



SYMPOSIUM

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

Diana S. Jones¹

Western Australian Museum, 49 Kew Street, Welshpool, Western Australia 6106, Australia

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.

¹E-mail: diana.jones@museum.wa.gov.au

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 endemism (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 endemism (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

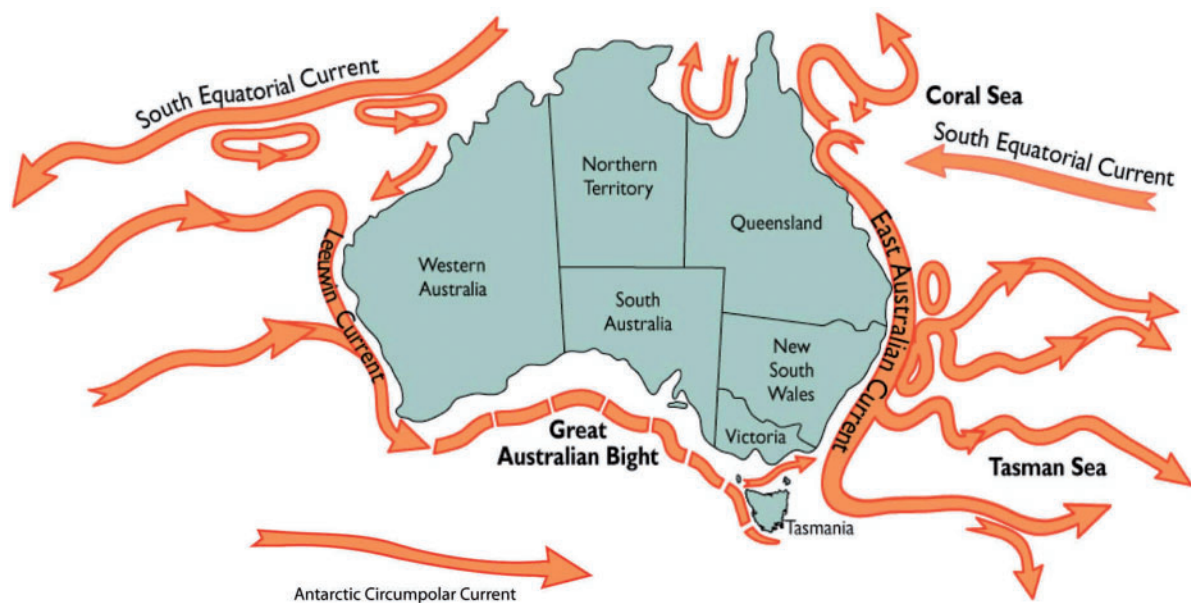


Image: CSIRO

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](http://www.csiro.au/Outcomes/Climate/Australasian%20Ocean%20Currents)). 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 $23^{\circ}26'22''\text{S}$, 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 endemism 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 ($21^{\circ}47'\text{S}$), and some as far south as the Houtman Abrolhos Islands ($28^{\circ}19'-29^{\circ}57'\text{S}$), and on the eastern coast approximately to Point Vernon, Qld ($25^{\circ}14' 53 \text{ S}$, $152^{\circ} 49'\text{E}$) (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

