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SPHAEROMATID ISOPODS FROM THE SWAN RIVER, WESTERN AUSTRALIA: DIVERSITY, DISTRIBUTION, AND GEOGRAPHIC SOURCES

BY

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ABSTRACT

Seven species of sphaeromatid isopod colonize the shallow littoral zone of the Swan River Estuary. Their distribution relates closely to the hydromorphology of the estuary and even reflects small scale interannual changes in salinity. The high diversity can partially be explained by the heterogeneous environment and the establishment of introduced species. Possible sources of the sphaeromatid fauna are discussed using the criteria of a test proposed by Chapman & Carlton (1994) to identify introductions.

ZUSAMMENFASSUNG

Sieben Sphaeromatidenarten besiedeln die Litoralzone des Swan-River Ästuars. Ihre Verteilung steht in so engem Zusammenhang mit den hydromorphologischen Besonderheiten dieses Systems, daß sie sogar geringe interannuale Salinitätsschwankungen widerspiegelt. Die hohe Artendiversität läßt sich teilweise auf heterogene Umweltbedingungen und auf eingeschleppte Fremdfauna zurückführen. Die Frage nach den Quellen der gefundenen Arten wird mit Hilfe eines von Chapman & Carlton (1994) vorgeschlagenen Tests erörtert.

INTRODUCTION

Isopods of the family Sphaeromatidae are cosmopolitan in their distribution. They inhabit a wide range of aquatic habitats, where their ability to tolerate changes in salinity as well as their resistance to desiccation give them the capacity to colonize unstable, physiologically demanding environments, such as estuaries.

Although five species of sphaeromatid isopod have been recorded, mostly from single sites, within the Swan River, Western Australia: *Sphaeroma quoyanum* H. Milne Edwards, 1840 by Serventy (1955), *Sphaeroma serratum* (Fabricius, 1787) by Holdich & Harrison (1983), *Paradella dianae* (Menzies, 1962) by Harrison & Holdich (1982), *Ptyosphaera alata* (Baker, 1926) by Baker (1926),

Syncassidina aestuaria Baker, 1928 by Baker (1928), their distribution within the estuary has not been documented in faunal surveys (Thompson, 1946; Riggert, 1978 for example). We found seven species of sphaeromatid, most of which appear to be year-long residents in the estuary, with one new to science.

This study records the distribution of sphaeromatids within estuaries of south-western Australia, particularly the Swan River Estuary, for the first time and contributes to the discussion of species diversity in estuaries and the sources of estuarine fauna.

MATERIALS AND METHODS

The Swan River was sampled between March 1994 and July 1995 and hard substrates from the Hardy, Harvey, Margaret River, and Vasse estuaries and Bunbury Harbour plus Leschenault Inlet were sampled on 7-8 December, 1995 (fig. 1). Sampling of the Swan River included 17 sites (fig. 3): selected sites were sampled weekly and all sites were sampled on at least one occasion in winter and one in summer. Hard substrates (rocks, empty barnacle tests, bivalve shells, dead wood) within the vertical range 20 cm below, to 10 cm above, mean high-tide level were examined carefully and collected sphaeromatids were preserved in a 3.6% formalin-seawater mixture. One female specimen of an unidentified species was collected from a sand core taken at 1.2 m water depth on the southern side of Pelican Point.

The Swan River estuary (fig. 3) comprises a broad basin upstream of the entrance channel. It experiences seasonal, rather than tidal, salinity changes (Spencer, 1956; Stephens & Imberger, 1996). In summer, marine salinities prevail throughout both the channel and basin sections. In winter, marine inputs are restricted to the channel, and surface water salinities in the basin decrease rapidly due to the riverine inputs (fig. 2). Consequently littoral fauna of the basin is exposed to two changes per year in salinity separated by two long periods of comparative stability, whereas the fauna of the channel experiences stable salinities in summer and potentially quite changeable salinities in winter depending upon the position along the channel.

RESULTS

We collected seven species of sphaeromatid within the 33 km stretch of the Swan River between sites 1 and 14 (fig. 3), between March 1994 and July 1995, five exclusively in the basin.

