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Their distribution in the Indian
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THE ANOMURAN CRABS OF WESTERN AUSTRALIA: THEIR DISTRIBUTION IN THE INDIAN OCEAN AND ADJACENT SEAS*

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ABSTRACT

Excluding the hermit crabs, 58 species of Crustacea Anomura belonging to six families have been recognised from the state of Western Australia. There are 21 genera, of which ten are Indo-West Pacific only and 11 are shared with the Eastern Pacific and Atlantic.

Seven of the species are temperate forms and Australian endemics. One of these is monotypic; two have their closest relative in New Zealand; and four have their affinities with tropical Indo-West Pacific species.

Two species are larger and more abundant in the warm-temperate region but range well into the tropics, including areas outside Australia.

The remaining 49 species are strictly tropical members of the Indo-West Pacific fauna, and most are of wide distribution. Some are confined to the tropical coast of Western Australia, while others penetrate the warm-temperate province.

Twenty-four tropical species extend throughout all or most of the Indian Ocean. Seven of these have their eastern limit in Australia and the Indo-Malaysian region; 17 extend northward to Japan and/or eastward to Oceania.

Five tropical species extend westward only to the central sector of the Indian Ocean. Of these, three are confined at the eastern limit of their range to Australia and Indo-Malaysia, while two range northward to Japan.

Three species occur only in the eastern sector of the Indian Ocean; all extend northward to Japan and eastward to Oceania.

Seventeen species have the western limit of their range in Western Australia, and occur nowhere else in the Indian Ocean. Seven of these are apparently endemic in tropical Australia. Five are confined to Indo-Malaysia; three extend northward to Japan; and two extend eastward to Oceania.

INTRODUCTION

UNTIL quite recently, information on the Crustacea Anomura of Western Australia was very limited. Papers by Balss (1921), Rathbun (1924), and Hale (1929), dealing specifically with crustaceans from that state, treated several anomurans; outside of these there were only a few scattered references in the literature. Nothing was known about the probable number of anomuran species on Western Australian shores or about their distribution in that area.

During the past several years the author has been making a series of studies on anomurans of Western Australia, based principally on a large and still expand-

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ing collection in the Western Australian Museum, Perth. Anomura from the collection of the Hamburg Museum, derived from the Hamburg Southwest-Australia Expedition of 1905, were made available for examination, as was material from the Australian Museum, the Smithsonian Institution, and the British Museum (Natural History). The scope of these studies, and their progress at this writing, may be summarized as follows:

Superfamily Hippidea: Revisionary studies are underway on this superfamily, which comprises families Hippidae and Albuneidae. Two albuneids from Western Australia were recently described (Efford and Haig, 1968).

Superfamily Paguridea: The hermit crab families have not been studied and practically nothing is known about them within the area under discussion. Lithodidae, although known from the Indian Ocean, are not yet reported from Western Australia. Family Lomidae (Lomisidae of authors; see Glaessner, 1969: 481), containing a single genus and species, will be treated in a future publication.

Superfamily Galatheidea: The Porcellanidae of Western Australia have been reviewed (Haig, 1965) and additional information on these will be included in a forthcoming revision of Australian porcellanids. Studies are in progress on families Chirostyliidae and Galatheidae.

The Thalassinidea are considered to be Anomura by some carcinologists, but others place them with the reptant Macrura. The group has been left out of consideration in the present series of studies.

Considerable work has been done during the past decade on anomuran Crustacea from areas outside Australia. A number of papers have appeared which have contributed greatly to the understanding of the systematic status and distribution of Western Australian species. Among these should be mentioned studies on the Albuneidae of the Philippine Islands (Serène and Umali, 1965); Hippidea of Madagascar (Thomassin, 1969); Anomura of the Red Sea (Lewinsohn, 1969); Galatheidae of the Indian Ocean (Tirmizi, 1966); Porcellanidae of Madagascar (Haig, 1966a), of the Gulf of Iran (Haig, 1966b), and of western India (Sankolli, 1966); and a series of papers on Galatheidea of Japan and adjacent waters (Baba, 1969a, 1969b; Miyake and Baba, 1963, 1964, 1967, 1968; Nakasone and Miyake, 1968a, 1968b, 1969).

