On *Halicarcinus planatus* (Fabricius) (Brachyura, Hymenosomatidae) transported from Chile to Brazil along with the exotic oyster *Crassostrea gigas* (Thunberg).

Tavares, M.

Museu de Zoologia, Universidade de São Paulo, Av. Nazareth, 481, Ipiranga, 04263-000 São Paulo, SP, Brasil. e-mail: mdst@usp.br

Abstract

Transportation of infested stocks of commercially important exotic oysters has been known for long time to be the vector for unintentional introductions of aquatic organisms world-wide. The transport of the hymenosomatid crab *Halicarcinus planatus* (Fabricius, 1775) from Chile to Rio de Janeiro in live stocks of the Pacific oyster *Crassostrea gigas* (Thunberg, 1793) is reported herein. The crabs were found alive during two oyster surveys carried out in Rio de Janeiro from March to April 1997. The accompanying fauna of *C. gigas* also included peracarid crustaceans, mollusks, and sea weeds. In Brazil, *H. planatus* has not been found in the wild. Although *C. gigas* is farmed in Brazil, adults and seeds sometimes are brought from Chile to sustain the Brazilian oyster industry. The importation of exotic live oysters from abroad, whether as adults or seeds, can result in introductions of aquatic organisms living cryptically in the oyster shells, including parasites and pathogens. A detailed inventory of accompanying non-indigenous organisms should be required before the use of exotic shellfish.

Key words: *Halicarcinus planatus*, *Crassostrea gigas*, exotic species, Brazil, Chile.

Introduction

The role played by human activities in transferring non-indigenous marine and estuarine species into new areas is widely recognized as a critical element of ecosystem change (Mack *et al.* 2000; Crooks 2002; Perrings 2002). A wide variety of dispersal pathways have been documented for non-indigenous marine species, including ballast water, biofouling adhering to naval structures and to floating anthropogenic debris, navigation canals, and the aquarium and aquaculture industries (Quayle, 1964; Hanna, 1966; Aron and Smith, 1971; Jones, 1972; Carlton, 1975; Por, 1978; 1990; Bourne, 1979; Forster and Willan, 1979; Andrews, 1980; Zibrowius, 1983; 1992; Sindermann, 1991; Ruiz *et al.* 2000; Wasson *et al.* 2001; Wonham *et al.* 2001; Barnes, 2002). Oysters are the most transported commercial shellfish. The Pacific oyster *Crassostrea gigas* (Thunberg, 1793), for instance, is native to the western Pacific but has been transported to many different places around the world such as the Pacific coast of North America, the Atlantic coast of Europe, the Mediterranean Sea (e.g., France, Italy, Algeria, Tunisia, Malta, Cyprus), the Red Sea and Maurice and Reunion Islands, the Atlantic coast of Marroco, South Africa, Argentina, Brazil, Chile, Australia, New Zealand, Hawaii, Palau, New Caledonia, Vanuatu, Fiji, Tahiti, and Tonga (Zibrowius, 1983; Orensanz *et al.*) 2002. The transoceanic transfer of commercially important oysters dates back to 19th century on the Atlantic coast of France (Andrews, 1980), and according to some authors might have started even earlier in the 16th century between Japan and Portugal (see Zibrowius, 1992). Transportation of infested stocks of commercially important exotic oysters has been known for a long time to be a vector for unintentional introductions of

many aquatic organisms world-wide. For the example, the introductions of the American oyster *C. virginica* (Gmelin, 1791) from the western Atlantic to Great Britain in the late 1800's, and of the Pacific oyster *C. gigas* to the Pacific coast of North America (1902) and the Atlantic coast of France (1966) brought numerous exotic species of macrophytes and invertebrates, some of which developed into pests (Gruet *et al.*, 1976; Zibrowius, 1978; 1983; 1992; Andrews, 1980). As many as 15 species of macrophytes were introduced into the Mediterranean as a result of oyster farming, ten of which are native to Japan (Galil, 2001).

