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SYMPOSIUM

Australian Barnacles (Cirripedia: Thoracica), Distributions and Biogeographical Affinities

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From the symposium "Barnacle Biology: Essential Aspects and Contemporary Approaches" presented at the annual meeting of the Society for Integrative and Comparative Biology, January 3–7, 2012 at Charleston, South Carolina.

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Synopsis Currently, 279 barnacle species are recognized in Australia waters. The barnacle fauna of tropical Australia exhibits high species diversity (221), with a high incidence of tropical species (87 Indo-west Pacific [IWP], 16 West Pacific and 65 Indo-Malayan), a low species endemicity (8), and 44 cosmopolitan and 1 Australasian species. Conversely, that of temperate Australia shows lower species diversity (129), with a lower incidence of tropical species (26 IWP, 10 West Pacific and 25 Indo-Malayan), higher species endemicity (23), 37 cosmopolitan, 6 Australasian species, and 3 Australasian/Antarctic species. Distributions corroborate the general patterns demonstrated by the shallow-water biota of northern tropical and southern temperate Australian biogeographic provinces. Tropical and temperate provinces grade into each other in a broad overlap zone along both the western and eastern Australian coasts. This overlap zone is essentially a transitional region, with the gradual replacement of a tropical barnacle fauna in the north by a predominantly temperate barnacle fauna in the south. Both western and eastern Australian coasts are bounded by major poleward-flowing warm currents that have considerable influence on the marine flora and fauna, distributing tropical species of many taxa much farther south than could be predicted by latitude. Currently, 16 barnacle species introduced into Australian waters are identified, although this number may increase in the future due to new port developments and increased shipping arrivals.

Introduction

The island continent of Australia, lying between 9–44°S and 112–154°E, has a vast coastline of ~34,218 km. Bounded by the Indian, Pacific and Southern oceans on its western, eastern, and southern margins, and the Arafura and Timor seas on its northern margin, its complex biogeographical positioning has resulted in diverse terrestrial and marine faunas.

First collections of barnacles in Australia were made during early French expeditions of discovery (Bonnemains and Jones 1990) but Darwin's monographs (1852, 1854) initiated the documentation of the barnacles of temperate Australia. During the late 19th and early 20th centuries, various expeditions added to the knowledge of this fauna (e.g., Hoek 1883, 1907, 1913; Krüger 1914; Broch 1916, 1922, 1931). Pioneering studies by Pope (e.g., 1943, 1945, 1958, 1965) increased knowledge of cirripede distributions in eastern Australia, and since the mid 1980s, comprehensive field collecting throughout Australian waters by Jones greatly augmented documentation of the barnacle fauna (e.g., Jones 1987, 1990a, 1990b, 1991, 1992a, 1992b, 1992c, 1993, 1994, 1998, 2003, 2004, 2010; Jones et al. 1990; Jones and Hewitt 1995, 1996, 1997; Jones and Berry 2000).

Two hundred and seventy-nine barnacle species are known in Australian waters. This article discusses the distributions and biogeographic affinities of the barnacles of the tropical and temperate waters of Australia. Abbreviations are as follows: WA (Western Australia), SA (South Australia), Tas. (Tasmania), Vic. (Victoria), NSW (New South Wales), Qld (Queensland), and NT (Northern Territory).

Marine biogeographical zonation of Australia

Currents

Four oceanic and coastal currents in the Australasian region are significant in shaping the climate and marine environmental conditions of Australia, namely, the Indonesian Throughflow, the Leeuwin Current, the East Australian Current (EAC), and the Antarctic Circumpolar Current (Fig. 1).

The Indonesian Throughflow is a series of currents that carry water westward from the Pacific Ocean to the Indian Ocean through the straits and deep passages of the Indonesian Archipelago. This warm tropical water influences the character of the Leeuwin Current, a poleward flowing, eastern boundary current off the western and southern coasts of Australia, which is the world's longest coastal current (>5000 km) (Cresswell and Golding 1980). It originates near the North West Shelf on Australia's northwestern coast and is a broad body, ~50 km wide and 200 m deep, of warm, relatively low salinity water flowing along the outer edge of the continental shelf (Godfrey and Ridgeway 1985). The Leeuwin Current is mostly quiescent in the austral summer (November–February) but flows to the south intensify in autumn (March), are strongest in late autumn/early winter (April–June), and disappear in September–October (Feng et al. 2003). In the autumn/early winter, the Leeuwin Current accelerates, rounds Cape Leeuwin (34°27′S 116°22′E) in southwestern WA, and continues as an eastward shelf current, the South Australian Current, along the southern coast of Australia (Ridgeway and Condie 2004; Middleton and Bye 2007). As the Leeuwin Current travels poleward, it breaks into a series of southward and eastward flowing eddies (Feng et al. 2005), eventually dissipating in the Tasman Sea and Southern Ocean.

The Leeuwin Current disperses tropical representatives of many taxa (e.g., asteroids, holothurians, tuna, and tropical reef fishes) to the southwestern and southern coasts of Australia, farther south than could be predicted by latitude (Maxwell and Cresswell 1981; Hutchins and Pearce 1994). It is very different from the other Southern-Hemisphere eastern-boundary currents, the Humboldt Current of South America, and the Benguela Current of South Africa, which are northward flowing, cool, and associated with upwelling. The Leeuwin Current roughly parallels the EAC, which brings warm waters southward to ~33°S (Newcastle, NSW) before diverting as eddies into the Tasman Sea.

The EAC is a complex western boundary system in the southwestern Pacific off eastern Australia (Ridgeway and Dunn 2003; Ridgeway and Hill 2009). It flows southward from ~25°S (near Fraser Island, Qld) and begins to dissipate beyond 33°S, with remnants continuing to drift south. It provides both the western boundary of the South Pacific Gyre and the linking element between the Pacific and Indian Ocean gyres (Speich et al. 2002). The EAC is strongest in the austral summer (November–February). It is weaker than other western boundary

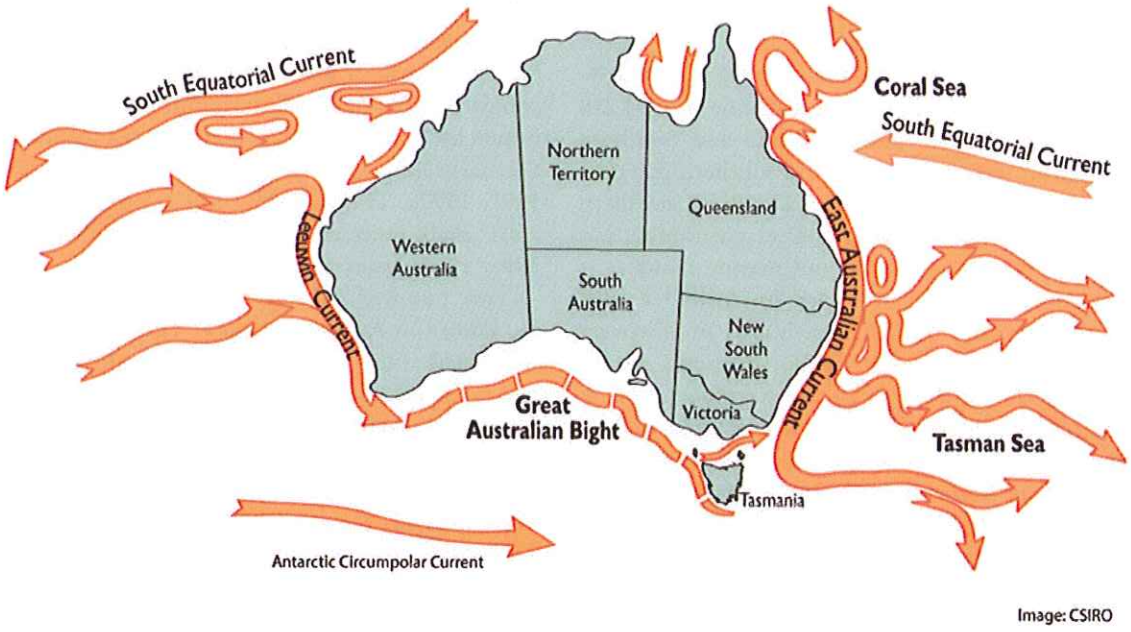

Fig. 1 Oceanic and coastal currents of Australia

currents and a series of mesoscale eddies dominate, producing highly variable patterns of strength and direction of currents (Bowen et al. 2005; Mata et al. 2007). Long-term data indicate that the EAC has strengthened and extended further southward over the past 60 years, so that tropical waters from the Coral Sea region are forced further south, warming the Tasman Sea (Ridgeway 2007). Evidence from biological sources indicates southward range extensions of biota (Edgar et al. 1997; Pittock 2003; Thresher et al. 2003; Ling et al. 2008), which have been attributed to enhanced flow (Edyvane 2003). Thus, Australia is unique among continents in that both the western and eastern coasts are bounded by major poleward-flowing warm currents that have considerable influence on marine flora and fauna (Richardson and Poloczanska 2009).