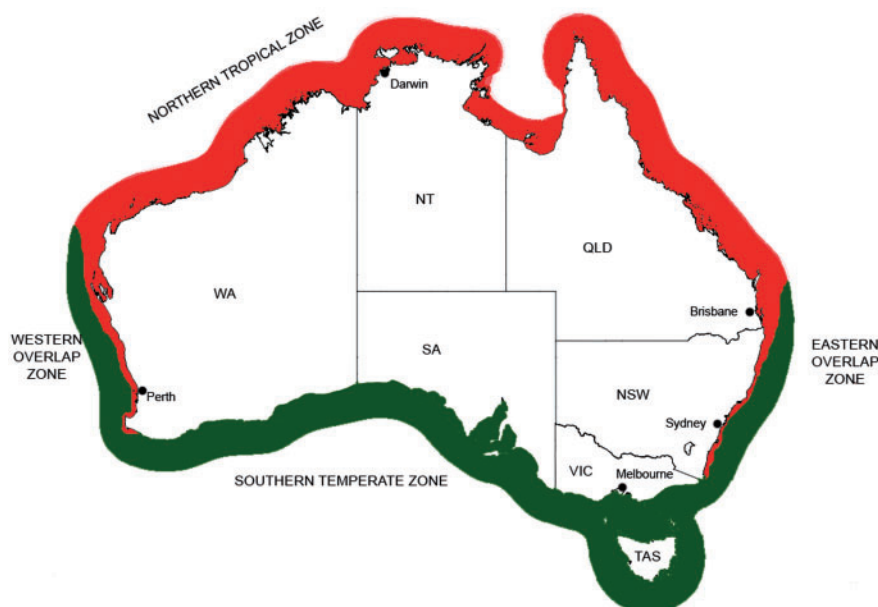


Fig. 2 Northern tropical and southern temperate biogeographic provinces of Australia

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 <i>Ibla</i> Leach, 1825
<i>Ibla cumingi</i> Darwin, 1852
<i>Ibla quadrivalvis</i> Cuvier, 1817
Family Idioiblididae Buckeridge and Newman, 2006
Subfamily Idioiblinae Buckeridge and Newman, 2006
Genus <i>Idioibla</i> Buckeridge and Newman, 2006
<i>Idioibla pygmaea</i> Broch, 1922
Subfamily Chaetolepadinae Buckeridge and Newman, 2006
Genus <i>Chaetolepas</i> Stüder, 1889
<i>Chaetolepas calcitergum</i> Buckeridge and Newman, 2006
Order Lepadiformes Buckeridge and Newman, 2006
Suborder Heteralepdomorpha Newman, 1987
Family Heteralepadidae Nilsson-Cantell, 1921
Genus <i>Heteralepas</i> Pilsbry, 1907
<i>Heteralepas adiposa</i> Zevina, 1982
<i>Heteralepas cornuta</i> (Darwin, 1852)
<i>Heteralepas dubia</i> Broch, 1922
<i>Heteralepas japonica</i> (Aurivillius, 1892)
<i>Heteralepas utinomii</i> Newman, 1960
Genus <i>Paralepas</i> Pilsbry, 1907
<i>Paralepas dannevigii</i> (Broch, 1922)
<i>Paralepas georgei</i> Daniel, 1970
<i>Paralepas intermedia</i> (Hoek, 1907)
<i>Paralepas minuta</i> (Phillipi, 1836)
<i>Paralepas morula</i> (Hoek, 1907)
<i>Paralepas palinuri urea</i> Newman, 1960
<i>Paralepas pedunculata</i> (Hoek, 1883)
<i>Paralepas quadrata</i> (Aurivillius, 1894)
<i>Paralepas scyllarusi</i> Utinomi, 1967a
<i>Paralepas tuberosa</i> (Nilsson-Cantell, 1932)
Family Malacolepadidae Hiro, 1933
Genus <i>Arcalepas</i> Jones and Morton, 2009
<i>Arcalepas brucei</i> Jones and Morton, 2009
Suborder Lepadomorpha Pilsbry, 1916
Family Oxynaspididae Gruvel, 1905
Genus <i>Oxynaspis</i> Darwin, 1852
<i>Oxynaspis celata</i> Darwin, 1852 [includes <i>Oxynaspis indica</i> Annandale, 1910]
Family Poecilasmatidae Annandale, 1910
Genus <i>Poecilasma</i> Darwin, 1852
<i>Poecilasma dubium</i> 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 kilepoeae 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 (Lesson and Tapparone-Canefri, 1874)
Octolasmis cf bullata (Aurivillius, 1892)
Octolasmis clubii Daniel, 1953
Octolasmis cor (Aurivillius, 1892)
Octolasmis geryonophila geryonophila Pilsbry, 1907
Octolasmis hawaiiense 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 acanthosubarinae 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 halothea (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 ophiophilus Lanchester, 1902
 Genus *Stomatolepas* Pilsbry, 1910
Stomatolepas dermochelys Monroe and Limpus, 1979
Stomatolepas elegans (Costa, 1838)
Stomatolepas praegustator Pilsbry, 1910

