

FIRST RECORD OF *ORCHESTIA GAMMARELLUS* (CRUSTACEA: AMPHIPODA: TALITROIDEA) IN CHILE, WITH COMMENTS ON ITS MORPHOLOGIC VARIABILITY

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Abstract

The presence of *Orchestia gammarellus* is confirmed for first time in Chile, based on specimens of three populations from Changa beach (Coquimbo Region), Los Lilenes beach (Valparaíso Region) and Pelluco (Los Lagos Region). This species is the third amphipod reported as exotic in the country and meet 7 of 10 criteria for recognition of introduced crustacean species. Information for the identification of the species and comments about morphologic variability of Chilean specimens are given. Differences between specimens of Chilean populations suggest the occurrence of different colonization events from European and Northamerican pathways.

Key words: Talitridae, introduced species, southeastern Pacific, morphology.

Primer registro de *Orchestia gammarellus* (Crustacea: Amphipoda: Talitroidea) in Chile, con comentarios sobre su variabilidad morfológica

Resumen

Se confirma por primera vez la presencia de *Orchestia gammarellus* en Chile, con base en especímenes de tres poblaciones: Playa Changa (Región de Coquimbo), Playa Los Lilenes (Región de Valparaíso) y Pelluco (Región de Los Lagos). Esta especie es el tercer anfípodo registrado como exótico en el país y cumple con 7 de los 10 criterios propuestos para el reconocimiento de especies de crustáceos introducidos. Se proporciona información para la identificación de la especie y algunos comentarios acerca de la variabilidad morfológica de los especímenes chilenos. Las diferencias entre organismos de las poblaciones chilenas sugieren la presencia de diferentes eventos de colonización a partir de rutas europeas y norteamericanas.

Palabras Clave: Talitridae, especie introducida, Pacífico sureste, morfología.

Introduction

The presence of introduced talitrid amphipod species has been reported several times in the past in different areas of the world (Vader, 1972; Carlton, 1979; Kotta, 2000; Defeo *et al.*, 2009; Konopacka *et al.*, 2009; Eutropio & Krohling, 2013); however, not always the status of the populations has been clearly established, and some species were considered cryptogenic, as in the Southeastern Atlantic coast (Orensanz *et al.*, 2002).

In Chile, has been documented eight species of talitrid amphipod (*Transorchestia chiliensis* Milne Edwards, 1840; *Transorchestia gracilis* Chilton, 1920; *Protorchestia nitida* Dana, 1852; "*Orchestia*"

selkirki Stebbing, 1888, "*Orchestia*" *scutigera* Dana, 1852; *Orchestoidea tuberculata* Nicolet, 1849; *Orchestia gayi* Nicolet, 1849), belonging to three of the systematic-ecological groups proposed by Bousfield (1982, 1984), apparently all of them are native. The current knowledge of Chilean talitrids is summarized in two catalogues with distributional information (González, 1991b; González *et al.*, 2008) and a review with diagnosis and illustrations for each species (González, 1991a); however, still is necessary more exploration for additional species (Pérez-Schultheiss *et al.*, 2010), new geographic records of known species (*e.g.*, Baessolo *et al.*, 2010), and specially looking for the presence of introduced species.

The occurrence of native species of the genus *Orchestia* Leach, 1814 in Chile seems to be very improbable (Bousfield, 1982); some species remain in this genus, but all of them needs to be allocated in different genera, when more detailed morphologic information be available (*e.g.*, *O. gayi* Nicolet, 1849, *O. selkirki* Stebbing, 1888 and *O. scutigera* Dana, 1853). Lowry & Fanini (2013) have confirmed the *Orchestia* species are restricted to the North Atlantic coast, with some species in New Zealand, which remain provisionally in the genus. Populations of *Orchestia* sensu Lowry & Fanini, 2013, outside the two natural areas of distribution probably represent introduction events as exotics, but this have not been confirmed (*e.g.*, Escofet *et al.*, 1978; Alonso, 1986).