The Antarctic Circumpolar Current is the dominant feature of the Southern Ocean. It connects the Atlantic, Pacific, and Indian Oceans in an eastward flow, allowing water, heat, salt, and other properties to flow from one to the other and is considered the powerhouse of the global climate (www.csiro.au/Outcomes/Climate/Australasian Ocean Currents). It is confined by land between Tasmania and Antarctic and this region features high oceanic nutrient production.

Australian biogeographic provinces

In Australia, the Tropic of Capricorn lies at 23°26′22″S, with latitudes to the south in the southern zone and those to the north in the tropics (Fig. 2). A northern tropical and a southern temperate biogeographic province are recognized, which overlap extensively on both western and eastern coasts (Wilson and Allen 1987; O'Hara and Poore 2000; Poore 2001, 2004; Poore and O'Hara 2007; Poore et al. 2008; Waters 2010).

The northern tropical province has a tropical marine biota that is continuous with other parts of the IWP. It exhibits high species diversity, a high incidence of tropical species and low endemicity at the species level (Wells 1980; Wilson and Allen 1987). Conversely, the southern temperate province has lower species diversity and harbors much higher numbers of endemic species, due to their long history of geographic isolation from other temperate regions over geological time. For example, approximately 95% of molluscan species, 90% of echinoderm species, and 85% of fish species are unique to these southern waters Australia (Poore 2001). This high endemism is also apparent in Australia's temperate macroalgae (Phillips 2001).

In general, species diversity decreases with increasing latitude but there are no major distributional boundaries. On the western coast, most IWP tropical species extend to North West Cape, WA (21°47′S), and some as far south as the Houtman Abrolhos Islands (28°19′-29°57′S), and on the eastern coast approximately to Point Vernon, Qld (25°14′ 53 S, 152° 49′E) (Jones 2003, 2010). However, the importance of the major currents in structuring marine communities can be seen in the biogeographic distributions of many species, functional groups, and

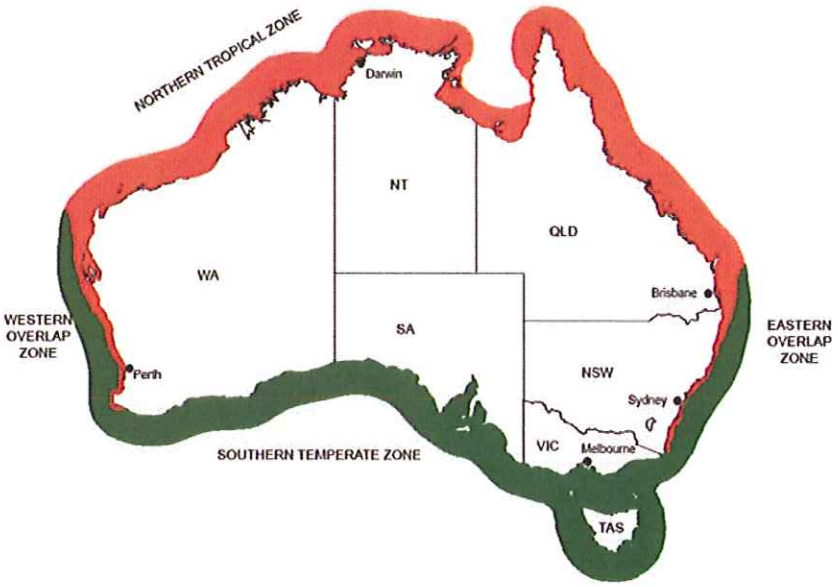

Fig. 2 Northern tropical and southern temperate biogeographic provinces of Australia

communities. For example, tropical species can occur much farther south at latitudes inhabited by wholly temperate species due to the effects of the Leeuwin and the East Australian currents (Maxwell and Cresswell 1981; Morgan and Wells 1991; Dunlop and Wooller 1986; O'Hara and Poore 2000; Edyvane 2003; Griffiths 2003).

Distributions and biogeographic affinities of barnacles in Australian waters

Currently, 279 barnacle species are known in Australian waters (Table 1). Fifty-four are cosmopolitan (C) species, 92 have IWP affinities and 21 West Pacific (WP), and 76 Indo-Malayan (IM) affinities. Six species are Australasian (AA), occurring in Australia and New Zealand waters, and two are Southern Ocean species (SAA), occurring in Australia, New Zealand, and Antarctica. Twenty-eight species are endemic (AE) to Australian waters (Tables 2 and 3).

Northern Australian tropical province

The tropical barnacle fauna is continuous with other parts of the IWP region and exhibits the high species diversity, high incidence of tropical species, and low species endemicity pattern. It consists of 221 species, 44 of which are C species. Eighty-seven have IWP affinities and 16 have WP and 65 IM affinities. One species has AA affinities and eight are AE species (Tables 2 and 3).

A dominant IWP faunistic element in the northern Australian tropical province also has been documented in other groups, e.g., Thalassinidea, Anomura, and Brachyura (78%) (Morgan 1990); Penaeidae (Dall 1957; Racek 1959); Portunidae (Stephenson 1972); Stomatopoda (Stephenson and McNeil 1955); Echinodermata (77%) (Marsh and Marshall 1983); Mollusca (71%) (Wells 1980); fishes (Blaber et al. 1985); and marine algae (Womersley 1960). Similarly, a low AE element has been documented in brachyuran and anomuran decapods (17–22%) (Griffin and Yaldwyn 1967; Morgan 1990; Morgan and Wells 1991); echinoderms (13%) (Marsh 1976; Marsh and Marshall 1983); molluscs (10%) (Wilson and Allen 1987); corals (0%) (Wilson and Allen 1987; Veron and Marsh 1988), and fishes (13%) (Wilson and Allen 1987).

Currently, there are no specific field data regarding the barnacle faunas of the remote tropical northern and northeastern coasts of Australia, where collecting is logistically extremely difficult. Field data from north-western Australia indicate 101 species in 40 genera within 15 families, including 26 C,

Table 1 Barnacles (Cirripedia: Thoracica) of Australian waters

Subclass CIRRIPEDIA Burmeister, 1834
Superorder THORACICA Darwin, 1854
Order Ibliformes Buckeridge and Newman, 2006
Suborder Iblomorpha Newman, 1987
Family Iblidae Leach, 1825
Genus *Ibla* Leach, 1825
Ibla cumingi Darwin, 1852
Ibla quadrivalvis Cuvier, 1817
Family Idioiblidae Buckeridge and Newman, 2006
Subfamily Idioiblinae Buckeridge and Newman, 2006
Genus *Idioibla* Buckeridge and Newman, 2006
Idioibla pygmaea Broch, 1922
Subfamily Chaetolepadinae Buckeridge and Newman, 2006
Genus *Chaetolepas* Stüder, 1889
Chaetolepas calcitergum Buckeridge and Newman, 2006
Order Lepadiformes Buckeridge and Newman, 2006
Suborder Heteralepdomorpha Newman, 1987
Family Heteralepadidae Nilsson-Cantell, 1921
Genus *Heteralepas* Pilsbry, 1907
Heteralepas adiposa Zevina, 1982
Heteralepas cornuta (Darwin, 1852)
Heteralepas dubia Broch, 1922
Heteralepas japonica (Aurivillius, 1892)
Heteralepas utinomii Newman, 1960
Genus *Paralepas* Pilsbry, 1907
Paralepas dannevigi (Broch, 1922)
Paralepas georgei Daniel, 1970
Paralepas intermedia (Hoek, 1907)
Paralepas minuta (Phillipi, 1836)
Paralepas morula (Hoek, 1907)
Paralepas palinuri urea Newman, 1960
Paralepas pedunculata (Hoek, 1883)
Paralepas quadrata (Aurivillius, 1894)
Paralepas scyllarusi Utinomi, 1967a
Paralepas tuberosa (Nilsson-Cantell, 1932)
Family Malacolepadidae Hiro, 1933
Genus *Arcalepas* Jones and Morton, 2009
Arcalepas brucei Jones and Morton, 2009
Suborder Lepadomorpha Pilsbry, 1916
Family Oxynaspididae Gruvel, 1905
Genus *Oxynaspis* Darwin, 1852
Oxynaspis celata Darwin, 1852 [includes *Oxynaspis indica* Annandale, 1910]
Family Poecilasmatidae Annandale, 1910
Genus *Poecilasma* Darwin, 1852
Poecilasma dubium Hoek, 1907

