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BRILL

LEIDEN—BOSTON—KÖLN
SPHAEROMATID ISOPODS FROM THE SWAN RIVER, WESTERN AUSTRALIA: DIVERSITY, DISTRIBUTION, AND GEOGRAPHIC SOURCES

BY

CHRISTINE G. HASS and BRENTON KNOTT
Department of Zoology, The University of Western Australia, Nedlands, Western Australia, 6907, Australia

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


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 diana (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 southwestern 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.
Sphaeroma quovanum (H. Milne-Edwards, 1840)
Sphaeroma serratum Fabricius, 1787
Syncassidina aestuaria Baker, 1928
Pyosphaera alata (Baker, 1926)
Cynodetta sp.
Paradella dianae (Menzies, 1962)
Exosphaeroma serventii Baker, 1928
Isocladus excavatus Baker, 1910
Exosphaeroma sp.
Cerceis trilobita Baker, 1908
unidentified species

1 Fremantle Harbour
2 Fremantle Bridges
3 Rocky Bay
4 Point Walter
5 Mosman
6 Peppermint Grove
7 Claremont Jetty
8 Victoria Avenue
9 Beacon Park
10 Pelican Point
11 Old Brewery
12 South Perth
13 Heirisson Island
14 Garrat Road Bridge
15 Coffee Point
16 Mount Pleasant
17 Bull Creek
20 Harvey Estuary
21 Leschenault Estuary, head
22 Leschenault Estuary, Collie River Bridge
23 Bunbury Harbour, jetty
24 Bunbury Harbour, groin
25 Vasse Estuary
26 Margaret River
27 - 29 Hardy Estuary

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.
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 singaporenensis* 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
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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 servantii* 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*. 
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 di-anae* (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 *Syn-cassidina aestuaria* (Denmark River) and *Sphaeroma quoyanum* (Kalgan River, Normalup 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, *lais 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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