This paper reports for the first time the presence of *Orchestia gammarellus* Pallas, 1766 in Chile, including the background for his recognition and a discussion on some morphological differences between populations. Additionally, the criteria of Chapman & Carlton (1991) for recognition of the Chilean populations as an introduced species were used.

Materials and Methods

The samples were borrowed from the collection of the author, maintained in the Departamento de Sistemática Animal, Centro de Estudios en Biodiversidad, Osorno, Chile. Appendices of dissected specimens were mounted in glycerin for microscopic observation and then conserved in a vial along with the carcass. The body length was obtained following the method of Barnard & Karaman (1991), superimposing a curve line from the frontal zone of the head to base of telson, measured in digital images of specimens, by mean of the software Adobe Illustrator. Taxonomic identification is based principally in papers of Bousfield (1973), Lincoln (1979) and Bellan-Santini (1993). The Chapman & Carlton (1991) criteria for recognition of introduced species, based in ecological, evolutionary and geographical attributes of the organisms was applied.

Results

SYSTEMATICS

Order AMPHIPODA Latreille, 1816

Suborder SENTICAUDATA Lowry & Myers, 2013

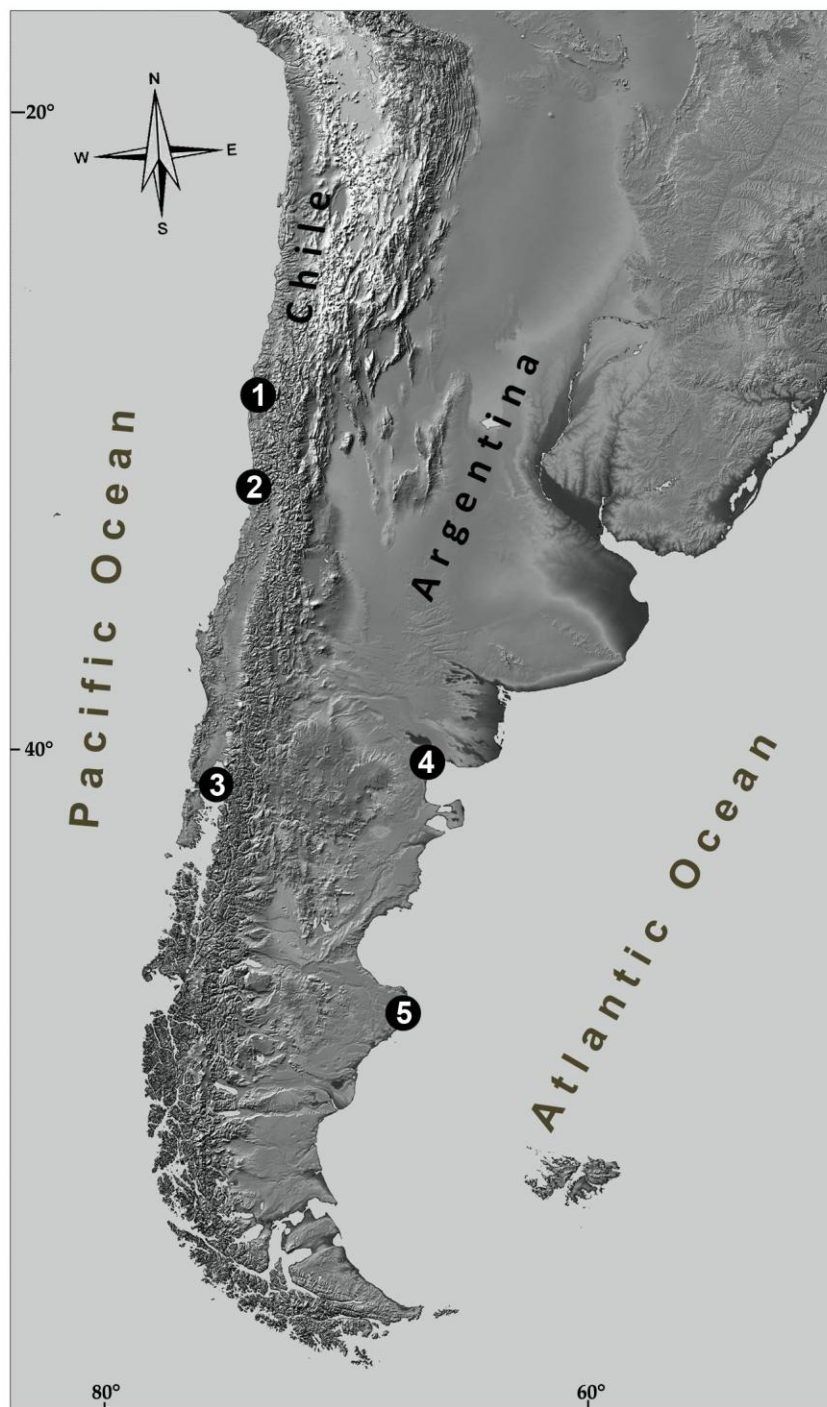


Figure 1. South American records of *Orchestia gammarellus* (Pallas, 1766). 1. Changa beach, Coquimbo, Chile (this work); 2. Los Lilenes beach, Concón, Chile (this work); 3. Pelluco, Puerto Montt, Chile (this work); 4. Golfo de San Matías, Argentina (Escofet *et al.*, 1978); 5. Ría Deseado, Argentina (Alonso, 1986).