(continued)

Table 1 Continued

Poecilasma kaempferi Darwin, 1852
Genus *Glyptelasma* Pilsbry, 1907
Glyptelasma carinatum (Hoek, 1883)
Glyptelasma gigas (Annandale, 1916)
Glyptelasma gracile (Hoek, 1883)
Glyptelasma hamatum Calman, 1919
Glyptelasma orientale Calman, 1919
Glyptelasma pilsbryi Calman, 1919
Glyptelasma rectum (Pilsbry, 1907)
Genus *Megalasma* Hoek, 1883
Megalasma minus (Annandale, 1906)
Megalasma striatum Hoek, 1883
Genus *Temnaspis* Fischer, 1884
Temnaspis amygdalum (Aurivillius, 1894)
Temnaspis bathynomi (Annandale, 1906)
Temnaspis excavatum (Hoek, 1907)
Temnaspis fissum (Darwin, 1852)
Temnaspis kilepoae Zevina, 1968
Temnaspis tridens (Aurivillius, 1894)
Temnaspis tridens asymmetrica Broch, 1947
Genus *Octolasmis* Gray, 1825
Octolasmis angulata (Aurivillius, 1894: 22) [includes *O. aperta* Aurivillius, 1894: 24]
Octolasmis aymonini (Lessona and Tapparone-Canefri, 1874)
Octolasmis cf *bullata* (Aurivillius, 1892)
Octolasmis clubii Daniel, 1953
Octolasmis cor (Aurivillius, 1892)
Octolasmis geryonophila geryonophila Pilsbry, 1907
Octolasmis hawaiense Pilsbry, 1907
Octolasmis hoeki (Stebbing, 1894)
Octolasmis indubia Newman, 1961
Octolasmis lowei (Darwin, 1852)
Octolasmis neptuni neptuni (MacDonald, 1869)
Octolasmis nierstraszi (Hoek, 1907)
Octolasmis scuticosta Hiro, 1939
Octolasmis warwickii Gray, 1825 (includes *Dichelaspis equina* Lanchester, 1902)
Octolasmis weberi (Hoek, 1907)
Genus *Dichelaspis* Darwin, 1852
Dichelaspis orthogonia Darwin, 1852
Genus *Trilasmis* Hinds, 1844
Trilasmis eburnea Hinds, 1844
Family Lepadidae Darwin, 1852
Genus *Lepas* Linnaeus, 1758
Subgenus *Nonfurcata* Memmi, 1980
Lepas Nonfurcata nonfurcata (Nilsson-Cantell, 1927)

(continued)

Table 1 Continued

Subgenus *Anatifa* Bruguière, 1789
Lepas Anatifa anatifera anatifera Linnaeus, 1758
Lepas Anatifa anatifera dentata Linnaeus, 1758
Lepas Anatifa anatifera striata de Graef, 1952
Lepas Anatifa anserifera Linnaeus, 1767
Lepas Anatifa australis Darwin, 1852
Lepas Anatifa hillii (Leach, 1818)
Lepas Anatifa indica Annandale, 1910
Lepas Anatifa pectinata Spengler, 1793
Lepas Anatifa testudinata Aurivillius, 1892
Genus *Dosima* Gray, 1825
Dosima fascicularis Ellis and Solander, 1786
Genus *Conchoderma* Olfers, 1814
Conchoderma auritum (Linnaeus, 1767)
Conchoderma chelonophilum (Leach, 1818)
Conchoderma hunteri (Owen, 1830)
Conchoderma virgatum (Spengler, 1790)
Genus *Alepas* Sander-Rang, 1829
Alepas pacifica Pilsbry, 1907
Order Scalpelliformes Buckeridge and Newman, 2006
Suborder Scalpellomorpha Newman, 1987
Family Calanticidae Zevina, 1978
Genus *Calantica* Gray, 1825
Calantica affinis Broch, 1922
Calantica darwini Jones and Hosie, 2009
Calantica studeri (Weltner, 1922)
Calantica trispinosa (Hoek, 1883)
Genus *Crosnieriella* Jones, 1998
Crosnieriella acanthosubcarinae Jones, 1998
Genus *Scillaelepas* Seguenza, 1876
Scillaelepas cf *fosteri* Newman, 1980 (see Buckeridge, 1999: 528)
Genus *Smilium* Gray, 1825
Smilium nudipes (Annandale, 1916)
Smilium peronii Gray, 1825
Smilium sinense (Annandale, 1910)
Smilium zancleanum (Withers, 1953)
Family Lithotryidae Gruvel, 1905
Genus *Lithotrya* Sowerby, 1822
Lithotrya dorsalis (Ellis, 1786)
Lithotrya nicobarica Reinhardt, 1850
Lithotrya valentiana (Gray, 1825)
Family Scalpellidae Pilsbry, 1907
Subfamily Scalpellinae Pilsbry, 1907
Genus *Scalpellum* Leach, 1817
Scalpellum inerme Annandale, 1905

(continued)

Table 1 Continued

Scalpellum stearnsii Pilsbry, 1890
Subfamily Meroscalpellinae Zevina, 1978
Genus *Litoscalpellum* Newman and Ross, 1971
Litoscalpellum giganteum (Gruvel, 1902)
Litoscalpellum intermedium (Hoek, 1883)
Litoscalpellum juddi (Calman, 1918)
Litoscalpellum nipponense (Pilsbry, 1907)
Genus *Alcockianum* Zevina, 1978
Alcockianum alcockianum (Annandale, 1906)
Alcockianum persona (Annandale, 1916)
Genus *Gymnoscalpellum* Newman and Ross, 1971
Gymnoscalpellum tarasovi Newman and Ross, 1971
Genus *Annandaleum* Newman and Ross, 1971
Annandaleum laccadivicum (Annandale, 1906)
Annandaleum lambda (Annandale, 1910)
Subfamily Arcoscalpellinae Zevina, 1978
Genus *Arcoscalpellum* Hoek, 1907
Arcoscalpellum dubium (Hoek, 1883)
Arcoscalpellum gryllum Zevina, 1981
Arcoscalpellum inum Zevina, 1981
Arcoscalpellum mendelevii Zevina, 1981
Arcoscalpellum pertosum Foster, 1978
Arcoscalpellum sociabile (Annandale, 1905)
Arcoscalpellum truncatum (Hoek, 1883)
Genus *Planoscalpellum* Zevina, 1978
Planoscalpellum planum (Hoek, 1883)
Genus *Weltnerium* Zevina, 1978
Weltnerium poculum (Hoek, 1907)
Genus *Verum* Zevina, 1978
Verum australicum (Hoek, 1883)
Verum candidum (Hoek, 1907)
Verum novaezelandiae (Hoek, 1883)
Verum proclive (Hoek, 1907)
Verum virgatum (Hoek, 1907)
Genus *Anguloscalpellum* Zevina, 1978
Anguloscalpellum pedunculatum (Hoek, 1883)
Genus *Amigdoscalpellum* Zevina, 1978
Amigdoscalpellum costellatum (Withers, 1935)
Amigdoscalpellum daschae Zevina, 1981
Amigdoscalpellum elegans (Hoek, 1907)
Amigdoscalpellum torbenbenwolffi Zevina, 1981
Amigdoscalpellum vitreum (Hoek, 1883)
Genus *Trianguloscalpellum* Zevina, 1978
Trianguloscalpellum annandalei (Calman, 1918)
Trianguloscalpellum hamulus (Hoek, 1907)