The role played by exotic oysters as vectors for introduction of exotic species has been well documented in the Pacific and Atlantic coasts of North America, in the Atlantic and Mediterranean coasts of Europe, and in Australia and New Zealand (Quayle, 1964; Hanna, 1966; Carlton, 1975; Gruet *et al.*, 1976; Bourne, 1979; Walne and Helm, 1979; Andrew, 1980; Zibrowius, 1978; 1983; 1992; and references therein). Yet, Zibrowius (1992) experienced some difficulties in tracking down precisely the introduction of both, the exotic oysters and its accompanying non-indigenous species into the Mediterranean: "Data are widely dispersed, including in technical reports, and it is likely that many introductions (not only among the early ones) did not leave traces in the official record".

In Brazil the importation of living *C. gigas* started in 1974 from North Wales, UK, the Pacific coast of the United States, and Japan (Muniz *et al.*, 1986). The importation of living oysters from those regions was carried out for more than ten years before ending around 1986. More recently, adults and seeds of *C. gigas* have been imported from Chile. Surprisingly, virtually no data are available in the literature on the accompanying organisms transported unintentionally along with *C. gigas* to Brazil, whether from Wales, USA, and Japan, or the more recent ones from Chile. Without this basic information, no prevention and control strategies can be implemented.

In 1997, a survey of the Pacific oyster *C. gigas* transferred alive from Chile to Rio de Janeiro revealed the presence of a number of unwanted accompanying marine organisms, including the non-indigenous hymenosomatid crab *Halicarcinus planatus* (Fabricius, 1775). The circumstances of this transportation are presented herein.

The studied material has been deposited in the collection of the Museu de Zoologia da Universidade de São Paulo (MZUSP). Abbreviation: IEAPM, Instituto de Estudos do Mar Almirante Paulo Moreira, Arraial do Cabo, RJ; USU, Universidade Santa Úrsula, Rio de Janeiro.

Halicarcinus planatus (Fabricius, 1775) (fig. 1)

Restricted synonymy: see Melrose, 1975: 34; Boschi *et al.*, 1992: 64; Davie, 2002: 246.

Material examined.- Brazil, Rio de Janeiro, A. M. Sakatsume coll., 25.iii.1997: 2 young males found alive on the Pacific oyster *Crassostrea gigas* imported from Chile (MZUSP 10275). Ibidem, 1 young male found alive on the Pacific oyster *Crassostrea gigas* imported from Chile (MZUSP 15543).

Comparative material.- Argentina, Puerto Deseado, Punta Cavendish, RV Alm. Sandanha?, 17.i.1970, St. 42: 1 adult female (MZUSP 10274). Roca de los Hermanos, RV Almirante Sandanha: 6 females (MZUSP 3637). Roca-Roca, J. Tundisi coll., 22.ii.1962: 1 adult female (MZUSP 3657). Chile, Chiloé, Talcán, J. Stuardo, 17.ii.1961: 7 females (MZUSP 2093).

Distribution.- Uruguay, Argentina, Peru, Chile, and circum-subantarctic region (Melrose, 1975; Boschi *et al.*, 1992; Ng and Chuang, 1996; Retamal, 1996; Davie, 2002).