The six families under study—Hippidae, Albuneidae, Lomidae, Chirostyliidae, Galatheidae, and Porcellanidae—appear, at this time, to be represented in Western Australia by 58 species in 21 genera. Enough information about these species has now accumulated so that their distribution, within Australia and in other areas, is fairly well understood. The present paper consists of a generalized discussion of various distribution patterns that characterize this fauna. It must be considered of a preliminary nature only, because there are still gaps in our knowledge of the distribution of several forms; future work in geographical areas now unexplored or inadequately sampled will provide a more accurate picture, and may also add a few species to the Western Australian faunal list.

Ecological requirements, length of larval life, and other factors that influence the distribution of marine animals are unknown or imperfectly understood for most of these species. Therefore an explanation of their distribution patterns will have to await future studies.

Sincere thanks are due to the following persons who arranged the loan of Western Australian anomurans: Dr. R. W. George, Western Australian Museum; Dr. J. C. Yaldwyn and the late Mr. F. A. McNeill, Australian Museum; Dr. A. Panning, Zoologisches Museum, Hamburg; and Dr. F. A. Chace, Jr., Smithsonian Institution. Drs. George and Yaldwyn and Mr. McNeill provided many courtesies during visits to their respective institutions, during which considerable Western Australian material was examined. Type and other material was examined at the British Museum (Natural History) through the courtesy of Dr. Isabella Gordon, who also supplied important information.

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BIOGEOGRAPHICAL PROVINCES OF WESTERN AUSTRALIA

Knox (1963: 368-380) presented a historical survey of papers that discussed the biogeographical provinces of Australian shores. On the basis of conclusions of some earlier workers, he recognised (p. 381) the following divisions for Western Australia: the tropical-subtropical Dampierian Province, with its southern limit at 28°50'S in the vicinity of the Houtman Abrolhos Islands (which mark the southern extent of the growth of reef corals on this coast); the warm-temperate West Australian Province, from about the Houtman Abrolhos Islands to the southern Australian coast between Albany and Esperance; and the transitional warm-temperate Flindersian Province, extending eastward from that point. He proposed that the West Australian Province should be provisionally recognised until its distinctiveness is substantiated by future research. The area which Knox termed the West Australian Province was considered by Bennett and Pope (1953) to be not a distinct province, but a broad overlap area containing elements of both the tropical Dampierian and warm-temperate Flindersian provinces.

Of the 58 Western Australian anomuran species (excluding hermit crabs), 28, or nearly half, have been collected in the overlap area or transition zone between Houtman Abrolhos Islands and Geraldton to the north and Esperance to the east. These include 20 tropical species out of a total of 49, and eight of the nine temperate forms. None of these species offers additional evidence for the presence of a distinct West Australian Province.

THE TEMPERATE SPECIES

Excluding the hermit crabs, there are nine species in Western Australia that may be considered temperate forms:

HIPPIDAE

Hippa australis Hale

LOMIDAE

Lomis hirta (Lamarck)

GALATHEIDAE

- Munida haswelli* Henderson
Galathea australiensis Henderson
Galathea magnifica Haswell
Phylladorhynchus pusillus (Henderson)

PORCELLANIDAE

- Petrocheles australiensis* (Miers)
Pisidia dispar (Stimpson)
Polyonyx transversus (Haswell)

Seven of these species are apparently Australian endemics. *Lomis hirta* is the only representative of its genus and family. *Petrocheles australiensis* is closely allied to a New Zealand species, *P. spinosus* (Miers); these two species are the only representatives of genus *Petrocheles*. *Munida haswelli* occurs in depths of about 90 to 420 metres and its closest relative seems to be another deep-water species, *M. gracilis* Henderson from New Zealand waters.

Bennett and Pope (1953) recognised a cool-temperate Maugean Province for the shores of Victoria and Tasmania, and cited *Lomis hirta* among animals characteristic of this province (p. 147). However, *Lomis* also penetrates the warm-temperate Flindersian, where it was collected at several localities; there is a published record from as far north as Shark Bay. *Petrocheles australiensis* should undoubtedly be classed with the cool-temperate fauna as well. The same is probably true of *Munida haswelli*, although Bennett and Pope based their cool-temperate province on intertidal animals only.