(continued)

Table 1 Continued

Trianguloscalpellum hirsutum (Hoek, 1883)
Trianguloscalpellum michelottianum (Seguenza, 1876)
Trianguloscalpellum moluccanum (Hoek, 1883)
Trianguloscalpellum regium regium (Hoek, 1883)
Trianguloscalpellum rubrum (Hoek, 1883)
Genus *Teloscalpellum* Zevina, 1978
Teloscalpellum ecaudatum (Calman, 1918)
Teloscalpellum gracile (Hoek, 1907)
Teloscalpellum latisculum (Newman and Ross, 1971)
Order Sessilia Lamarck, 1818
Suborder Verrucomorpha Pilsbry, 1916
Family Verrucidae Darwin, 1854
Genus *Altiverruca* Pilsbry, 1916
Altiverruca gibbosa (Hoek, 1883)
Altiverruca navicula (Hoek, 1913)
Costatoverruca Young, 1998
Costatoverruca pacifica (Buckeridge, 1994)
Cristallinaverruca Young, 1998
Cristallinaverruca cristallina (Gruvel, 1907)
Genus *Metaverruca* Pilsbry, 1916
Metaverruca halotheca (Pilsbry, 1907) [includes *M. recta* (Aurivillius, 1898)]
Metaverruca sculpta (Aurivillius, 1898)
Newmaniverruca Young, 1998
Newmaniverruca albatrossiana (Pilsbry, 1912)
Genus *Rostratoverruca* Broch, 1922
Rostratoverruca intexta (Pilsbry, 1912) [includes *Altiverruca conchula* (Hoek, 1913)]
Suborder Balanomorpha Pilsbry, 1916
Superfamily Pachylasmatoidea Utinomi, 1968
Family Pachylasmatidae Utinomi, 1968
Subfamily Bathylasmatinae Newman and Ross, 1976
Genus *Bathylasma* Newman and Ross, 1971
Bathylasma alearum (Foster, 1978)
Genus *Tetrachaelasma* Newman and Ross, 1971
Tetrachaelasma tasmanicum Buckeridge, 1999
Subfamily Hexelasmatinae Newman and Ross, 1976
Hexelasma Hoek, 1913
Hexelasma arafurae Hoek, 1913
Hexelasma nolearia Foster, 1978
Subfamily Pachylasmatinae Utinomi, 1968
Genus *Eutomolasma* Jones, 2000
Eutomolasma chinense (Pilsbry, 1912)
Eutomolasma japonicum (Hiro, 1933)
Eutomolasma maclaughlinae Jones, 2000
Genus *Pachylasma* Darwin, 1854

(continued)

Table 1 Continued

Pachylasma scutistriata Broch, 1922
Genus *Tetrapachylasma* Foster, 1988
Tetrapachylasma aurantiacum (Darwin, 1854)
Tetrapachylasma ferrugomaculosa Jones, 1993
Superfamily Chthamaloidea Darwin, 1854
Family Catophragmidae Utinomi, 1968
Genus *Catomerus* Pilsbry, 1916
Catomerus polymerus (Darwin, 1854)
Family Chthamalidae Darwin, 1854
Subfamily Notochthamalinae Foster and Newman, 1987
Genus *Chamaesipho* Darwin, 1854
Chamaesipho tasmanica Foster and Anderson, 1986
Nesochthamalus Foster and Newman, 1987
Nesochthamalus intertextus (Darwin, 1854)
Genus *Octomeris* Sowerby, 1825
Octomeris brunnea Darwin, 1854
Octomeris intermedia Nilsson-Cantell, 1921
Subfamily Euraphiinae Newman and Ross, 1976
Genus *Caudoeuraphia* Poltarukha, 1997
Caudoeuraphia caudata (Pilsbry, 1916)
Genus *Euraphia* Conrad, 1837
Euraphia hembeli Conrad, 1837
Microeuraphia Poltarukha, 1997
Microeuraphia withersi (Pilsbry, 1916)
Subfamily Chthamalinae Darwin, 1854
Genus *Chthamalus* Ranzani, 1817
Chthamalus antennatus Darwin, 1854
Chthamalus malayensis Pilsbry, 1916
Superfamily Coronuloidea Leach, 1817
Family Chelonibiidae Pilsbry, 1916
Subfamily Chelonibiinae Pilsbry, 1916
Genus *Chelonibia* Leach, 1817
Chelonibia caretta (Spengler, 1790)
Chelonibia patula (Ranzani, 1818)
Chelonibia testudinaria (Linnaeus, 1758)
Family Platylepadidae Newman and Ross, 1976
Genus *Platylepas* Gray, 1825
Platylepas coriacea Monroe and Limpus, 1979
Platylepas decorata Darwin, 1854
Platylepas hexastylos (Fabricius, 1798)
Platylepas ophiophilius Lanchester, 1902
Genus *Stomatolepas* Pilsbry, 1910
Stomatolepas dermochelys Monroe and Limpus, 1979
Stomatolepas elegans (Costa, 1838)
Stomatolepas praegustator Pilsbry, 1910
Stomatolepas transversa Nilsson-Cantell, 1930
Genus *Cylindrolepas* Pilsbry, 1916
Cylindrolepas darwiniana Pilsbry, 1916
Genus *Stephanolepas* Fischer, 1886
Stephanolepas muricata Fischer, 1886
Family Coronulidae Leach, 1817
Genus *Coronula* Lamarck, 1802
Coronula diadema (Linnaeus, 1767)
Coronula reginae (Darwin, 1854)
Genus *Cetopirus* Ranzani, 1817
Cetopirus complanatus (Mörch, 1852)
Chelolepas Ross and Frick, 2007
Chelolepas cheloniae (Monroe and Limpus, 1979)
Genus *Tubicinella* Lamarck, 1802
Tubicinella major Lamarck, 1802
Genus *Xenobalanus* Steenstrup, 1852
Xenobalanus globicipitus Steenstrup, 1852
Superfamily Tetraclitoidea Gruvel, 1903
Family Tetraclitidae Gruvel, 1903
Subfamily Austrobalaninae Newman and Ross, 1976
Genus *Austrobalanus* Pilsbry, 1916
Austrobalanus imperator (Darwin, 1854)
Genus *Epopella* Ross, 1970
Epopella simplex (Darwin, 1854)
Subfamily Tetraclitellinae Newman and Ross, 1976
Genus *Tetraclitella* Hiro, 1939
Tetraclitella costata (Darwin, 1854)
Tetraclitella divisa (Nilsson-Cantell, 1921)
Tetraclitella multicostata (Nilsson-Cantell, 1930)
Tetraclitella pilsbryi Utinomi, 1962
Tetraclitella purpurascens (Wood, 1815)
Subfamily Newmanellinae Ross and Perreault, 1999
Genus *Yamaguchiella* Ross and Perreault, 1999
Subgenus *Yamaguchiella* Ross and Perreault, 1999
Yamaguchiella Yamaguchiella coerulescens (Spengler, 1790)
Subgenus *Neonrosella* Jones, 2010
Yamaguchiella Neonrosella vitiata (Darwin, 1854)
Subfamily Tetraclitinae Gruvel, 1903
Genus *Tesseropora* Pilsbry, 1916
Tesseropora rapax Jones, 1993
Tesseropora rosea (Krauss, 1848)
Tesseropora wireni (Nilsson-Cantell, 1921)
Genus *Tetraclita* Schumacher, 1817
Tetraclita squamosa (Bruguière, 1789)
Superfamily Balanoidea Leach, 1817

(continued)

