycinde* sp. and *Platynereis bicanaliculata;* amphipods, *Ampelisca milleri*, *Corophium acherusicum*, and *Photis brevipes*; bivalves, *Macoma balthica* and *Macoma nasuta*.

Aquatic Park, Berkeley, Alameda Co: among *Ruppia*, 0.5 m: 29:VII:1967: Coll. J. T. Carlton.

Lake Merritt, Oakland, Alameda Co: in fouling, 0.5 m: 22:XII:1966: Coll. J. T. Carlton. Associates: polychaete, *Mercierella enigmatica*; amphipod, *Melita* sp.; insect, Corixidae.

Lake Merritt, Oakland, Alameda Co: Sailboat Clubhouse, in fouling; intertidal, abundant: 19:IX:1970: Coll. J. T. Carlton.

Bay Farm Island, Alameda Co: 100 m N Bay Farm Island Bridge (State Highway 61); mud-sand, intertidal, abundant; 15:III:1972: Coll. J. Chapman. Associates: polychaetes, *Capitella capitata* and *Pseudopolydora kempi*; amphipods, *Ampelisca milleri* and *Corophium acherusicum*; bivalves, *Ostrea lurida* and *Tapes japonica*.

Burlingame, San Mateo Co: 1 mi W Coyote Point; hard mud, intertidal, abundant: 13:III:1972: Coll. J. Chapman and J. Dorman. Associates: polychaetes, *Capitella capitata*, *Glycinde* sp. and *Pseudopolydora kempi*; amphipod, *Corophium insidiosum*.

Redwood City, San Mateo Co: 2 mi S San Mateo Bridge, 1 mi W west bay shore; in mud and oyster (*Ostrea lurida*) beds, 4–13 m, moderately abundant: 12:II:1972: Coll. J. Chapman and J. F. Gustafson. Associates: anemone, *Haliplanella luciae*; polychaetes, *Glycinde* sp. and *Harmothoe imbricata*; barnacle, *Balanus improvisus*; amphipods *Ampelisca milleri* and *Corophium acherusicum*.

Mode of introduction: *Grandidierella japonica* was first recorded from the benthos of the brackish waters of the Abasiri River, Hokkaido and Mokoto-numa Lake (near Abasiri) in Japan (Stephensen, 1938). Nagata (1960) found *G. japonica* in great abundance in mud substratum in a *Zostera* region throughout the brackish waters of Mihara Bay, Japan. The North American *G. japonica* is also found in estuarine environments typified by brackish water and mud substratum.

Grandidierella japonica probably arrived on the west coast through passive dispersal means. Since all life stages are found together in the benthos (indicating little or no planktonic dispersal) and this amphipod appears to be restricted to estuaries, introduction due to transoceanic drift seems unlikely. It is probable that *G. japonica* was introduced with commercial oyster (*Crassostrea gigas*) spat transplants from Japan (see Barrett, 1963). Japanese oysters were widely introduced in large numbers into bay environments on the Pacific Coast, and introductions still continue. It is probable that *G. japonica* was also introduced with the oysters.

A large number of Japanese estuarine invertebrates, judged to have been introduced similarly with commercial oyster plantings, are also now well established on the Pacific Coast. These include the flatworm, *Pseudostylochus ostreophagus* (Hyman, 1955), the gastropods, *Batillaria zonalis* and *Ocenebra japonica*, the bivalves, *Musculus senhousia* and *Tapes japonica* (as *Paphia philippinarum*) (Hanna, 1966), the endoparasitic copepod, *Mytilicola orientalis* (Odlaug, 1946), the isopod *Gnorimosphaeroma rayi* (Hoestlandt, 1969), possibly the amphipod *Corophium uenoi* (Barnard, 1952; Barnard and Reish, 1959), additionally several spionid polychaetes and the ctenostome bryozoan *Victorella pavida* (J. T. Carlton, pers. comm.).

If *Grandidierella japonica* was introduced with oyster transplants, it could have arrived in central California as early as 1928 with the first Japanese oyster spats transplanted to Tomales Bay. There are no collections dating earlier than 1966 at hand, but judging from its wide distribution in San Francisco Bay at that date, *G. japonica* was probably introduced well before that time.

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