The other four endemic species, *Hippa australis*, *Galathea australiensis*, *G. magnifica* and *Polyonyx transversus*, have their affinities with tropical or subtropical Indo-West Pacific forms. *G. australiensis* should perhaps be included in the cool-temperate fauna; the other three species are warm-temperate.

Phylladorhynchus pusillus and *Pisidia dispar* are here considered to be temperate species because they reach their best development (in terms of both size and abundance) in the Australian temperate region, but they occur in the tropics as well. *Ph. pusillus* penetrates the Australian tropics and has been reported from various extra-Australian localities, ranging westward to Providence Island in the western Indian Ocean and northward to Japan. It also occurs in New Zealand waters. *Pi. dispar* is distributed all around the Australian continent. Until recently it was believed to be restricted to Australia, but it is now reported from Japan and the Ryukyu Islands (Nakasoné and Miyake, 1968b: 97). Both these species have their closest relatives in the tropical Indo-West Pacific.

THE TROPICAL SPECIES

Forty-nine of the 58 Western Australian anomurans are tropical (Table 1) and their affinities are with other tropical Indo-West Pacific species. Most of them are of wide distribution.

TABLE 1. *Tropical Anomura of Western Australia (Hermit Crabs Excluded)**

Hippidae	Porcellanidae
<i>Mastigochirus quadrilobatus</i> Miers (B)	<i>Petrolisthes scabriculus</i> (Dana) (C)
<i>Hippa pacifica</i> Dana (A)	<i>Petrolisthes militaris</i> (Heller) (A)
Albuneidae	<i>Petrolisthes moluccensis</i> (De Man) (A)
<i>Austrolepidopa trigonops</i> Efford & Haig (D)	<i>Petrolisthes boscii</i> (Audouin) (A)
<i>Albunea</i> , undescribed sp. (D)	<i>Petrolisthes haswelli</i> Miers (D)
<i>Albunea dayriti</i> Serène & Umali (D)	<i>Petrolisthes teres</i> Melin (B)
<i>Albunea steinitzi</i> Holthuis (A)	<i>Petrolisthes penicillatus</i> (Heller) (A)
<i>Stemonopa insignis</i> Efford & Haig (D)	<i>Petrolisthes maculatus</i> (H. Milne Edwards) (A)
Chirostylidae	<i>Pachycheles sculptus</i> (H. Milne Edwards) (C)
<i>Uroptychus</i> sp. (D)	<i>Pachycheles johnsoni</i> Haig (D)
<i>Chirostylus dolichopus</i> Ortmann (D)	<i>Pachycheles pisoides</i> (Heller) (A)
Galatheididae	<i>Porcellana habei</i> Miyake (D)
<i>Munida elegantissima</i> De Man (A)	<i>Porcellana gravelei</i> Sankolli (B)
<i>Munida japonica</i> Stimpson (A)	<i>Porcellana ornata</i> Stimpson (B)
<i>Munida spinulifera</i> Miers (A)	<i>Pisidia spinuligera</i> (Dana) (C)
<i>Allogalatea elegans</i> (White) (A)	<i>Pisidia</i> sp. (D. S. Johnson MS) (A)
<i>Galathea aegyptiaca</i> Paulson (A)	<i>Aliaporcellana nitida</i> (Haswell) (D)
<i>Galathea corallicola</i> Haswell (D)	<i>Aliaporcellana furcillata</i> (Haig) (D)
<i>Galathea orientalis</i> Stimpson (B)	<i>Aliaporcellana</i> sp. (? A)
<i>Galathea ternatensis</i> De Man (A)	<i>Aliaporcellana sulvensis</i> (Dana) (A)
<i>Galathea aculeata</i> Haswell (D)	<i>Aliaporcellana telestophilus</i> (Johnson) (D)
<i>Galathea genkai</i> Miyake & Baba (A)	<i>Polyonyx biunguiculatus</i> (Dana) (A)
<i>Galathea pubescens</i> Stimpson (? A)	<i>Polyonyx obesulus</i> Miers (A)
<i>Galathea gardineri</i> Laurie (A)	<i>Polyonyx triunguiculatus</i> Zehntner (A)
<i>Phylladorhynchus</i> , undescribed sp. (D)	<i>Polyonyx maccullochi</i> Haig (D)
	<i>Porcellanella triloba</i> White (A)
	<i>Raphidopus ciliatus</i> Stimpson (D)