Table 1 Continued

Family Archaeobalanidae Newman and Ross, 1976
Subfamily Archaeobalaninae Newman and Ross, 1976
Genus *Armatobalanus* Hoek, 1913
Armatobalanus allium (Darwin, 1854)
Armatobalanus arcuatum Hoek, 1913
Armatobalanus cepa (Darwin, 1854)
Armatobalanus filigranus (Broch, 1916)
Armatobalanus quadrivittatus (Darwin, 1854)
Armatobalanus quinquivittatus (Hoek, 1913)
Armatobalanus terebratus (Darwin, 1854)
Genus *Striatobalanus* Hoek, 1913
Striatobalanus amaryllis (Darwin, 1854)
Striatobalanus bimae (Hoek, 1913)
Striatobalanu krugeri (Pilsbry, 1916)
Striatobalanus tenuis (Hoek, 1883)
Genus *Solidobalanus* Hoek, 1913
Solidobalanus auricoma (Hoek, 1913)
Solidobalanus ciliatus (Hoek, 1913)
Solidobalanus compressus (Hoek, 1913)
Solidobalanus socialis (Hoek, 1883)
Solidobalanus solidus (Broch, 1931)
Genus *Membranobalanus* Hoek, 1913
Membranobalanus cuneiformis (Hiro, 1936)
Genus *Conopea* Say, 1822
Conopea calceolus (Ellis, 1758)
Conopea cymbiformis (Darwin, 1854)
Conopea dentifer (Broch, 1922)
Conopea mjobergi (Broch, 1916)
Conopea navicula (Darwin, 1854)
Subfamily Acastinae Kolbasov, 1993
Genus *Archiacasta* Kolbasov, 1993
Archiacasta spinitergum (Broch, 1931)
Genus *Neoacasta* Kolbasov, 1993
Neoacasta glans (Lamarck, 1818)
Neocasta laevigata (Gray, 1825)
Genus *Euacasta* Kolbasov, 1993
Euacasta antipathidus (Broch, 1916)
Euacasta dofleini (Krüger, 1911)
Euacasta porata (Nilsson-Cantell, 1921)
Euacasta zuiho (Hiro, 1936)
Genus *Acasta* Leach, 1817
Acasta conica Hoek, 1913
Acasta cyathus Darwin, 1854
Acasta echinata Hiro, 1937a
Acasta fenestrata Darwin, 1854
Acasta hirsuta Broch, 1916

(continued)

Table 1 Continued

Acasta idiopoma Pilsbry, 1912
Acasta japonica Pilsbry, 1911
Acasta purpurata Darwin, 1854
Acasta spongites (Poli, 1795)
Acasta sulcata Lamarck, 1818 [includes *Acasta serrata* Hiro, 1937b]
Genus *Pectinoacasta* Kolbasov, 1993
Pectinoacasta pectinipes (Pilsbry, 1912)
Subfamily Elminiinae Foster, 1982
Genus *Hexaminius* Foster, 1982
Hexaminius foliorum Anderson et al., 1988
Hexaminius popeiana Foster, 1982
Austrominius Buckeridge, 1983
Austrominius adelaidae (Bayliss, 1988)
Austrominius covertus (Foster, 1982)
Austrominius erubescens (Bayliss, 1994)
Austrominius flindersi (Bayliss, 1994)
Austrominius modestus (Darwin, 1854)
Austrominius placidus (Bayliss, 1994)
Family Pyrgomatidae Gray, 1825
Subfamily Pyrgomatinae Gray, 1825
Tribe Hoekiini Ross and Newman, 1995
Genus *Australhoekia* Ross and Newman, 1995
Australhoekia cardenae Ross and Newman, 2000
Tribe Pyrgomatini Ross and Newman, 1995
Genus *Cantellius* Ross and Newman, 1973
Cantellius acutum (Hiro, 1938)
Cantellius euspinulosum (Broch, 1931)
Cantellius gregarious (Sowerby, 1823)
Cantellius iwayama (Hiro, 1938)
Cantellius pallidus (Broch, 1931)
Cantellius secundus (Broch, 1931)
Cantellius septimus (Hiro, 1938)
Cantellius sumbawae Hoek, 1913
Cantellius tredecimus (Kolosváry, 1947)
Genus *Creusia* Leach, 1817
Creusia spinulosa Leach, 1818
Genus *Galkinia* Ross and Newman, 1995
Galkinia indica (Annandale, 1924)
Genus *Hiroa* Ross and Newman, 1973
Hiroa stubbingsi Ross and Newman, 1973
Genus *Darwiniella* Anderson, 1992
Darwiniella conjugatum (Darwin, 1854)
Genus *Nobia* Sowerby, 1823
Nobia grandis Sowerby, 1839
Genus *Arossella* Anderson, 1993
Arossella projectum (Nilsson-Cantell, 1938)

(continued)

Table 1 Continued

Genus *Pyrgoma* Leach, 1817
Pyrgoma cancellata Leach, 1818
Genus *Savignium* Leach, 1825
Savignium crenatum (Sowerby, 1823)
Genus *Trevathana* Anderson, 1992
Trevathana dentatum (Darwin, 1854)
Genus *Wanella* Anderson, 1993
Wanella andersonorum Ross, 1999
Wanella milleporae (Darwin, 1854)
Subfamily Megatrematinae Holthuis, 1982
Tribe Pyrgominini Ross and Pitombo, 2002
Genus *Pyrgomina* Ross and Pitombo, 2002
Pyrgomina djanae Ross and Pitombo, 2002
Family Balanidae Leach, 1817
Subfamily Amphibalaninae Pitombo, 2004
Genus *Amphibalanus* Pitombo, 2004
Amphibalanus amphitrite (Darwin, 1854)
Amphibalanus cirratus (Darwin, 1854)
Amphibalanus improvisus (Darwin, 1854)
Amphibalanus littoralis (Ren and Liu, 1978)
Amphibalanus poecilotheca (Krüger, 1911)
Amphibalanus reticulatus Utinomi, 1967b
Amphibalanus variegatus Darwin, 1854
Amphibalanus zhujiangensis (Ren, 1989)
Subfamily Balaninae Leach, 1817
Genus *Balanus* Da Costa, 1778
Balanus trigonus Darwin, 1854
Genus *Fistulobalanus* Zullo, 1984
Fistulobalanus albicostatus (Pilsbry, 1916)
Fistulobalanus pallidus (Darwin, 1854)
Subfamily Megabalaninae Newman, 1979
Genus *Austromegabalanus* Newman, 1979
Austromegabalanus nigrescens (Lamarck, 1818)
Genus *Megabalanus* Hoek, 1913
Megabalanus ajax (Darwin, 1854)
Megabalanus coccopoma (Darwin, 1854)
Megabalanus concinnus (Darwin, 1854)
Megabalanus occator (Darwin, 1854)
Megabalanus rosa (Pilsbry, 1916)
Megabalanus tintinnabulum (Linnaeus, 1758)
Megabalanus validus (Darwin, 1854)
Megabalanus volcano (Pilsbry, 1916)
Megabalanus zebra (Darwin, 1854)
Genus *Notomegabalanus* Newman, 1979
Notomegabalanus algicola (Pilsbry, 1916)
Notomegabalanus krakatauensis (Nilsson-Cantell, 1934)

45 IWP and 25 IM species, and 6 AE species (Jones 2003).

More specifically, the fauna of the vast and poorly studied Kimberley region of WA (13°44′S-18°00′S, 126°47′E-122°15′ E) contains 56 shallow-water species in 22 genera within eight families presently documented (Jones 1992a; Jones and Hewitt 1997), including 2 C, 46 IWP, 7 IM, and 1 AE species (Jones 2003). At the Dampier Archipelago (20°20′S–20°45′S, 116°24′E-117°05′E), 49 species in 24 genera within 11 families, including 10 C, 27 IWP, and 8 IM species, and 4 AE species are recorded (Jones 2003, 2004). In the North West Cape area, 44 species in 20 genera within 11 families have been documented from the Montebello Islands (20°27′S 115°31′E), the Muiron Islands (21.66°S 114.32°E) and the eastern shores of Exmouth Gulf (21° 55′S 114°23′E) (Jones and Hewitt 1996; Jones and Berry 2000), including 4 C, 38 IWP, and 2 IM species, no AE species being recorded (Jones 2003, 2004).

Tetraclita squamosa (Bruguière 1789) and *Caudoeuraphia caudata* (Pilsbry 1916) are examples of tropical barnacles commonly occurring in the littoral across the northern Australian tropical province. *Tetraclita squamosa* extends from Red Bluff, Kalbarri, WA (27°54′S 114°26′E), across the NT to Point Vernon, Qld (25°14′ 53 S, 152° 49′E) (Jones 1992a, 2004, 2010). Similarly, *C. caudata* extends from the Dampier Archipelago, WA (20°20′S 116°24′E), to Point Vernon (Jones 2004, 2010). Examples of tropical endemic species are *Calantica darwini* Jones and Hosie (2009) collected north of Port Hedland, WA (18°30′S 118°36E to 18°31′S 118°37′E, depth 196 km) and *Crosnieriella acanthosubcarinae* (Jones 1998) from northeastern Qld (22°27′S 152°15′E, depth 175m) (Jones 1998; Jones and Hosie 2009).