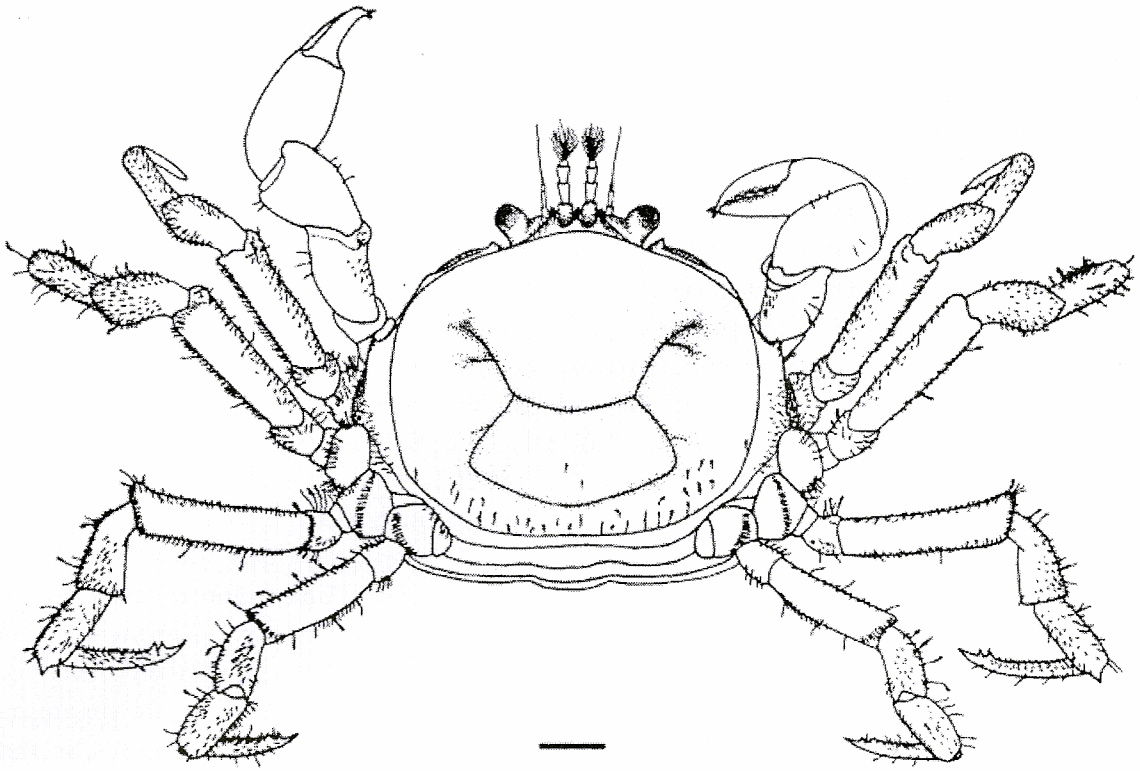

Figure 1: *Halicarcinus planatus* (Fabricius, 1775), after Retamal (1981: 79, fig. 136). Scale bar 1 mm.

Discussion

Altogether, three specimens of *H. planatus* have been unintentionally transferred from Chile to Rio de Janeiro in boxes along with adults of the Pacific oyster *C. gigas*. The crabs were found alive during two surveys carried out in March and April 1997. The accompanying fauna of *C. gigas* also included peracarid crustaceans, mollusks, and sea weeds. In the southwestern Atlantic, *H. planatus* occurs naturally in Argentina and Uruguay (Boschi *et al.* 1992: 64; Retamal, 1996: 151). Because it is a cold water species, new areas in the southwestern Atlantic suitable for colonization are basically restricted to the south coast of Brazil; it is unlikely that *H. planatus* could colonize waters as far north as Rio de Janeiro (22°S). In the Americas, the only case of well succeeded introduction of a hymenosomatid crab is that of the freshwater species *Neorhynchoplax kempi* (Chopra and Das, 1930) known from Iraq brought to the Panama Canal, probably along with the exotic aquatic plant *Hydrilla verticillata* (L.f.) Presl (Abele, 1972).

Potential risks.- Two species of oysters are farmed in Brazil, the native mangrove oyster *Crassostrea rhizophorae* (Guilding, 1828) and the exotic Pacific oyster *C. gigas* (Costa, 1978; Manzoni *et al.*, 1998; Anonymous, 2001; Proença *et al.*, 2001). It appears that the exotic oysters *Spondylus americanus* Herman, 1781, and the pearls oyster *Pinctata margaritifera* (Linnaeus, 1758) are been experimentally cultured in Brazil as well (Anonymous, 2001). While *C. rhizophorae* is farmed in several areas along the Brazilian coast, the mariculture of *C. gigas* is currently restricted to Angra dos Reis and Santa Catarina. *Crassostrea gigas* was first introduced to Brazil in 1974. Adults and seeds imported from north Wales, UK, the Pacific coast of the United States, and Japan were shipped repeatedly to the oceanographic facilities of the Brazilian Navy (IEAPM) in Arraial do Cabo, Rio de Janeiro. The shipments of *C. gigas* to Brazil contained individuals cultured in laboratory conditions and in open waters. As a result, exotic aquatic organisms were unintentionally brought to Brazil along with the oysters (Martins, pers. comm.). After acclimatization in the