Figura 1. Registros de *Orchestia gammarellus* (Pallas, 1766) en Sudamérica. 1. Playa Changa, Coquimbo, Chile (este trabajo); 2. Playa Los Lilenes, Chile (este trabajo); 3. Pelluco, Puerto Montt, Chile (este trabajo); 4. Golfo de San Matías, Argentina (Escofet *et al.*, 1978); 5. Ría Deseado, Argentina (Alonso, 1986).

Infraorder TALITRIDA Rafinesque, 1815
Parvorder TALITRIDIRA Rafinesque, 1815
Superfamily TALITROIDEA Rafinesque, 1815
Family TALITRIDAE Rafinesque, 1815
Orchestia group Lowry & Coleman, 2012
Genus *Orchestia* Leach, 1814
Orchestia gammarellus (Pallas, 1766)

(Figure 1-3)

Material Examined: Collection data of the samples analyzed are cited verbatim from the labels. 8 females and 10 males (JPS-301), 1 dissected adult female (JPS-302) and 1 dissected adult male (JPS-303), “Playa Changa (29°57'40,9''S; 71°19'20,9''W), Coquimbo, 23-VI-2005, Col. J. Pérez, Bajo piedras, supramareal, junto a laguna costera”. 1 dissected adult male (JPS-307), 1 partially dissected ovigerous female (JPS-308), 1 partially dissected adult female (JPS-309), 22 adults and immature males (JPS-310), 24 adult and immature females (JPS-311) and 53 juveniles (JPS-312), “Playa Los Lilenes (35°55'50,57''S; 71°32'13,25W), Concón, Reg. de Valparaíso, 20-V-2005, Col. J. Pérez, Bajo herbacea supramareal, troncos y detritos”. 1 adult male and 1 adult female (JPS-305), “Desembocadura rio Pelluco, Puerto Montt, Región de Los Lagos (41°29'14.15''S, 72°53'58.66''W), 26-IX-2013, Col. J. Pérez, Bajo piedras, en marisma”. 3 adult males and 3 adult females (JPS-324), “Desembocadura rio Pelluco, Puerto Montt, Región de Los Lagos (41°29'14.15''S, 72°53'58.66''W), 25-X-2013, Col. J. Pérez, Bajo piedras, en marisma”.