(continued)

Table 1 Continued

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 Tetracitoidea Gruvel, 1903
 Family Tetracitidae 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 Tetracitellinae Newman and Ross, 1976
 Genus *Tetracitella* Hiro, 1939
Tetracitella costata (Darwin, 1854)
Tetracitella divisa (Nilsson-Cantell, 1921)
Tetracitella multicostata (Nilsson-Cantell, 1930)
Tetracitella pilsbryi Utinomi, 1962
Tetracitella 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 vitata (Darwin, 1854)
 Subfamily Tetracitinae Gruvel, 1903
 Genus *Tesseropora* Pilsbry, 1916
Tesseropora rapax Jones, 1993
Tesseropora rosea (Krauss, 1848)
Tesseropora wireni (Nilsson-Cantell, 1921)
 Genus *Tetracita* Schumacher, 1817
Tetracita squamosa (Bruguère, 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)
Striatobalanus 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 *Neocasta* Kolbasov, 1993
Neocasta 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 *Hexaminus* Foster, 1982
Hexaminus foliorum Anderson et al., 1988
Hexaminus popeiana Foster, 1982
Austrominus Buckeridge, 1983
Austrominus adelaidae (Bayliss, 1988)
Austrominus covertus (Foster, 1982)
Austrominus erubescens (Bayliss, 1994)
Austrominus flindersi (Bayliss, 1994)
Austrominus modestus (Darwin, 1854)
Austrominus 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 gregarius (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 <i>Pyrgoma</i> Leach, 1817
<i>Pyrgoma cancellata</i> Leach, 1818
Genus <i>Savignium</i> Leach, 1825
<i>Savignium crenatum</i> (Sowerby, 1823)
Genus <i>Trevathana</i> Anderson, 1992
<i>Trevathana dentatum</i> (Darwin, 1854)
Genus <i>Wanella</i> Anderson, 1993
<i>Wanella andersonorum</i> Ross, 1999
<i>Wanella milleporae</i> (Darwin, 1854)
Subfamily Megatrematinae Holthuis, 1982
Tribe Pyrgomini Ross and Pitombo, 2002
Genus <i>Pyrgomina</i> Ross and Pitombo, 2002
<i>Pyrgomina djanae</i> Ross and Pitombo, 2002
Family Balanidae Leach, 1817
Subfamily Amphibalaninae Pitombo, 2004
Genus <i>Amphibalanus</i> Pitombo, 2004
<i>Amphibalanus amphitrite</i> (Darwin, 1854)
<i>Amphibalanus cirratus</i> (Darwin, 1854)
<i>Amphibalanus improvisus</i> (Darwin, 1854)
<i>Amphibalanus littoralis</i> (Ren and Liu, 1978)
<i>Amphibalanus poecilotheca</i> (Krüger, 1911)
<i>Amphibalanus reticulatus</i> Utinomi, 1967b
<i>Amphibalanus variegatus</i> Darwin, 1854
<i>Amphibalanus zhuijiangensis</i> (Ren, 1989)
Subfamily Balaninae Leach, 1817
Genus <i>Balanus</i> Da Costa, 1778
<i>Balanus trigonus</i> Darwin, 1854
Genus <i>Fistulobalanus</i> Zullo, 1984
<i>Fistulobalanus albicostatus</i> (Pilsbry, 1916)
<i>Fistulobalanus pallidus</i> (Darwin, 1854)
Subfamily Megabalaninae Newman, 1979