laboratory the imported individuals of *C. gigas* were unrestrictedly introduced into open waters at Forno Beach, Arraial do Cabo, where subsequently several aquaculture tests were carried out (Muniz *et al.*, 1986). No quarantine techniques were employed at that time to prevent invasions. The experiments with *C. gigas* in Arraial do Cabo were resumed around 1986. There are few records on these early introductions of this oyster to Brazil (Costa, 1978; 1983; Costa *et al.*, 1981; Muniz *et al.*, 1986), and virtually no record of any accompanying exotic aquatic organisms. More recently, adults and seeds of *C. gigas* have been imported from Chile to Angra dos Reis and Santa Catarina. In addition to the introduction of unwanted aquatic organisms living cryptically in the oyster shells, such as parasites and pathogens, it is also known that exotic species and pathogens may move in several ways from natural environments to aquaculture facilities and vice versa. Costs associated with the introduction of non-indigenous species are high (Pimentel *et al.*, 1999), and mitigation of environmental and socio-economic damage caused by non-indigenous species can be more expensive than prevention (Leung *et al.* 2002). In some countries such as France the oyster industry is more than 100 years old and the deliberate unrestricted movement of imported oysters resulted in high mitigation costs (Andrews, 1980), and have been deeply regretted: "L'introduction en France de *C. gigas* est le cas le plus flagrant d'une action menée en toute irresponsabilité à une époque et dans un pays où on aurait pu faire mieux." (Zibrowius, 1983: 343). Conversely, the Brazilian oyster industry is relatively recent and expenditure on prevention can still avoid mitigation costs. There is an urgent need for a detailed survey of exotic organisms brought with imported oysters before and after application of quarantine procedures, so that current quarantine techniques can be evaluated and improved to reduce the risk of introductions or, at least, keep the risks of introductions at acceptable levels.

Acknowledgements

I thank Alex Massanobu Sakatsume (USU) for conducting the surveys of *C. gigas* and for making the specimens of *H. planatus* available for study. I also thank Gustavo Augusto S. de Melo (MZUSP) and Gary C. B. Poore for their comments on the manuscript. Gary also streamlined the English text. Joel Braga de Mendonça Junior and Philip C. Scott (both from USU) helped in the search for literature. The National Council for the Development of Science and Technology (CNPq) supported this research through an ongoing grant (proc. # 520254/95-3).

References

Abele, L. G. 1972. Introductions of two freshwater decapods crustaceans (Hymenosomatidae and Atyidae) into Central and North America. Crustaceana, 23 (3): 209-218.

Andrews, J. D. 1980. A review of introductions of exotic oysters and biological planning for the new importations. Marine Fisheries Review, 42(12): 1-10.

Anonymous, 2001. Panorama da Malacocultura Brasileira. Panorama da Aqüicultura, 11(64): 26-31.

Aron, W. I. and Smith, S. H. 1971. Ship canals and aquatic ecosystems. Science, 174 (4004): 13-20.

Barnes, D. K. A., 2002. Biodiversity: invasions by marine life on plastic debris. Nature, 416: 808-809.

Boschi, E. E., Fischbach, C. E. and Iorio, M. I. 1992. Catálogo ilustrado de los crrustáceos estomatópodos y decápodos marinos de Argentina. Frente Marítimo, Uruguay-Argentina, 10(A): 7-94.

Bourne, N. 1979. Pacific oysters, *Crassostrea gigas* Thunberg, in British Columbia and the South Pacific Islands. In Mann, R. (ed.), Exotic species in Mariculture. Massachusetts Institute of Technology Press, Cambridge, Massachusetts. pp. 1-53.