Diagnosis: Cuspidactilate beachfleas with lacinia mobilis of left mandible 4-dentate; antennae not geniculates. Merus of male gnathopod 1 without posterior lobe; propodus of male gnathopod 2 oval, palm evenly convex, without strong excavations and defined by a distinct prominence; dactylus not attenuated, evenly curved (Figures 3A and 3B). Merus and carpus of adult male pereopod 7 expanded (Figure 3C and 3D). Uropod 1 peduncle without robust distolateral seta; outer ramus of uropod 1-2 with at least one marginal robust seta. Coxal gills 2 and 6 bigger than 3-5. Basis of female gnathopod 2 expanded; setae in oostegites simple.

Distribution: *Orchestia gammarellus* is native to North Atlantic (Bousfield, 1982), found both in European (Lincoln, 1979; Bellan-Santini, 1993; Karaman, 1970) and North American coasts (Bousfield, 1973), with one report from southeastern Africa (Griffiths, 1975). The first South American reports were published by Escofet *et al.* (1978) from the Gulf of San Matías and from the Ria Deseado by Alonso (1986), both locations in Argentina (Figure 1). The specimens here studied represent the first record of the species in the southeastern Pacific coast (Figure 1).

Remarks

Criteria for introduced species recognition: Table 1 presents the results of applying the criteria of Chapman & Carlton (1991) for recognition of introduced species. These criteria are based on ecological, evolutionary and geographical attributes of the species. The Chilean populations of

Orchestia gammarellus here reported satisfies seven of ten criteria, most of them easily deduced with current knowledge.