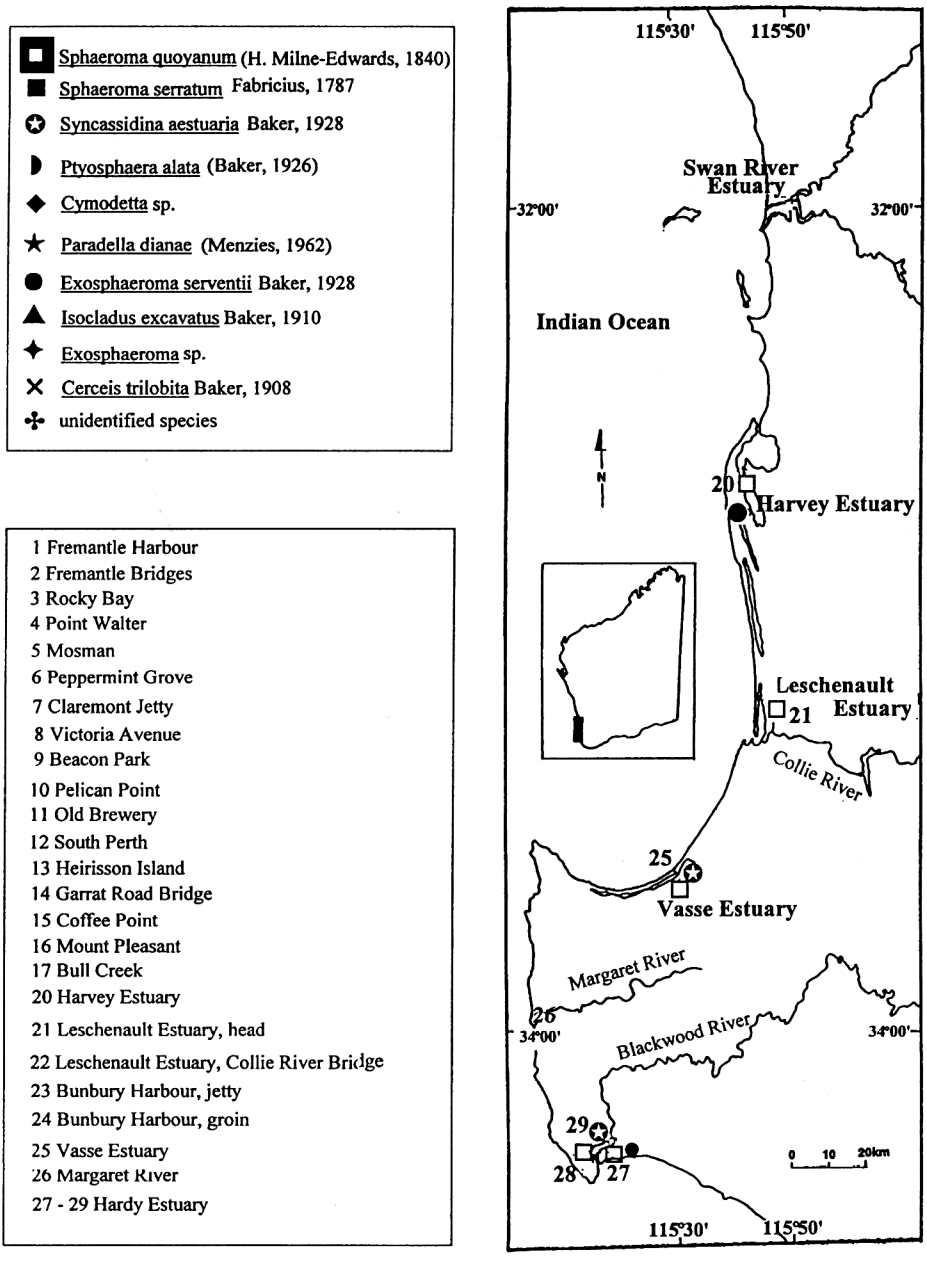

Fig. 1. Location of estuaries examined in south-west Western Australia with distribution of sphaeromatid isopods. Legend: top left, species collected; bottom left, sampling sites.