Genus <i>Austromegabalanus</i> Newman, 1979
<i>Austromegabalanus nigrescens</i> (Lamarck, 1818)
Genus <i>Megabalanus</i> Hoek, 1913
<i>Megabalanus ajax</i> (Darwin, 1854)
<i>Megabalanus coccopoma</i> (Darwin, 1854)
<i>Megabalanus concinnus</i> (Darwin, 1854)
<i>Megabalanus occator</i> (Darwin, 1854)
<i>Megabalanus rosa</i> (Pilsbry, 1916)
<i>Megabalanus tintinnabulum</i> (Linnaeus, 1758)
<i>Megabalanus validus</i> (Darwin, 1854)
<i>Megabalanus volcano</i> (Pilsbry, 1916)
<i>Megabalanus zebra</i> (Darwin, 1854)
Genus <i>Notomegabalanus</i> Newman, 1979
<i>Notomegabalanus algicola</i> (Pilsbry, 1916)
<i>Notomegabalanus krakatauensis</i> (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 *Crosnierella acantho-subcarinae* (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 endemism 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	Biogeographic affinities						
		C	IWP	WP	IM	AE	AA	SAA
<i>Ibla</i>	<i>cumingi</i>		IWP					
	<i>quadrivalvis</i>					AE		
<i>Idioibla</i>	<i>pygmaea</i>					AE		
<i>Chaetolepas</i>	<i>calcitergum</i>					AE		
<i>Heteralepas</i>	<i>adiposa</i>			WP				
	<i>cornuta</i>	C						
	<i>dubia</i>						AA	
	<i>japonica</i>		IWP					
	<i>utinomi</i>					AE		
<i>Paralepas</i>	<i>dannevigi</i>				IM			
	<i>georgei</i>					AE		
	<i>intermedia</i>				IM			
	<i>minuta</i>	C						
	<i>morula</i>				IM			
	<i>palinuri urae</i>			WP				
	<i>pedunculata</i>			WP				
	<i>quadrata</i>				IM			
	<i>scyllarusi</i>			WP				
	<i>tuberosa</i>			WP				
<i>Arcalepas</i>	<i>brucei</i>					AE		
<i>Oxynaspis</i>	<i>celata</i>	C						
<i>Poecilasma</i>	<i>dubium</i>		IWP					
	<i>kaempferi</i>	C						
<i>Glyptelasma</i>	<i>carinatum</i>	C						
	<i>gigas</i>				IM			
	<i>gracile</i>				IM			
	<i>hamatum</i>	C						
	<i>orientale</i>				IM			
	<i>pilsbryi</i>	C						
	<i>rectum</i>	C						
<i>Megalasma</i>	<i>minus</i>	C						
	<i>striatum</i>		IWP					
<i>Temnaspis</i>	<i>amygdalum</i>		IWP					
	<i>bathynomi</i>				IM			
	<i>excavatum</i>		IWP					
	<i>fissum</i>		IWP					
	<i>kilepoe</i>		IWP					
	<i>tridens</i>	C						
	<i>tridens asymmetrica</i>				IM			
<i>Octolasmis</i>	<i>angulata</i>		IWP					
	<i>aymonini</i>				IM			
	<i>cf bullata</i>				IM			
	<i>clubii</i>				IM			
	<i>cor</i>		IWP					
	<i>geryonophila geryonophila</i>	C						
	<i>hawaiense</i>			WP				
	<i>hoeki</i>	C						

(continued)

Table 2 Continued

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

(continued)

Table 2 Continued

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

(continued)

Table 2 Continued

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

(continued)

Table 2 Continued

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

(continued)