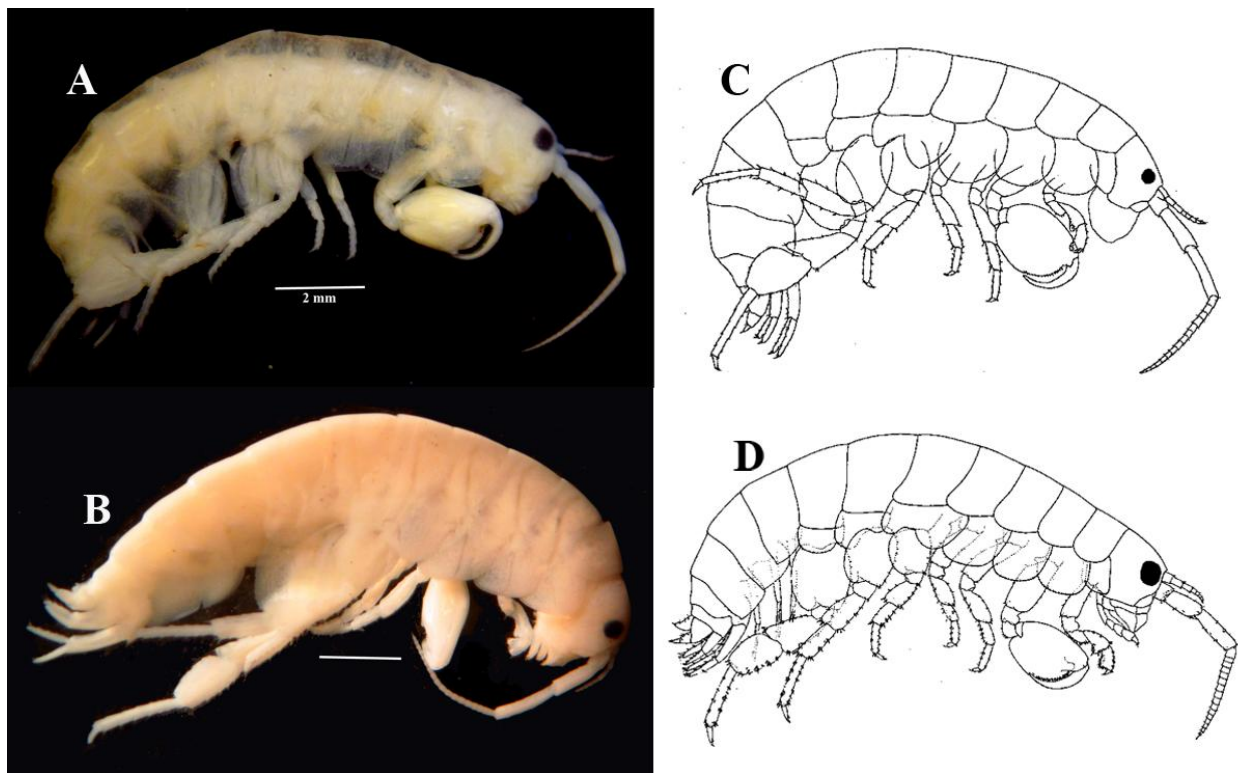


Figure 2. Comparison of specimens of *Orchestia gammarellus* (Pallas, 1766). A, specimen from Changa beach (JPS-303); B, Los Lilenes beach (JPS-307); C, European specimen (after Lincoln, 1979) and D, North American specimen (after Bousfield, 1973). Compare specially antennae and pereopod 7. Scale: 2 mm.

Figura 2. Comparación de especímenes de *Orchestia gammarellus* (Pallas, 1766). A, espécimen de Playa Changa (JPS-303); B, Playa Los Lilenes (JPS-307); C, Espécimen Europeo (extraído de Lincoln, 1979) y D, Espécimen de Norteamérica (extraído de Bousfield, 1973). Compárese especialmente las antenas y pereópodo 7. Escala: 2 mm.

Comparison with other Chilean talitrids: Among the beachfleas known in Chile, *O. gammarellus* differs from *Transorchestia* Bousfield, 1982 mainly in the palm of female gnathopod 1 shorter than dactylus; the telson shorter, with marginal and dorsal setae and especially in the oostegites with simple setae only (versus hook-tipped). *T. chiliensis* (Milne-Edwards, 1840) presents the dactyl of male gnathopod 2 sinuous, unlike *O. gammarellus*, where the male gnathopod 2 dactylus is evenly curved (Figures 3A and 3B). On the other hand, *T. gracilis* Chilton, 1920 presents a sinuous palm of gnathopod 2 and a slight subdistal convexity on the posterior margin of the dactylus.