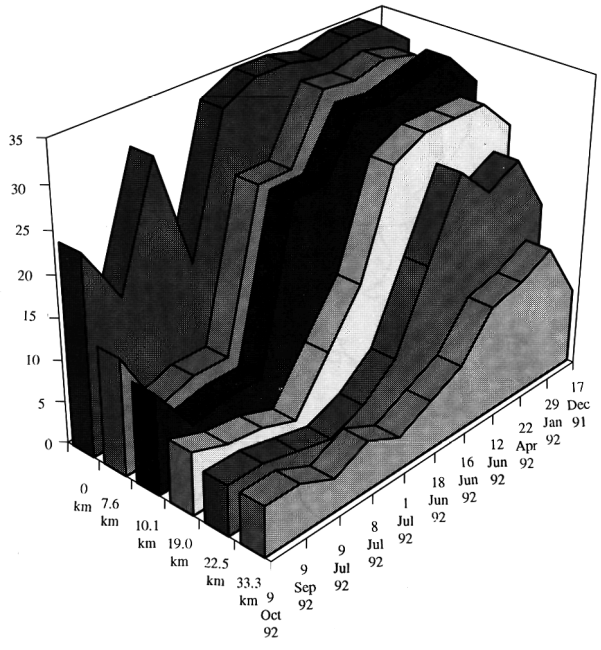

Fig. 2. Seasonal salinity changes in the Swan River Estuary for selected locations with increasing distance from the mouth (after Stephens & Imberger, 1996). *X*-axis, distance from the mouth; *Y*-axis, salinity; *Z*-axis, date.

Two species of *Sphaeroma* occur in the Swan River. *S. quoyanum* was found at salinities of 5 to 40 under stones, in crevices, empty barnacle tests and boring into wood substrates, such as old jetty piles where the uppermost specimens are subject to desiccation during periods of low tide. It commonly carried the commensal isopod *Iais singaporensis* Menzies & Barnard, 1951.

Sphaeroma serratum colonized the underside of rocks in shallow water at salinities of 20 to 35. Their distributions were not sympatric, with *S. serratum* being restricted to the channel and *S. quoyanum* to the the basin. In 1994, however, *S. serratum was* found at site 7 when the lowest salinity was 14, but was replaced there in 1995 (salinity 9) by *S. quoyanum*. *S. quoyanum*, but not *S. serratum*, occurred in the Harvey, Leschenault, Vasse, and Hardy estuaries (fig. 1). Neither species was found in Bunbury Harbour.

Paradella dianae occurred in Fremantle Harbour (site 2) among bivalves and rocks in shallow water at the head of Fremantle Harbour and associated with the introduced polychaete *Sabella spallanzanii* (Gmelin, 1791) in Bunbury Harbour (site 23). Water salinity was consistently 35.

Ptyosphaera alata, collected from water at salinities of 9 to 36, showed a patchy distribution within the Swan River. The biggest population occurred under

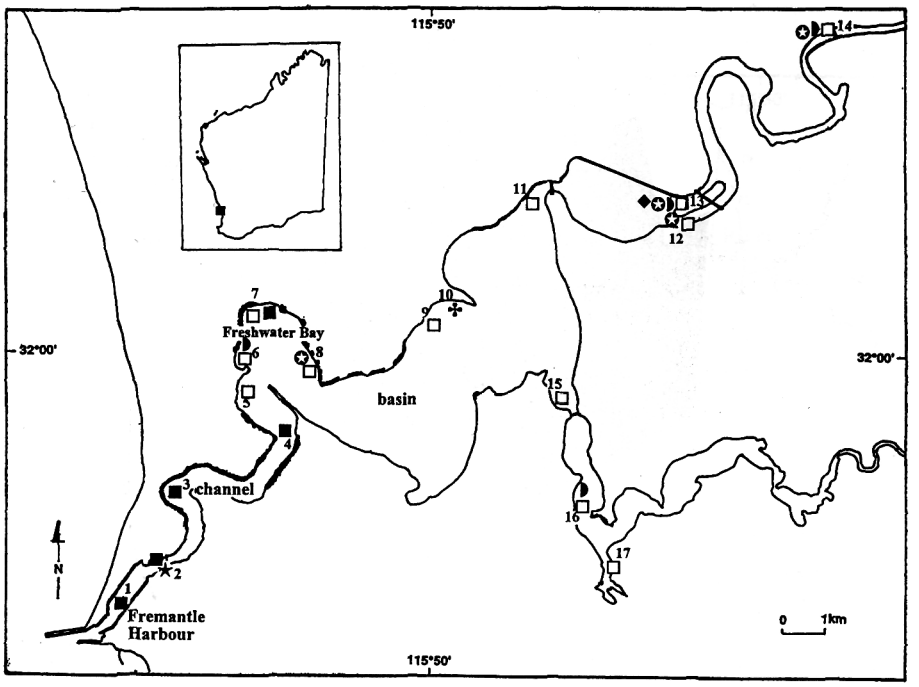

Fig. 3. Distribution of sphaeromatid isopods in the Swan River Estuary. Rocky shorelines are indicated by black markings. For legend, see fig. 1.

rocks of a retaining wall on the northern side of Heirisson Island (site 13) and single specimens were collected from rocks at sites 14 and 16 and from a barnacle colony on a jetty pile at site 6. It was absent from the five southern estuaries.