Carlton, J. T. 1975. Introduced intertidal invertebrates. In Smith, R. I. and Carlton, J. T. (eds),

Light's manual: intertidal invertebrates of the central California coast. University of California Press, Berkeley, California. pp. 17-25.

da Costa, P. F. 1978. Ostreicultura na região de Cabo Frio (RJ, Brasil). I. Aclimatação e crescimento da ostra do Pacífico *Crassostrea gigas* (Thunberg, 1793). V Simpósio Latino-Americano sobre Oceanografia Biológica, November 20-25, Instituto Oceanográfico da Universidade de São Paulo, SP, 1978. [Abstract.]

da Costa, P. F. 1983. Biologia e tecnologia para o cultivo de ostras. In Moreira da Silva, P. C. (ed.), Manual de Maricultura. Projeto Cabo Frio, Instituto de Pesquisas da Marinha Press, Rio de Janeiro. pp. 193-246.

da Costa, P. F., Martins, E. S. and Rodrigues, E. G. 1981. Brazil's first oyster hatchery. Fish Farming International, 8(3): 26.

Crooks, J. A. 2002. Characterizing ecosystem-level consequences of biological invasions: the role of ecosystem engineers. Oikos, 97: 153-166.

Davie, P. J. F. 2002. Crustacea: Malacostraca: Eucarida (Part 2) Decapoda - Anomura, Brachyura. In Wells, A. and Houston, W.W.K. (eds), Zoological Catalogue of Australia. Vol. 19.3B. CSIRO Publishing, Melbourne. 641 pp.

Forster, B. A. and Willan, R. C. 1979. Foreign barnacles transported to New Zealand on an oil platform. New Zealand Journal of Marine And Freshwater Research 13(1): 143-149.

Galil, B. 2001. Exotics in the Mediterranean. Bioindicators for a sea change. Biomare Newsletter, 1: 7-9.

Gruet, Y., Héral, M. and Robert, J.-M. 1976. Premières observations sur l'introduction de la faune associée au naissan d'huîtres japonaises *Crassostrea gigas* (Thunberg), importée sur la côte atlantique française. Cahiers de Biologie Marine, 17(2): 173-184.

Hanna, G. D. 1966. Introduced mollusks of the western North America. Occasional Papers of the California Academy of Sciences, 48: 1-108.

JSA, 1997. An evaluation of potential virus impacts on cultured shrimp and wild shrimp populations in the Gulf of Mexico and Southeastern U.S. Atlantic coastal waters. A report to the Joint Subcommittee on Aquaculture. Prepared by the JSA Shrimp Virus Work Group. National Marine Fisheries Service, U.S. Department of Commerce Animal and Plant Health Inspection Service, U.S. Department of Agriculture, National Center for Environmental Assessment, U.S. Environmental Protection Agency, Fish and Wildlife Service, U.S. Department of Interior, 65 pp.

Leung, B., Lodge, D. M., Finnof, D., Shogren, J. F., Lewis, M. and Lamberti, G. 2002. An ounce of prevention or a pound of cure: bioeconomic risk analysis of invasive species. Proceedings of the Royal Society of London, Series B Biological Sciences, 269: 2407-2413.

Mack, R.N., Simberloff, D., Mark Lonsdale, W., Evans, H., Clout, M. and Bazzaz, F. A. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications, 10 (3): 689-710.

Manzoni, G. C., Lugli, D. O. and Schmitt, J. F. 1998. Aspectos do crescimento e da biologia reprodutiva de *Crassostrea gigas* (Thunberg, 1795) cultivada na enseada da armação do Itapocoroy (26° 47'S-48° 36'W) (Penha-SC). Anais do Aquicultura Brasil 98. Vol. 2, November 2-6, Recife, 1998. [Abstract.]

Melrose, M. J. 1975. The Marine Fauna of New Zealand: Family Hymenosomatidae (Crustacea, Decapoda, Brachyura). New Zealand Oceanographic Institute Memoir, 34: 4-123.