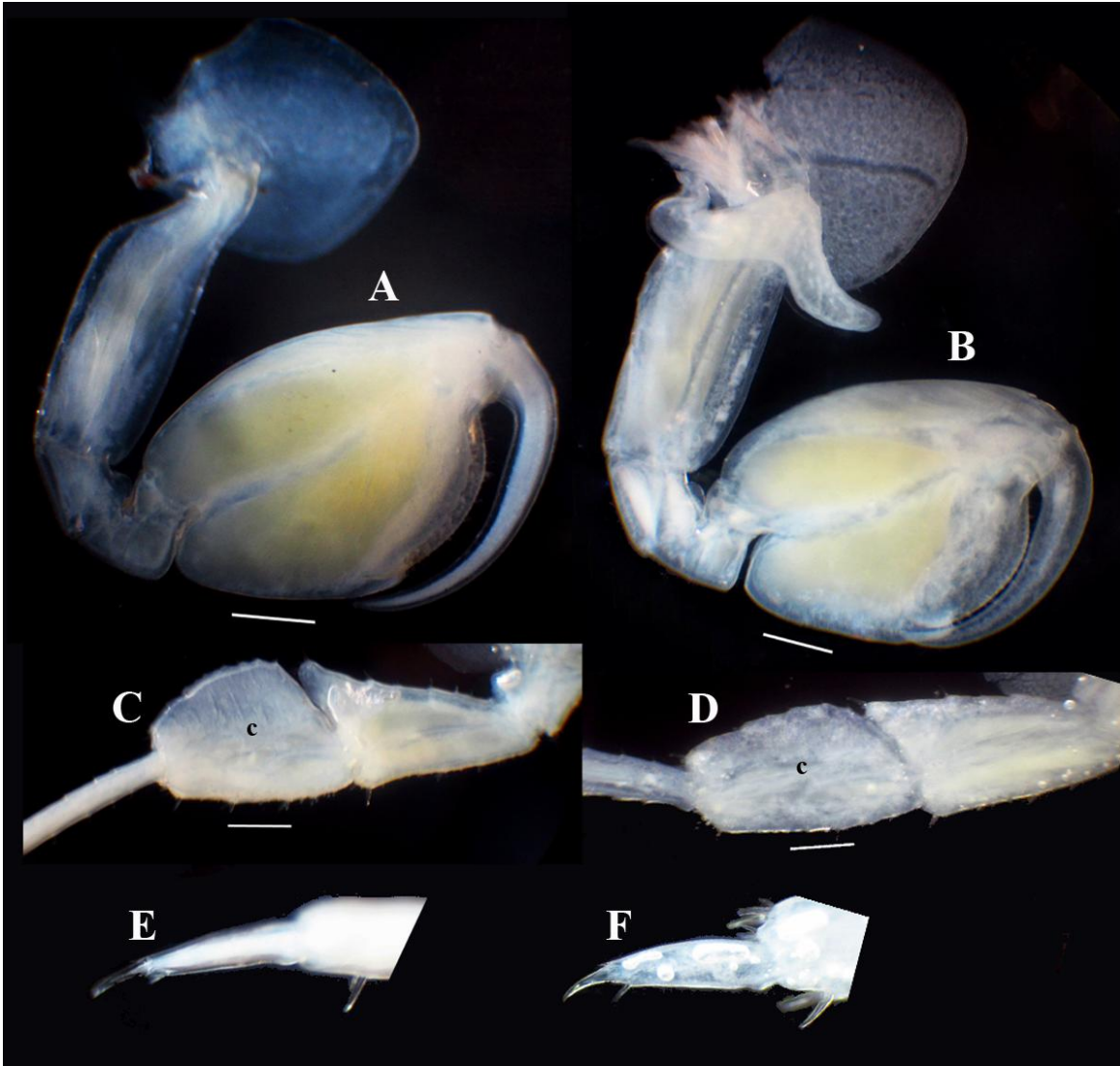


Figure 3. Comparison of male specimens of *Orchestia gammarellus* (Pallas, 1766) from Changa beach (A, C and E, JPS-303) and Los Lilenes beach (B, D and F, JPS-307). A-B, male gnathopod 2; C-D, carpus (c) of pereopod 7; and E-F, dactylus of pereopod 7. Scales: 500 μ m

Figura 3. Comparación de especímenes macho de *Orchestia gammarellus* (Pallas, 1766) de Playa Changa (A, C y E, JPS-303) y Playa Los Lilenes (B, D y F, JPS-307). A-B, gnathopod 2 del macho; C-D, carpo (c) del pereópodo 7; y E-F, dáctilo del pereópodo 7. Escala: 500 μ m

O. gammarellus differs from *Protorchestia* Bousfield, 1982 in left lacinia mobilis 4-dentate, the palp of maxilliped 3-segmented, the basis of female gnathopod 2 expanded and the telson with dorsal spines. *Protorchestia* has a robust distolateral seta on the uropod 1 and no marginal robust setae on outer ramus of uropods 1-2, unlike *O. gammarellus* that not have the distolateral robust seta and outer ramus of uropods 1-2 have marginal setae.

Table 1. Application of the Chapman & Carlton (1991) criteria for introduced species in *Orchestia gammarellus* from Chile. +, meets the criteria; I, information insufficient; P, probably meet the criteria.

Tabla 1. Aplicación de los criterios para especies introducidas de Chapman & Carlton (1991) en *Orchestia gammarellus* de Chile. +, cumple el criterio; I, información insuficiente; P, probablemente cumple el criterio.