Syncassidina aestuaria was collected within the basin at sites 8, 12, 13 and 14 (fig. 3), being more common at lower salinities (12-20). Most specimens were found on submerged wood but some also colonized rocks. The species also occurred in the Leschenault, Vasse, and Hardy estuaries (sites 22, 25 and 29).

Cymodetta sp. was found in the Swan River exclusively at site 13 where it occurred sympatrically with *Sphaeroma quoyanum*, *P. alata*, and *Syncassidina aestuaria* and at site 22 in the Collie River.

The southern estuaries harboured a further four species. *Exosphaeroma serventii* Baker, 1928 was collected from rocks and wood at sites 28 and 29 in the Hardy estuary. The salinity at both locations was 22.

Sampling at Bunbury Harbour (fig. 4) yielded *Exosphaeroma* sp. and *Isocladus excavatus* Baker, 1910 found under rocks of a groyne and *Cerceis trilobita* Baker, 1908 occurring sympatrically with *P. dianae* among specimens of the fanworm *Sabella spallanzanii*.

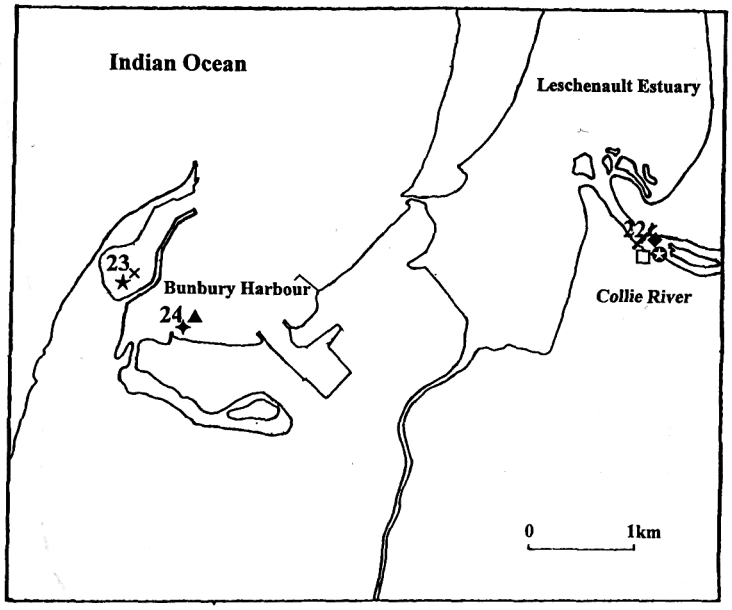

Fig. 4. Species distribution in Leschenault Estuary and Bunbury Harbour. For legend, see fig. 1.

DISCUSSION

The distribution of sphaeromatid isopods in the Swan River is clearly affected by the hydrological regime. This is most evident in the separation between *Sphaeroma serratum* and *Paradella dianae* in the channel and *S. quoyanum*, *Syncassidina aestuaria*, and *Ptyosphaera alata* in the basin. The restriction of *S. serratum* and *S. quoyanum* to the channel and the basin respectively particularly requires comment because the boundary between these two species is responsive to annual variations in the hydrological dynamics of the estuary: the distribution of *S. serratum* overlapped that of *S. quoyanum* at the channel/basin interface at Freshwater Bay (site 7) throughout the winter of 1994 (salinity: 12) but was replaced there by *S. quoyanum* in 1995 when the salinity dropped to 6. The current distribution of *S. serratum* and *S. quoyanum* may have developed in comparatively recent times because a sample taken from Fremantle Harbour (collection of the Western Australian Museum (WAM)) revealed that *S. quoyanum* occurred there in 1921. Since it tolerates salinities from 5 to 40 it consequently should be able to inhabit the entire estuary. It is therefore likely that *S. serratum*, which prefers near-seawater salinities (28-33.5; Nair et al., 1992), has replaced *S. quoyanum* from the channel in recent times.