Southern Australian temperate province

The southern Australian temperate barnacle fauna exhibits lower species diversity, a low incidence of tropical species, and high endemicity of species. It comprises 129 species, of which 37 are C and 26 have IWP, 10 have WP, and 25 have IM affinities. Six species have AA and 2 have SAA affinities, and 23 are AE (Tables 2 and 3).

In south-western Australia, 44 barnacle species in 24 genera and 12 families have been recorded (Jones 1990b, 2003), with 21 being C, and 10 I with WP and 3 with IM affinities. Seven are AE species and three have AA affinities. At Albany (35°02′S 117°54′E), of 31 species documented, three are

Table 2 Biogeographic affinities of Australian barnacles

Genus	Species	Biogeograpic affinities						
		C	IWP	WP	IM	AE	AA	SAA
Ibla	*cumingi*		IWP					
	quadrivalvis					AE		
Idioibla	*pygmaea*					AE		
Chaetolepas	*calcitergum*					AE		
Heteralepas	*adiposa*			WP				
	cornuta	C						
	dubia						AA	
	japonica		IWP					
	utinomi					AE		
Paralepas	*dannevigi*				IM			
	georgei					AE		
	intermedia				IM			
	minuta	C						
	morula				IM			
	palinuri urae			WP				
	pedunculata			WP				
	quadrata				IM			
	scyllarusi			WP				
	tuberosa			WP				
Arcalepas	*brucei*					AE		
Oxynaspis	*celata*	C						
Poecilasma	*dubium*		IWP					
	kaempferi	C						
Glyptelasma	*carinatum*	C						
	gigas				IM			
	gracile				IM			
	hamatum	C						
	orientale				IM			
	pilsbryi	C						
	rectum	C						
Megalasma	*minus*	C						
	striatum		IWP					
Temnaspis	*amygdalum*		IWP					
	bathynomi				IM			
	excavatum		IWP					
	fissum		IWP					
	kilepoae		IWP					
	tridens	C						
	tridens asymmetrica				IM			
Octolasmis	*angulata*		IWP					
	aymonini				IM			
	cf bullata				IM			
	clubii				IM			
	cor		IWP					
	geryonophila geryonophila	C						
	hawaiense			WP				
	hoeki	C						

(continued)

Table 2 Continued

Genus	Species	Biogeograpic affinities						
		C	IWP	WP	IM	AE	AA	SAA
	indubia		IWP					
	lowei	C						
	neptuni neptuni		IWP					
	nierstraszi		IWP					
	scuticosta				IM			
	warwickii		IWP					
	weberi		IWP					
Dichelaspis	*orthogonia*		IWP					
Trilasmis	*eburnea*		IWP					
Lepas (Nonfurcata)	*nonfurcata*		IWP					
Lepas (Anatifa)	*anatifera anatifera*	C						
	anatifera dentata	C						
	anatifera striata	C						
	anserifera	C						
	australis	C						
	hillii	C						
	Indica		IWP					
	pectinata	C						
	testudinata	C						
Dosima	*fascicularis*	C						
Conchoderma	*auritum*	C						
	chelonophilum	C						
	hunteri		IWP					
	virgatum	C						
Alepas	*pacifica*		IWP					
Calantica	*affinis*				IM			
	darwini					AE		
	studeri				IM			
	trispinosa				IM			
Crosnieriella	*acanthosubcarinae*					AE		
Scillaelepas	*cf fosteri*			WP				
Smilium	*nudipes*				IM			
	peronii				IM			
	sinense				IM			
	zancleanum				IM			
Lithotrya	*dorsalis*	C						
	nicobarica		IWP					
	valentiana		IWP					
Scalpellum	*inerme*				IM			
	stearnsii		IWP					
Litoscalpellum	*giganteum*	C						
	intermedium			WP				
	juddi				IM			
	nipponense			WP				
Alcockianum	*alcockianum*		IWP					
	persona				IM			
Gymnoscalpellum	*tarasovi*							SAA

(continued)

Table 2 Continued

Genus	Species	Biogeographic affinities C	IWP	WP	IM	AE	AA	SAA
Annandaleum	*laccadivicum*		IWP					
	lambda		IWP					
Arcoscalpellum	*dubium*			WP				
	gryllum					AE		
	inum					AE		
	mendeleevi					AE		
	pertosum				IM			
	sociabile		IWP					
	truncatum				IM			
Planoscalpellum	*planum*				IM			
Weltnerium	*poculum*				IM			
Verum	*australicum*				IM			
	candidum				IM			
	novaezelandiae		IWP					
	proclive				IM			
	virgatum				IM			
Anguloscalpellum	*pedunculatum*			WP				
Amigdoscalpellum	*costellatum*	C						
	daschae			WP				
	elegans		IWP					
	torbenwolffi			WP				
	vitreum		IWP					
Triangloscalpellum	*annandalei*		IWP					
	hamulus				IM			
	hirsutum				IM			
	michelottianum	C						
	moluccanum				IM			
	regium regium	C						
	rubrum				IM			
Teloscalpellum	*ecaudatum*				IM			
	gracile				IM			SAA
	latisculum							
Altiverruca	*gibbosa*	C						
	navicula		IWP					
Costatoverruca	*pacifica*		IWP					
Cristallinaverruca	*cristallina*		IWP					
Metaverruca	*halotheca*		IWP					
	sculpta		IWP					
Newmaniverruca	*albatrossiana*		IWP					
Rostratoverruca	*intexta*		IWP					
Bathylasma	*alearum*			WP				
Tetrachaelasma	*tasmanicum*			WP				
Hexelasma	*arafurae*				IM			
	nolearia						AA	
Eutomolasma	*chinense*				IM			
	japonicum			WP				
	maclaughlinae		IWP					
Pachylasma	*scutistriata*		IWP					

(continued)

Table 2 Continued

Genus	Species	Biogeographic affinities C	IWP	WP	IM	AE	AA	SAA
Tetrapachylasma	*aurantiacum*			WP				
	ferrugomaculosa					AE		
Catomerus	*polymerus*					AE		
Chamaesipho	*tasmanica*					AE		
Nesochthamalus	*intertextus*		IWP					
Octomeris	*brunnea*		IWP					
	intermedia				IM			
Caudoeuraphia	*caudata*				IM			
Euraphia	*hembeli*		IWP					
Microeuraphia	*withersi*		IWP					
Chthamalus	*antennatus*					AE		
	malayensis		IWP					
Chelonibia	*caretta*	C						
	patula	C						
	testudinaria	C						
Platylepas	*coriacea*		IWP					
	decorata		IWP					
	hexastylos	C						
	ophiophilius		IWP					
Stomatolepas	*dermochelys*	C						
	elegans	C						
	praegustator	C						
	transversa				IM			
Cylindrolepas	*darwiniana*	C						
Stephanolepas	*muricata*				IM			
Coronula	*diadema*	C						
	reginae	C						
Cetopirus	*complanatus*	C						
Chelolepas	*cheloniae*				IM			
Tubicinella	*major*	C						
Xenobalanus	*globicipitus*	C						
Austrobalanus	*imperator*					AE		
Epopella	*simplex*					AE		
Tetraclitella	*costata*				IM			
	divisa				IM			
	multicostata				IM			
	pilsbryi[a]				IM			
	purpurascens						AA	
Yamaguchiella	*coerulescens*		IWP					
	vitiate		IWP					
Tesseropora	*rapax*					AE		
	rosea						AA	
	wireni				IM			
Tetraclita	*squamosa*		IWP					
Armatobalanus	*allium*		IWP					
	arcuatum				IM			
	cepa		IWP					
	filigranus		IWP					

(continued)