Muniz, E. C., Jacob, S. A. and Helm, M. M. 1986. Condition index, meat yield and biochemical composition of *Crassostrea brasiliana* and *Crassostrea gigas* grown in Cabo Frio, Brazil. Aquaculture, 59: 235-250.

Orensanz, J. M. L., Schwindt, E., Pastorino, G., Bortolus, A., Casas, G., Darrigan, G., Elías, R., Gappa, J. J. L., Obenat, S., Pascual, M., Penchaszadeh, P., Piriz, M. L., Scarabino, F., Spivak, E. D. and Vallarino, E. A. 2002. No longer the pristine confines of the world ocean: a survey of exotic marine species in the southwestern Atlantic. Biological Invasions, 4: 115-143.

Perrings, C. 2002. Biological invasions in aquatic systems: the economic problem. Bulletin of Marine Science, 70 (2): 541-552.

Pimentel, D., Lach, L., Zuniga, R. and Morrison, D. 1999. Environmental and economic costs of nonindigenous species in the United States. Bioscience, 50: 53-65.

Por, F. D. 1978. Lesseptian migration – the influx of Red Sea biota into the Mediterranean by way of the Suez Canal. Ecological studies, 23: 1-238.

Por, F. D. 1990. Lesseptian migration. An appraisal and new data. Bulletin de l'Institut océanographique, Monaco, n° spécial 7: 1-10.

Proença, C. M. de, Avelar, J. C. and Oliveira Neto, F. M. (Orgs.) 2001. Plataforma do agronegócio da malacocultura. Conselho Nacional de Desenvolvimento Científico e Tecnológico. Brasília.

Quayle, D. B. 1964. Distribution of introduced marine molluscs in British Columbia waters. Journal of the Fisheries Research Board of Canada, 21(5): 1155-1181.

Retamal, M. A. 1981. Catalogo ilustrado de los crustaceos decapodos de Chile. Gayana (Zoologia), 44: 1-110.

Retamal, M. A. 1996. Los Decapodos de Chile. Editorial de la Facultad de Ciencias Biológicas, Universidad de Concepcion, Concepcion. Concepcion.

Ruiz, G. M., Rawlings, T. K., Dobbs, F. C., Drake, L. A., Mullady, T., Huq, A. and Colwell, R. R. 2000. Invasion biology: Global spread of microorganisms by ships. Nature, 408(6808): 49-50.

Sindermann, C. J. 1991. Case histories of effects of transfers and introductions on marine resources. Journal du Conséil international pour lÉxploration de la Mer, 47: 377-378.

Walne, P. R. and Helm, M. M. 1979. Introduction of *Crassostrea gigas* into the United Kingdom. In Mann, R. (ed.), Exotic species in Mariculture. Massachusetts Institute of Technology Press, Cambridge, Massachusetts. pp. 83-105.

Wasson, K., Zabin, C., Bedinger, L., Diaz, M. C. and Pearse, J. S. 2001. Biological invasions of estuaries without international shipping: the importance of intraregional transport. Biological Conservation 102: 143-153.

Wonham, M. J., Walton, W. C., Ruiz, G. M., Frese, A. M. and Galil, B. 2001. Going to the source: role of the invasion pathway in determining potential invaders. Marine Ecology Progress Series, 215: 1-12.

Zibrowius, H. 1978. Introduction du polychète Serpulidae japonais *Hydroides ezoensis* sur la côte atlantique française et remarques sur la répartion d'autres espèces de Serpulidae. Tethys, 8(2): 141-150.

Zibrowius, H. 1983. Extension de l'aires de répartition favorisée par l'homme chez les invertebrés marins. Oceanis, 9(4): 337-353.

Zibrowius, H. 1992. Ongoing modification of the Mediterranean marine fauna and flora by the establishment of exotic species. Mésogée, 51: 83-107.

Received: 20th Sep 2003
Accepted: 06th Oct 2003