Explanations for the distribution of the remaining species, particularly their patchy occurrence throughout the basin, cannot so easily be deduced. Habitat

preferences were evident for *Syncassidina aestuaria* (low salinity, wood substrates) but not for *Ptyosphaera alata* and *Cymodetta* sp. The patchiness of *P. alata*, *S. aestuaria*, and *Cymodetta* sp., particularly the concentration of *P. alata* and *Cymodetta* sp. along part of the northern shoreline of Heirisson Island, possibly indicates hydrological control generating a patchy resource distribution. Alternatively, the latter two species may be excluded from the main part of the basin by biologically stronger species, and they thrive on the Island in a narrow niche where the impact of other species is reduced. *P. dianae* seems to be a strictly marine species which is confined to the marine conditions of the harbour areas.

The results show that the highest diversity of sphaeromatid species occurs within the basin: a pattern contradicting general findings that the diversity of macrobenthic fauna is highest near the mouth and declines towards the head of the estuary (Kennish, 1990). It also differs from particular studies on the distribution of molluscs (Chalmer et al., 1976) and barnacles (Jones, 1987) in the Swan River Estuary. Attrill et al. (1996), however, have recently described another example of a peak in biodiversity in the region of a mid-estuary.

The diversity of sphaeromatid isopods in the Swan River Estuary is high: five species from the Milford Haven Estuary in South Wales (Harvey et al., 1973) and three species from a coastal lagoon in Central Italy (Gravina et al., 1989) constitute high values for Europe. Seven species have been found only in the Indian River Lagoon, Florida (Kensley et al., 1995). Explanations for faunal diversity within estuaries can be proposed in terms of: the numbers of potential colonizers in nearby habitats, environmental heterogeneity and introduced species.

If species diversity of an estuary is controlled by the species richness of the adjacent coastline, then estuaries in species-poor zones will harbour fewer species than those in species-rich zones. The Milford Haven Estuary, with five species, has the same species number as the adjacent coast (Harvey, 1969; Holdich, 1970). The Indian River Lagoon, in a transitional biogeographic zone, can recruit from two sources resulting in a higher species diversity. About fifteen species of sphaeromatid isopod occur in the intertidal to high subtidal zones of the coastline adjacent to the Swan River. The presence of seven species consequently is not surprising in terms of numbers alone but none of the species found in the Swan River occur along the adjacent coast, nor have any of the predominant coastal sphaeromatids such as *Isocladus excavatus*, *Exosphaeroma* sp., *Cerceis* sp. or *Cymodoce* sp. been recorded from the estuary. Of these coastal species, *I. excavatus*, *Exosphaeroma* sp., and *Cerceis trilobita* also occur in Bunbury Harbour.

Substrate diversity and the hydrological regime both contribute to the environmental heterogeneity of the Swan River. Numerous hard substrates are colonized by sphaeromatids, such as wood, rock and epifaunal growth.

Introductions within historical times may also account for the high number of sphaeromatid species in the Swan River. *Sphaeroma serratum* and *Paradella dianae* (the latter species is known from the Arabian and Mediterranean Seas, California, Florida, Puerto Rico, Brazil and the east coast of Australia) are widespread in harbours of the world, indicating extensive transfer between ports. Both species have been classified as introduced into the Swan River (Hutchings et al., 1987; Jones, 1992).

The sources of the remaining five species are difficult to determine. In order to solve this problem we apply the objective test suggested by Chapman & Carlton (1994) which offers a range of criteria to be evaluated. However, its application is difficult because there is no way for excluding the possibility of secondary translocations to smaller estuaries from the larger international shipping ports situated at Albany, Bunbury and Fremantle. Early samples of *Syncassidina aestuaria* (Denmark River) and *Sphaeroma quoyanum* (Kalgan River, Nornalup Inlet) in the WAM could indicate either original habitation or secondary translocation. *S. quoyanum* was the most widespread species in our study, and occurs in estuaries in eastern Australia, New Zealand (Marsden, 1982) and of western U.S.A. (Carlton & Iverson, 1981).