Table 2 Continued

Genus	Species	Biogeographic affinities							
		C	IWP	WP	IM	AE	AA	SAA	
	<i>ipayama</i>						WP		
	<i>pallidus</i>		IWP						
	<i>secundus</i>		IWP						
	<i>septimus</i>		IWP						
	<i>sumbawae</i>					IM			
	<i>tredecimus</i>		IWP						
Creusia	<i>spinulosa</i>		IWP						
Galkinia	<i>indica</i>		IWP						
Hiroa	<i>stubbingsi</i>					WP			
Darwinella	<i>conjugatum</i>		IWP						
Nobia	<i>grandis</i>		IWP						
Arossella	<i>projectum</i>					IM			
Pyrgoma	<i>cancellata</i>		IWP						
Savignium	<i>crenatum</i>		IWP						
Trevathana	<i>dentatum</i>		IWP						
Wanella	<i>andersonorum</i>		IWP						
	<i>milleporae</i>		IWP						
Pyrgominini	<i>djanae</i>						AE		
Amphibalanus	<i>amphitrite</i>	C							
	<i>cirratus</i>		IWP						
	<i>improvisus</i> ^a	C							
	<i>littoralis</i> ^a					IM			
	<i>poecilotheca</i> ^a		IWP						
	<i>reticulatus</i> ^a					IM			
	<i>variegatus</i>						AA		
	<i>zhujiangensis</i> ^a					IM			
Balanus	<i>trigonus</i>	C							
Fistulobalanus	<i>albicostatus</i> ^a		IWP						
	<i>pallidus</i>	C							
Austromegabalanus	<i>nigrescens</i>						AE		
Megabalanus	<i>ajax</i>		IWP						
	<i>coccopoma</i> ^a	C							
	<i>concinnus</i> ^a		IWP						
	<i>occator</i> ^a		IWP						
	<i>rosa</i> ^a					IM			
	<i>tintinnabulum</i>	C							
	<i>validus</i>					IM			
	<i>volcano</i> ^a					IM			
	<i>zebra</i> ^a		IWP						
Notomegabalanus	<i>algicola</i> ^a		IWP						
	<i>krakatauensis</i> ^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).

^aIntroduced 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 Cooe 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) (Jones 1990b, 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 Rottneest 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 Rottneest 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 Rottneest 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 Rottneest 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 Rottneest 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 Rottneest 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 Rottneest 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 Rottneest 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 Cooe 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 tetracitid, *Tetracitella squamosa* (Bruguère 1789), from Point Vernon to Red Bluff, Kalbarri, WA (27°54'S 114°26'E), while the southern *Tetracitella 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: *Tetracitella 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 endemism at the species level. Conversely, the southern Australian temperate barnacle fauna exhibits lower species diversity, a low incidence of tropical species, and high endemism 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 Cooe 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.

Acknowledgments

I sincerely thank Professor John Zardus for his tremendous efforts in organizing the symposium *Barnacle Biology: Essential Aspects and Contemporary Approaches*. I also thank Professor John Buckeridge and an anonymous reviewer for pertinent comments that significantly improved an earlier draft of this article. I acknowledge the CSIRO, Australia, for their kind permission to reproduce Figure 1. I also thank all the conference organizers and the symposium participants for such a successful and enjoyable meeting.

Funding

I wish to acknowledge the Society for Integrative and Comparative Biology for providing generous funding that allowed my attendance at the symposium. Funding for the work associated with data collection and completion of this paper has been generously provided through the following sources: the Western Australian Museum (1980 to present); Australian Museum Trust Postgraduate Scholarship (1984); Associate Professorship, Muséum national d'Histoire naturelle, Paris (1994, 1997, 2000); Department of Australian Heritage and CSIRO (1996–2005), National Ports Survey Project (1996–2005); Woodside Energy Ltd (1998–ongoing); Centre for Research on Introduced Marine Pests (CRIMP), CSIRO (1999); Gascoyne Development Commission (1999); Senckenberg Museum DAAD Research Fellowship (2000); Australian Heritage Commission (2003–2006); Western Australian Fisheries (2006); Australian Biological Resources Survey (2008–2012); Chevron Australia (2009–ongoing).

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