The Indo-Malaysian region is generally considered to be a central area from which other areas of the Indo-West Pacific have received a great part of their fauna (Ekman, 1953 : 18, and others). From this focal area many crustaceans and other animals are believed to have spread westward into the Indian Ocean, southward onto the northern shores of Australia, northward to Japan via the Philippine Islands and the east Asian mainland, and eastward to Oceania. Many species have spread in more than one direction. Western Australia's tropical anomuran fauna undoubtedly originated through dispersal southward from Indo-Malaysia onto the northern Australian coast and thence southward along the western shores of the continent. It then follows that the Western Australian component of the Indian Ocean anomuran fauna was derived independently from the principal Indian Ocean component, which was received through westward dispersal. It is not surprising, therefore, that 17 Western Australian anomurans out of 49, or roughly 34.6 per cent, do not otherwise occur in the Indian Ocean (see section D, below). Conversely, there are many anomurans that inhabit both the Pacific and Indian Oceans but have not reached Western Australia. These include about 18 Porcellanidae, a few species of *Hippa*, and probably several galatheids.

A. Species occurring in the western Indian Ocean

Twenty-four, or nearly half, of these species extend to the western part of the Indian Ocean (mainland as far east as the Gulf of Oman, and islands including Mada-

*A=Species occurring in the western Indian Ocean ; B=Species extending westward to the central sector of the Indian Ocean ; C=Species found in the Indian Ocean in the eastern sector only ; D=Species with the western limit of their range in Western Australia and not occurring elsewhere in the Indian Ocean.

gascar and Comoros, Amirantes, Seychelles, Cargados Carajos, Mascarenes). Six of them have become distributed by way of the continental land mass along the Indian subcontinent to the Gulf of Iran and Red Sea and southward along the east coast of Africa; they are absent from the oceanic islands. Four species occur on the oceanic islands, where they are probably restricted to coral reefs, but are absent from the continental land mass. Fourteen species have been found both on continental shores and on oceanic islands. Because of large gaps in their known distribution, it is difficult in many cases to trace their dispersal routes.

Seven of these species appear to have spread mainly southward and westward; they have not reached Japan or Oceania. Eight species moved northward to Japan, four eastward to penetrate Oceania, and five both northward and eastward.

B. Species extending westward to the central sector of the Indian Ocean

Four species reach the Indian subcontinent, two on the east coast and two on the west. They are all non-oceanic types, and the distribution of three of them can be clearly traced around the shores of the continental land mass. A fifth, deep-water form is reported from the southern Arabian Sea; very little is known about its distribution.

Two of these five species extend north to Japan, but none of them has spread very far to the east.

Johnson (1966 : 439-440) showed evidence that the west coast of India may be a barrier to the dispersal of some crustaceans, both westward and eastward. As far as the anomurans treated in the present report are concerned, more species have traversed the western Indian coast than have been limited by it; but the author has not analysed the number of non-Western Australian species whose distributions westward end in that area.

C. Species extending to the eastern sector of the Indian Ocean

Three species have penetrated the Indian Ocean as far as the Nicobar Islands, but have not been found further to the west. They are widespread in the Pacific Ocean, however, having reached Oceania and nearly as far north as Japan.

D. Species with the western limit of their range in Western Australia

As noted above, 17 species occur in the Indian Ocean in Western Australia only. Five of these spread to the south but are otherwise confined to the Indo-Malaysian region. Three range northward to Japan and two eastward to Oceania.

The remaining seven species appear to be Australian endemics. However, four of them are poorly known and they are likely to turn up in other parts of the Indo-West Pacific. Three are known from many localities around the tropical Australian coasts.

THE GENERA

The anomurans treated in this report are divided among 21 genera, of which ten are Indo-West Pacific only and 11 are shared with the East Pacific and Atlantic (Table 2). Of the two strictly temperate genera, one (*Lomis*) is endemic in Australia and the other (*Petrocheles*) occurs in New Zealand as well.