Introductions might occur by an association with a known introduction. *S. quoyanum* is frequently found in empty barnacle tests. Three fouling species of barnacle, *Balanus amphitrite*, *B. trigonus* and *B. variegatus*, occur in the Swan River (Jones, 1987). The global distribution of *S. quoyanum* may also indicate recent translocations but Rotramel (1972) considered that the likely direction was from Australia. Chapman & Carlton (1994) argued that discontinuous and local distribution indicates introduction. Concerning species occurring in nearby estuaries, *Ptyosphaera alata* of the five species is known in Western Australia exclusively from the Swan River. None of the five species are known to have mechanisms for long-distance, transoceanic dispersal. Dispersal occurs presumably by movement along the coastline. However, none have been recorded from hard substrates in marine environments. This does not preclude the possibility of species dispersing in pulses and it would be a matter of serendipity of detecting a pulse. Alternatively, dispersal of the estuarine species may have occurred in the past under different environmental conditions. If species are dependent on habitats and other resources which are presently provided by artificial or altered environments then this may indicate that these species have been introduced and could only establish themselves under those conditions. Although the shore-

line of the Swan River has altered markedly since the arrival of Europeans, what impact the changes might have had concerning the distribution of sphaeromatids within the estuary cannot be determined. Species preferring wooden substrates (*Sphaeroma quoyanum*, *Ptyosphaera alata*) possibly were able to colonize wooden piles in place of logs. *S. quoyanum* is the most successful species in adapting to the changing distribution and quality of hard substrates while the other species are much more patchy in their distribution now and this may indicate a lesser potential to exploit the resources presently available.

If *Sphaeroma quoyanum* is an introduced species, it may be possible to elucidate the geographic source by reference to its commensal, *Iais singaporensis*. This asellote has been recorded with the wood boring *Sphaeroma triste* Heller, 1865 from several locations (East Malaysia, Singapore, ? Philippines) north of Australia (Müller & Brusca, 1992). Since *S. quoyanum* has not previously been found associated with *I. singaporensis* but with *Iais californica* (Richardson, 1904) (Müller & Brusca, 1992) it is difficult to conclude that *S. quoyanum* has been introduced together with *I. singaporensis*. The real value for the argument concerning introductions of this association is further complicated by the fact that the asellotes from the Swan River are morphologically close but do not accord exactly with the morphology of the species description of *I. singaporensis*.

Consequently, the evidence to classify *Sphaeroma quoyanum* as native or introduced is ambiguous. This difficulty highlights the relevance of recording the global distribution of sphaeromatids. Genetic studies may help unravel the issue. *Ptyosphaera alata* (see Baker, 1926; Holdich & Harrison, 1983), *Syncassidina aestuaria* (see Holdich & Harrison, 1981) and closely related species of *Cymodetta* sp. (Bowman & Kühne, 1974; Holdich & Harrison, 1983) occur in estuaries of eastern Australia, from Queensland to Victoria. Distribution patterns of this kind have still to be explained.

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REFERENCES

ATTRILL, M. J., P. M. RAMSEY, R. M. THOMAS & M. W. TRETT, 1996. An estuarine biodiversity hot-spot. Journal of the Marine Biological Association of the United Kingdom, **76**: 161-175.

BAKER, W. H., 1926. Species of the isopod family Sphaeromidae from the eastern, southern and western coasts of Australia. Transactions of the Royal Society of South Australia, **50**: 247-277, pls. 1-16.

— —, 1928. Australian species of the isopod family Sphaeromidae. Transactions of the Royal Society of South Australia, **52**: 49-61, pls 1-6.

BOWMAN, T. E. & H. KÜHNE, 1974. *Cymodetta gambosa*, a new sphaeromatid isopod (Crustacea) from Australia, with notes on its mating behaviour. Records of the Australian Museum, **29**: 235-241.

CARLTON, J. T. & E. W. IVERSON, 1981. Biogeography and natural history of *Sphaeroma walkeri* Stebbing (Crustacea: Isopoda) and its introduction to San Diego Bay, California. Journal of Natural History, London, **15**: 31-48.

CHALMER, P. N., E. P. HODGIN & G. W. KENDRICK, 1976. Benthic faunal changes in a seasonal estuary of south-western Australia. Records of the Western Australian Museum, **4** (4): 383-409.

CHAPMAN, J. W. & J. T. CARLTON, 1994. Predicted discoveries of the introduced isopod *Synidotea laevidorsalis* (Miers, 1881). Journal of Crustacean Biology, **14**: 700-714.

GRAVINA, M. F., G. D. ARDIZZONE, F. SCALETTA & C. CHIMENZ, 1989. Descriptive analysis and classification of benthic communities in some Mediterranean coastal lagoons (Central Italy). Marine Ecology, **10**: 141-166.