Chapman & Carlton Criteria	
1. Previously unknown in local region	+
2. Post-introduction range expansion	I
3. Human mechanism of introduction	P
4. Association with known introductions	I
5. Association with new or artificial environments	+
6. Discontinuous regional distribution	+
7. Disjunct global distribution	+
8. Insufficient life history adaptations for global dispersal	+
9. Insufficient passive global dispersal mechanisms	+
10. Exotic evolutionary origin	+

According to descriptions of Stebbing (1888, 1906), *O. gammarellus* differs from "*Orchestia selkirki* Stebbing, 1888 in 3-segmented maxilliped palp (versus 4-segmented), the basis of female gnathopod 2 expanded (versus slightly expanded), the palm of male gnathopod 2 convex (versus sinuous), the dactyl uniformly curved (versus with two concavities in posterior margin) and the uropod 3 ramus shorter than peduncle (versus as long as peduncle). Finally, it differs from "*Orchestia scutigerula* Dana, 1852 (compared with description of Stephensen, 1949) in the female gnathopod 2 with basis expanded (versus not or slightly expanded), the pereopod 7 of adult male with normal basis (versus later expanded strongly on a plate), merus and carpus expanded (versus not expanded) and epimera with normal inferior margin (versus provided with robust marginal setae).

Morphological variability between populations: The majority of adults in the studied samples of *Orchestia gammarellus* showed scarce development in sexual dimorphism of pereopod 7, with exception of few terminal males used for comparison (Figure 2A and 2B). In these specimens there are differences between material of Changa beach–Pelluco and Los Lilenes beach: antenna 1 slightly longer than article 4 of peduncle antenna 2 (versus not exceeding article 4), peduncle of antenna 2 slightly longer and slender, with flagellum more or less cylindrical (versus flagellum gently compressed), palm of male gnathopod 2 more convex, propodus more slender, and basis of female gnathopod 2 more or less evenly spread (versus more expanded in proximal half, compare Figure 3A and 3B).

The differences are remarkable in the expansion of merus and carpus of male pereopod 7. In specimens of Changa beach and Pelluco (versus Los Lilenes) the expansion is more pronounced toward posterodistal margin of merus and entire length of carpus, which is expanded especially to the posterior half (versus uniformly expanded in both articles, similar to *Transorchestia chiliensis*) (Figure 3C and 3D). The latter article presents the anterior margin entire strongly flattened, with two marginal rows of robust setae (versus anterior margin slightly flattened, while maintaining the two rows of robust setae) and the posterior margin is flattened only in 2/3 basal, with two rows of marginal robust setae (versus not flattened, with only one marginal row of robust setae). In Changa beach specimens the dactylus of pereopod 7, is comparatively thinner (versus slightly thickened, with convex posterior margin, compare Figure 3E and 3F). As an additional difference, the male specimens of Changa beach usually were fixed with the dactyl of gnathopod 2 open, unlike the specimens of Los Lilenes, usually fixed with the dactyl closed on the palm.

It is possible that observed differences correspond to variations resulting from different ontogenetic stages, however, adult terminal males of Los Lilenes beach are slightly longer (bigger male of 17.4 mm, see Figure 2B) than terminal males of Changa beach (bigger male of 15.8 mm, see Figure 2A), suggesting that the minor growth in the articles of pereopod 7 not corresponds to an earlier ontogenetic stage. In addition, both samples contained several male specimens in different development stages, which were also easily assigned to their respective forms based on characters not related to sexual dimorphism.

Discussion

Chapman & Carlton (1991) proposed a set of 10 criteria for the recognition of introduced species of peracarid crustaceans. The studied material is the first reference of the species in the Southeast Pacific and the three locations are separated by approximately 350 km (Changa beach–Los Lilenes beach) and 950 km (Los Lilenes beach–Pelluco), indicating that the criterion 1, "previously unknown in local region" and the sixth criterion, "discontinuous regional distribution" would be positive. Should be noted that surveys in other areas of Chile, especially in middle and southern zones produced no samples of *Orchestia gammarellus*, but the native species (*Transorchestia chiliensis*, *Protorchestia* sp.) are very common.