Table 2 Continued

Genus	Species	Biogeographic affinities						
		C	IWP	WP	IM	AE	AA	SAA
	quadrivittatus		IWP					
	quinquivittatus				IM			
	terebratus		IWP					
Striatobalanus	*amaryllis*		IWP					
	bimae				IM			
	krugeri[a]				IM			
	tenuis		IWP					
Solidobalanus	*auricoma*	C						
	ciliatus		IWP					
	compressus				IM			
	socialis		IWP					
	solidus				IM			
Membranobalanus	*cuneiformis*				IM			
Conopea	*calceolus*	C						
	cymbiformis		IWP					
	dentifer		IWP					
	mjobergi		IWP					
	navicula		IWP					
Archiacasta	*spinitergum*				IM			
Neocasta	*glans*		IWP					
	laevigata		IWP					
Euacasta	*antipathidus*					AE		
	dofleini				IM			
	porata				IM			
	zuiho				IM			
Acasta	*conica*				IM			
	cyathus	C						
	echinata				IM			
	fenestrata		IWP					
	hirsuta				IM			
	idiopoma				IM			
	japonica				IM			
	purpurata				IM			
	spongites	C						
	sulcata		IWP					
Pectinoacasta	*pectinipes*		IWP					
Hexaminius	*foliorum*					AE		
	popeiana					AE		
Austrominius	*adelaidae*					AE		
	covertus					AE		
	erubescens					AE		
	flindersi					AE		
	modestus						AA	
	placidus					AE		
Australhoekia	*cardenae*			WP				
Cantellius	*acutum*			WP				
	euspinulosum		IWP					
	gregarius				IM			

(continued)

Table 2 Continued

Genus	Species	Biogeographic affinities						
		C	IWP	WP	IM	AE	AA	SAA
	iwayama			WP				
	pallidus		IWP					
	secundus		IWP					
	septimus		IWP					
	sumbawae				IM			
	tredecimus		IWP					
Creusia	*spinulosa*		IWP					
Galkinia	*indica*		IWP					
Hiroa	*stubbingsi*			WP				
Darwinella	*conjugatum*		IWP					
Nobia	*grandis*		IWP					
Arossella	*projectum*				IM			
Pyrgoma	*cancellata*		IWP					
Savignium	*crenatum*		IWP					
Trevathana	*dentatum*		IWP					
Wanella	*andersonorum*		IWP					
	milleporae		IWP					
Pyrgominini	*djanae*					AE		
Amphibalanus	*amphitrite*	C						
	cirratus		IWP					
	improvisus[a]	C						
	littoralis[a]				IM			
	poecilotheca[a]		IWP					
	reticulatus[a]				IM			
	variegatus						AA	
	zhujiangensis[a]				IM			
Balanus	*trigonus*	C						
Fistulobalanus	*albicostatus*[a]		IWP					
	pallidus	C						
Austromegabalanus	*nigrescens*					AE		
Megabalanus	*ajax*		IWP					
	coccopoma[a]	C						
	concinnus[a]		IWP					
	occator[a]		IWP					
	rosa[a]				IM			
	tintinnabulum	C						
	validus				IM			
	volcano[a]				IM			
	zebra[a]		IWP					
Notomegabalanus	*algicola*[a]		IIWP					
	krakatauensis[a]				IA			
TOTAL	**279**	**54**	**92**	**21**	**76**	**28**	**6**	**2**

Notes: C, cosmopolitan species; IWP, Indo-west Pacific species (extending from eastern Africa to Hawaii); WP, West Pacific species (extending from eastern Australia to Hawaii); IM, Indo/Malayan species (extending from the eastern Indian Ocean, Indo-Malayan Archipelago, Australia and New Guinea, to Japan); AE, Australian endemic species (only occurring in Australia); AA, Australasian species (occurring in Australian and New Zealand); SAA, Australasian/Antarctic species (occurring in Australia, New Zealand and Antarctica).

[a]Introduced species.

Table 3 Biogeographic affinities of barnacles of northern, southern, western, and eastern Australia

	Species numbers	C	IWP	WP	IM	AE	AA	SAA
Australia	279	54	92	21	76	28	6	22
N. Australia	221	44	87	16	65	8	1	0
S. Australia	129	37	26	10	25	23	6	2
W. Australia	189	41	73	4	56	12	3	0
E. Australia	205	47	62	20	47	21	6	2

Notes: C, cosmopolitan species; IWP, Indo-west Pacific species (extending from eastern Africa to Hawaii); WP, West Pacific species (extending from eastern Australia to Hawaii); IM, Indo/Malayan species (extending from the eastern Indian Ocean, Indo-Malayan Archipelago, Australia and New Guinea, to Japan); AE, Australian endemic species (only occurring in Australia); AA, Australasian species (occurring in Australia and New Zealand); SAA, Australasian/Antarctic species (occurring in Australia, New Zealand and Antarctica).

tropical IWP and six AE (Jones 1990b, 2003). A higher endemic element has been documented in other groups, e.g., decapods (77%) (Morgan and Jones 1991); stomatopods (Stephenson and McNeill 1955); molluscs (95%) (Wells 1980; Wilson and Allen 1987); echinoderms (90%) (Clark 1946; Rowe and Vail 1982), and fishes (85%) (Wilson and Allen 1987).

IWP species representation in the southern Australian temperate province decreases from west to east while most temperate species occurring along the southern coast of WA reach as far west as 34°27′S (Morgan and Jones 1991). Currently, there are no comparable field data regarding the shallow-water barnacle faunas occurring along remote temperate southern and southeastern coasts of Australia as, again, collecting is logistically extremely difficult.

Austrobalanus nigrescens (Lamarck 1818), *Catomerus polymerus* (Darwin 1854), and *Chthamalus antennatus* (Darwin 1854) are examples of barnacle species endemic to southern Australian waters. *Austrobalanus nigrescens* occurs from Kalbarri, WA (27°42′S 114°10′E), across southern Australia and northward to Double Island Point, Qld (25°56′S 153°11′E); *Chthamalus antennatus* from Eucla, WA (31°41′S 128°53′E), to Cooee Bay, Qld (23°08′S 150°45′E); and *Catomerus polymerus* from the Eyre Peninsula, SA (34.05°S 135.04°E), to Ballina Headland, NSW (28°52′S 153°36′E) (Jones1990b, 2010).

The overlap zones

The western and eastern coasts of Australia harbor diverse, distinct barnacle faunas. The western barnacle fauna comprises 189 species, of which 41 have C, 73 have IWP, 4 have WP and 56 have IM affinities. Twelve species are AE and three have AA affinities (Tables 2 and 3); that of the eastern coast of Australia is composed of 205 species, of which 47 are C, 62 have IWP, 20 have WP, and 47 have IM affinities. Twenty-one species are AE, six have AA, and two SAA affinities (Tables 2 and 3).

In the western and eastern overlap zones, numbers of tropical species diminish with increasing latitude (Wilson and Allen 1987). In the western overlap zone, the percentage of IWP barnacle species at Shark Bay (25°56′S 113°32′ E) reduces from 55% to 15% at Rottnest Island (32°00′S 115°30′E) (Jones 1990a, 1993; Jones and Hewitt 1995). Similarly, a reduction in the IWP element is documented in other groups, e.g., 74% of the decapod fauna at Shark Bay (Jones 1990c) and 39% of the marine crustacean fauna of Rottnest Island (Jones and Morgan 1993) are tropical IWP species.

A recognizable endemic component occurs in the western overlap zone, but the proportion of endemics varies between marine groups, e.g., 18% of the Shark Bay decapod fauna (Jones 1990c) and 48% of the marine crustacean fauna of Rottnest Island (Jones and Morgan 1993) are endemic, but less than 10% of prosobranch molluscs (Wells 1980) and 20% of shallow-water asteroids (Marsh 1976) are endemic. At Shark Bay (Jones 1990a; Jones and Hewitt 1995) and Rottnest Island (Jones 1993), 22% and 23% of the barnacle species, respectively, are endemic. Most of these endemic species have at least part of their range in the western overlap zone and often achieve their greatest numbers there (Wells 1980; Wilson and Allen 1987).

Paralepas georgei (Daniel 1970), *Tesseropora rapax* (Jones 1993), and *Tetrapachylasma ferrugomaculosa* (Jones 1993) are examples of barnacle species endemic to the western overlap zone. *Paralepas georgei* attaches to the gills of the Western Rock Lobster, *Panulirus cygnus*, which itself is endemic to the western coast of WA. *Tesseropora rapax* and *T. ferrugomaculosa* have limited distributions at Rottnest Island and along the mid-western coast.