TABLE 2. Families and Genera of Western Australian Anomura (Hermit Crabs excluded)

HIPPIDAE (IP, EP, AT)

Mastigochirus Miers, 1878. IP; trop.*Hippa* Fabricius, 1787. IP, EP, AT; trop., temp.

ALBUNEIDAE (IP, EP, AT)

Austrolepidopa Efford & Haig, 1968. IP; trop.*Albunea* Weber, 1795. IP, EP, AT; trop.*Stemonopa* Efford & Haig, 1968. IP; trop.

LOMIDAE (IP)

Lomis H. Milne Edwards, 1837. IP; temp.

CHIROSTYLIDAE (IP, EP, AT)

Uroptychus Henderson, 1888. IP, EP, AT; trop., temp.*Chirostylus* Ortmann, 1892. IP (as presently restricted; see Miyake and Baba, 1968: 379); trop., temp.

GALATHEIDAE (IP, EP, AT)

Munida Leach, 1820. IP, EP, AT; trop., temp.*Allogalatea* Baba, 1969. IP; trop.*Galatea* Fabricius, 1793. IP, EP, AT; trop., temp.*Phylladorhynchus* Baba, 1969. IP, EP; trop., temp.

PORCELLANIDAE (IP, EP, AT)

Petrocheles Miers, 1876. IP; temp.*Petrolisthes* Stimpson, 1858. IP, EP, AT; trop., temp.*Pachycheles* Stimpson, 1858. IP, EP, AT; trop., temp.*Porcellana* Lamarck, 1801. IP, EP, AT; trop., temp. This is an unnatural group and requires revision.*Pisidia* Leach, 1820. IP, EP, AT; trop., temp.*Aliaporcellana* Nakasone & Miyake, 1969. IP; trop.*Polyonyx* Stimpson, 1858. IP, EP, AT; trop., temp.*Porcellanella* White, 1852. IP; trop.*Raphidopus* Stimpson, 1858. IP; trop.

IP=Indo-West Pacific; EP=Eastern Pacific; AT=Atlantic.

CONCLUSIONS

1. Fifty-eight Crustacea Anomura, in families Hippidae, Albuneidae, Lomidae, Chirostylidae, Galatheididae, and Porcellanidae, are known to occur in Western Australia. Nine of these belong to the temperate and 49 to the tropical component of the Australian fauna.

2. These 58 species are divided among 21 genera. Two genera are strictly temperate; one is an Australian endemic and the other occurs in Australia and

New Zealand only. Eight of the remaining genera are Indo-West Pacific only and 11 are Eastern Pacific and Atlantic as well.

3. Twenty-eight species, 20 tropical and eight temperate, occur in the transition zone or overlap area between the tropical Dampierian and warm-temperate Flindersian provinces.

4. Seven of the nine temperate species are Australian endemics. One is the only representative of its genus and family; another has a single congener which inhabits New Zealand; and a third is most closely related to a New Zealand species. The other four endemics have their affinities with tropical Indo-West Pacific species. The two non-endemic temperate species occur in the tropics both in Australia and in other areas.

5. The 49 tropical anomurans have their affinities with other tropical Indo-West Pacific forms. Only seven of them appear to be Australian endemics, and this number may be reduced when some of them become better known.

6. Seventeen of the tropical species (about 34.6 per cent) occur nowhere in the Indian Ocean except Western Australia; an even larger number of Indian Ocean anomurans, derived from the Indo-Malaysian central area, are absent from Western Australia. It is believed that most Indian Ocean anomurans of Indo-Malaysian affinities were derived through distribution westward, but that Western Australia received its Anomura independently via the northern coast of Australia.

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ADDENDUM

Since this paper went to press, the species listed in Table 1 as '*Pisidia* sp.' has been described (Johnson, 1970, Bull. Natn. Mus. Singapore, 35 : 29) and should be known as *Pisidia gordonii* (Johnson). *Galathea gardineri* is now *Lauriea gardineri* (Laurie) (Baba, 1971, Men. Fac. Educ. Kumamoto Univ., 9 : 51). The *Albunea* listed as an undescribed species is *Albunea mariellae* Serène (Serène, 1973, Crustaceana, 24 : 261).