HARRISON, K. & D. M. HOLDICH, 1982. Revision of the genera *Dynamenella*, *Ischyromene*, *Dynamenopsis* and *Cymodocella* (Crustacea: Isopoda), including a new genus and five new species of eubranchiate sphaeromatids from Queensland waters. Journal of Crustacean Biology, **2**: 84-19.

HARVEY, C. E., 1969. Breeding and distribution of *Sphaeroma* (Crustacea: Isopoda) in Britain. Journal of Animal Ecology, **38**: 399-406.

HARVEY, C. E., M. B. JONES & E. NAYLOR, 1973. Some factors affecting the distribution of estuarine isopods (Crustacea). Estuarine and Coastal Marine Science, **1**: 113-124.

HOLDICH, D. M., 1970. The distribution and habitat preferences of the Afro-European species of *Dynamene* (Crustacea: Isopoda). Journal of Natural History, London, **4**: 419-438.

HOLDICH, D. M. & K. HARRISON, 1981. Platybranch sphaeromatids (Crustacea: Isopoda) from the Australian region with a description of a new genus. Records of the Australian Museum, **33**: 617-643.

— — & — —,1983. Sphaeromatid isopods (Crustacea) from brackish waters in Queensland, Australia. Zoologica Scripta, **12**: 127-140.

HUTCHINGS, P. A., J. T. VAN DER VELDE & S. J. KEABLE, 1987. Guidelines for the conduct of surveys for detecting introductions of nonindigenous marine species by ballast water and other vectors — and a review of marine introductions to Australia. Occasional Reports of the Australian Museum, **3**: 27-54.

JONES, D. S., 1987. Preliminary investigations on the barnacles of the Swan-Canning Estuary. In: J. JOHN (ed.), The Swan River Estuary. Ecology and management: 153-163. (Curtin University Environmental Studies Group Report 1, Perth).

— —, 1992. A review of Australian fouling barnacles. Asian Marine Biology, **9**: 89-100.

KENNISH, M. J., 1990. Ecology of Estuaries, 2. Biological aspects: 241-245. (CRC Press Boca Raton, Florida).

KENSLEY, B., W. G. NELSON & M. SCHOTTE, 1995. Marine isopod diversity of the Indian River Lagoon, Florida. Bulletin of Marine Science, University Miami, **57**: 136-142.

MARSDEN, I. D., 1982. Population biology of the commensal asellotan *Iais pubescens* (Dana) and its sphaeromatid host *Exosphaeroma obtusum* (Dana) (Isopoda). Journal of Experimental Marine Biology and Ecology, **58**: 233-257.

MENZIES, R. J. & J. L. BARNARD, 1951. The isopodan genus *Iais* (Crustacea). Bulletin Southern California Academy of Sciences, **50** (3): 136-151.

MÜLLER, H.-G. & C. BRUSCA, 1992. Validation and redescription of *Iais singaporensis* Menzies & Barnard, 1951, a commensal with *Sphaeroma triste* Heller, 1865, from Malaysian coral reef. Zoologischer Anzeiger, **229** (1/2): 73-82.

NAIR, G. A., A. A. ALJETLAWI & H. H. KASSEM, 1992. Effects of salinity and temperature on the survival of *Sphaeroma serratum* Fabricius (Isopoda: Sphaeromatidae) in Benghazi, Libya. Tropical Ecology, **33**: 157-163.

RIGGERT, T. L. (ed.), 1978. The Swan River Estuary: development, management and preservation: 66. (Swan River Conservation Board).

ROTRAMEL, G., 1972. *Iais californica* and *Sphaeroma quoyanum*, two symbiotic isopods introduced to California (Isopoda, Janiridae and Sphaeromatidae). Crustaceana, (suppl.) **3**: 193-197.

SERVENTY, D. L., 1955. The fauna of the Swan River Estuary: 70-77. (Swan River Reference Committee, Report by the Subcommittee on Pollution of the Swan River).

SPENCER, R. S., 1956. Studies in Australian estuarine hydrology. II. The Swan River. Australian Journal of Marine and Freshwater Research, **7**: 193-253.

STEPHENS, R. & J. IMBERGER, 1996. Dynamics of the Swan River Estuary; the seasonal variability. Journal of Marine and Freshwater Research, **47**: 517-529.

THOMPSON, J. M., 1946. The fauna of the algal zone of the Swan River Estuary. A preliminary survey of Freshwater Bay with notes on the chief species. Journal of the Royal Society of Western Australia, **30**: 55-73.

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