The Leeuwin Current extends the southern latitudinal distributional limits of various marine taxa down the western coast. The Houtman Abrolhos Islands (28°19′–29°57′S) are generally considered to be the southern-most limit of the tropical marine biota (Wells 1980; Wilson and Allen 1987). Coral reefs are richly developed and marine faunas occurring there are essentially tropical (Montgomery 1931; Wilson and Marsh 1979; Wells 1980; Marsh and Marshall 1983; Veron and Marsh 1988).

At Rottnest Island, *Pocillopora damicornis* (Linnaeus 1758) forms one of the most southerly developments of reefs in the world and its associated symbiotic decapod crustacean fauna is similar to that found in many other tropical localities across the IWP (Black and Prince 1983). A substantial proportion of other marine faunas at Rottnest Island, including zoanthids, echinoids, gastropods, and fishes, are of tropical origin (Hodgkin et al. 1959; Black and Johnson 1983; Hutchins 1994; Wells 1980).

When shallow-water and deep-water barnacles are considered, of the 73 species of IWP barnacles known to occur on the northern and western coasts of WA, 10 reach Cape Leeuwin (34°27′S 116°22′E) and 6 extend onto the southern Australian coast (35°S) (Jones 1990b, 1990c, 1992a, 1993, 2003, 2004; Jones and Hewitt 1995, 1996, 1997; Jones et al. 1990; Jones and Berry 2000). Similar trends can be demonstrated in other groups; of 308 tropical prosobranch gastropod species, 9 reach Cape Leeuwin and 5 extend onto the southern coast (Wells 1980); of 318 hermatypic corals, 25 reach as far south as Rottnest Island and 9 occur on the southern coast (Veron and Marsh 1988); certain tropical echinoderm species extend into the Great Australian Bight (Maxwell and Cresswell 1981).

On the eastern Australian coast, south-eastern Queensland represents a transitional area between the tropical and southern temperate provinces and this is reflected in the composition of the barnacle fauna. Seventy-three barnacle species are recorded, with 22 C, 25 IWP, 9 IM, and 2 WP species (Jones 1992c, 2010). Three species have AA affinities and 12 are AE species. These figures demonstrate the influence of the tropical northern fauna and the 12 endemics reflecting the southern influence in this transitional zone.

The tropical chthamalids, *C. caudata* (Pilsbry 1916) and *Microeuraphia withersi* (Pilsbry 1916), extend from Point Vernon (25°14′S 152° 49′E) northward across the NT and to the Dampier Archipelago, WA (20°20′S 116°24′E), with *Chthamalus malayensis* (Pilsbry 1916) further extending to Shark Bay (25°56′S 113°32′ E) (Jones 1990a, 2003, 2004, 2010). Conversely, their southern counterpart, the endemic *Chthamalus antennatus* (Darwin 1854) extends from Cooee Bay (23°08′S 150°45′E) southward then westward to Eucla, WA (31°41′S 128°53′E) (Jones 2010). A similar pattern can be demonstrated for the tropical tetraclitid, *Tetraclita squamosa* (Bruguière 1789), from Point Vernon to Red Bluff, Kalbarri, WA (27°54′S 114°26′E), while the southern *Tetraclitella purpurescens* (Wood 1815) and *Tesseropora rosea* (Krauss 1848) extend from Double Island Point (25°56′S 153°11′E) and Bustard Heads (24°01′S 151°46′ E) southward then westward to Red Bluff, Kalbarri, WA, and Cottesloe, WA (31°59′S 115° 45′E), respectively (Jones 1990b, 2004, 2010). The northern tropical iblomorph, *Ibla cumingi* (Darwin 1852), occurs from Point Vernon northward, across the NT to Burnside Island, Exmouth Gulf, WA (22°06′S 114°30.80′E), while its southern temperate counterpart, *Ibla quadrivalvis* (Cuvier 1817), extends from Currumbin (28°08′S 153°29′E) to Bunbury, WA (33°19′S 115°39′E) (Jones 1990b, 2010). The endemic malacolepadid, *Arcalepas brucei* (Jones and Morton 2009), is only known from Moreton Bay, Qld (27°28′00″S, 153°28′00″E) (Jones and Morton 2009).

Introduced species

Records of introduced barnacles in Australian waters are not numerous. Pertinent literature documenting fouling and introduced Australian barnacle species was reviewed by Jones (1992b). Subsequent publications have documented introductions (Hass and Jones 1999; Jones 2003, 2004; Huisman et al. 2008; Wells et al. 2009; Yamaguchi et al. 2009), mainly focusing on Western Australian introductions. Information relating to introduced barnacle species is also contained in unpublished reports to industry and other stakeholders (D. S. Jones, unpublished data). Currently, 16 species are recognized as introductions into Australian waters: *Tetraclitella pilsbryi*, *Striatobalanus krugeri*, *Amphibalanus improvisus*, *A. littoralis*, *A. poecilotheca*, *A. reticulatus*, *A. zhujiangensis*, *Fistulobalanus albicostatus*, *Megabalanus coccopoma*, *M. concinnus*, *M. occator*, *M. rosa*, *M. volcano*, *M. zebra*, *Notomegabalanus algicola*, and *N. krakatauensis* (Table 2). This number may well increase with a number of new ports being developed in Australia and therefore a concomitant increase in future shipping arrivals.

Conclusions

This brief overview of the distributions and biogeographic affinities of Australian barnacles presents all data available to date. There are major gaps in information due to the vastness of the Australian coastline (~34,218 km), the logistics, and costs associated with accessing remote areas and the scarcity of cirripede workers. However, comprehensive field collecting in WA and southeastern Queensland, plus data from the literature and material in Australian museum collections, allows some general statements to be made.

Distributions corroborate the general patterns demonstrated for the shallow-water biota of the northern tropical and southern temperate Australian biogeographic provinces. The barnacle fauna of the northern Australian tropical province is continuous with other parts of the IWP and exhibits high species diversity, a high incidence of tropical species, and low endemicity at the species level. Conversely, the southern Australian temperate barnacle fauna exhibits lower species diversity, a low incidence of tropical species, and high endemicity of species. The IWP element constitutes the bulk of the tropical Australian shallow-water barnacle fauna, but representation of IWP species in the southern Australian temperate province is low and decreases from west to east.

Tropical and temperate provinces grade into each other in a broad overlap zone along both the western and eastern Australian coasts. This overlap zone is essentially a transitional region, with the gradual replacement of a tropical barnacle fauna in the north by a predominantly temperate barnacle fauna in the south. Most tropical IWP species reach as far south as North West Cape (21°47′S) on the western coast. The northern Australian tropical province thus extends to about 22°S inshore and to about 29°S at the Houtman Abrolhos (28°19′–29°57′S). On the eastern coast, the northern Australian tropical province extends to approximately Point Vernon, Qld (25°15′S, 152°49′E). In eastern Australia, the northern limit of temperate species is Cooee Bay, Qld (23°08′S 150°45′E), while in the west it is Red Bluff, Kalbarri, WA (27°54′S 114°26′E).

The barnacle faunas of western and eastern Australian coasts are diverse and distinct. On western coasts, IWP, IM, and C species dominate and AE, WP, and AA species have low representation, with SAA species not represented. On eastern Australian coasts, IWP, IM, C, AE, and WP species dominate, with AA and SAA species having low representation.

Both the western and eastern Australian coasts are bounded by major poleward-flowing warm currents, which have considerable influence on the marine flora and fauna. Tropical IWP barnacle species, and many other taxa, are distributed to the southwestern and southern coasts of Australia, much farther south than could be predicted by latitude, or by the warm, southward-flowing Leeuwin Current. A significant tropical IWP element is evident as far south as Rottnest Island (32°00′S) and a number of tropical species range farther south into the Great Australian Bight (39°00′S). While evidence is beginning to emerge that southward range extensions of biota in eastern Australia are attributable to an enhanced EAC, no range extensions of barnacles have been reported to date.

Sixteen barnacle species are currently recognized as introductions into Australian waters, but this number may increase with the development of a number of new port facilities.

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