All samples analyzed here come from urban sectors with strong anthropic intervention; in Changa beach, the specimens were found near a small coastal lagoon at side of the road, hidden under rocks and debris, specimens from Pelluco were collected in a small salt marsh at mouth of Pelluco river, in a strongly impacted touristic urban beach, while Los Lilenes corresponds to a very short beach, located in the middle of a residential area and surrounded by human constructions, with significant accumulations of organic and anthropogenic waste. According to this, the criterion 5, "association with new or artificial environments" would also be positive.

The presence of *O. gammarellus* in geographical areas widely separated, such as Europe, North America, South America and South Africa, in addition to the new records here reported, can confirm the criterion 7, "disjunct global distribution".

The criterion number 8, "insufficient life history adaptations for global dispersal" and number 9 "Insufficient passive global dispersal mechanisms" can be considered positive taking into account that talitrid amphipods generally have limited dispersal capabilities due to the absence of free-living larval stages and that females retain eggs throughout their development in a marsupium (Bellan-Santini, 1999; Wildish, 2012). While natural dispersal over long distances in talitrids is possible through rafting (Persson, 2001), their occurrence appears to be rare (compared with other groups of amphipods) and is difficult to ascertain. Other talitrid species have been reported as rafters only on indirect way, based on distributional or genetic evidence (Thiel & Gutow, 2005), with only few concrete examples of specimens on floating objects (*e.g.*, Wildish, 1970; Hinojosa *et al.*, 2007).

According to Bousfield (1982, 1984) and Lowry & Fanini (2013), the genus *Orchestia* Leach, 1814 is restricted only to a limited group of species from the North Atlantic, characterized by a series of characters, which although not yet assessed phylogenetically, suggest their monophyly. Accordingly, the majority of species from other geographical areas that have been assigned to *Orchestia*, shall be transferred to different genera (Bousfield, 1982). These records suggest that the criterion 10, "exotic evolutionary origin", is positive.

The third criterion, "human mechanism of introduction", was considered probably positive despite the absence of direct evidence, because the introduction of this species could hardly have occurred naturally in the southeastern Pacific coast. Criteria 2, "post-introduction range expansion" and 4 "association with known introductions" were considered as without information due to the limited survey of the species and the colonized community at regional and national level, although it is probable that these could also be considered as positive when the data becomes available. Concerning criterion 2, it should be noted the case of Argentina, where after records of Escofet *et al.* (1978) and Alonso (1986), the species has been recently reported in other five locations: Riacho, Fracasso, Ship, San Julian and Loyola (Bortolus *et al.*, 2009), suggesting that it is expanding.

Our records of *O. gammarellus* in Chile represents the first reference of its occurrence in southeastern Pacific, and is the third confirmed species of exotic amphipod, after reports of *Jassa marmorata* Holmes, 1903 and *Monocorophium acherusicum* (Costa, 1851) (Pérez-Schultheiss, 2009). The three localities reported for *O. gammarellus* are widely separated geographically. Considering the scarce opportunities for dispersion of the species through such long distances in recent times, its apparent circumscription to habitats strongly disturbed and absence of evidence of populational expansions, is highly probable that each population represent an independent event of introduction.

Although there is no direct evidence, it has been suggested that North American populations of *O. gammarellus* are introductions from the Northeast Atlantic (Chapman, 2000), however, morphological differences observed in the literature suggest otherwise. The figures and descriptions of material from Europe (Bellan-Santini, 1993; Chevreux & Fage, 1925; Gurjanova, 1951; Lincoln, 1979, see figure 2C; Sars, 1890-1895; Schellenberg, 1942) agree among themselves and with specimens from Changa beach and Pelluco (Figure 2A) in most of the characters discussed here, especially in pereopod 7, but differ from the illustration of specimens from

North America (Bousfield, 1973, see figure 2D) and the material from Los Lilenes beach (Figure 2B). According to this, the presence of *O. gammarellus* in Chile would be product of at least two independent invasion events, however, the presumable occurrence of a different and probably new species for North American populations and specimens of Los Lilenes beach will be confirmed only after a complete taxonomic evaluation of the species.

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