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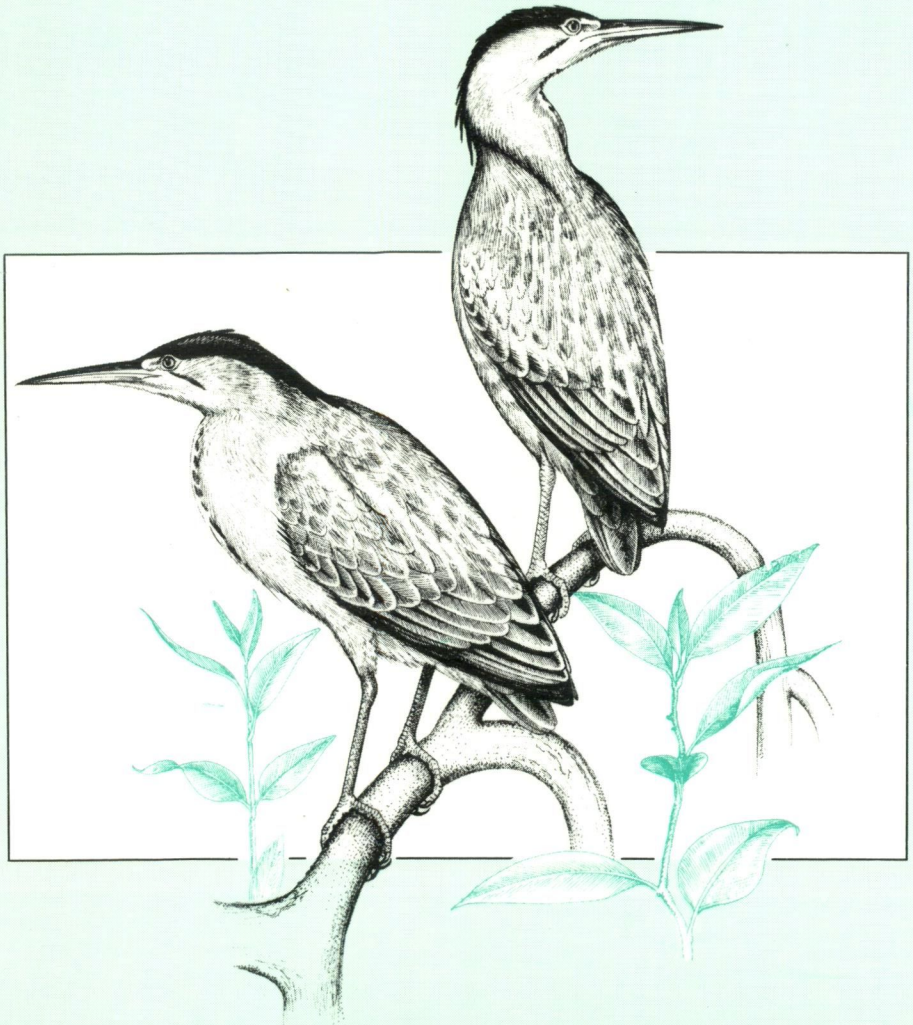
MANGROVES AND MANGROVE BIRDS of Western Australia

R.E. Johnstone



MANGROVES AND MANGROVE BIRDS OF WESTERN AUSTRALIA

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TABLE OF CONTENTS

ABSTRACT

Eighty-three blocks of mangroves were visited in Western Australia from Cambridge Gulf to Shark Bay between 1973 and 1982. The vegetation and substrate at each site are described. Twenty-two species of bird were found to be confined to mangroves or limited to them for at least part of their range in this State: Great-billed Heron (*Ardea sumatrana*), Mangrove Heron (*Butorides striatus*), Grey Goshawk (*Accipiter novaehollandiae*), Chestnut Rail (*Eulabeornis castaneoventris*), Bar-shouldered Dove (*Geopelia humeralis*), Little Bronze Cuckoo (*Chrysococcyx minutillus*), Mangrove Kingfisher (*Halcyon chloris*), Lemon-breasted Flycatcher (*Microeca flavigaster*), Mangrove Robin (*Eopsaltria pulverulenta*), Mangrove Golden Whistler (*Pachycephala melanura*), White-breasted Whistler (*Pachycephala lanioides*), Wood Fantail (*Rhipidura dryas*), Mangrove Grey Fantail (*Rhipidura phasiana*), Broad-billed Flycatcher (*Myiagra ruficollis*), Shining Flycatcher (*Myiagra alecto*), Mangrove Flycater (*Gerygone levigaster*), Dusky Flycater (*Gerygone tenebrosa*), Large-billed Flycater (*Gerygone magnirostris*), Yellow White-eye (*Zosterops lutea*), Red-headed Honeycater (*Myzomela erythrocephala*), White-breasted Woodswallow (*Artamus leucorhynchus*), and Black Butcherbird (*Cracticus quoyi*). For each species, data are given on distribution, status, ecology, voice, food, breeding, colour of unfeathered parts, and for some species notes on geographic variation and taxonomy.

INTRODUCTION

The narrow discontinuous belt of mangrove habitats along the northern and north-western coasts of Australia from Normanton, Queensland, to Broome, Western Australia, support the richest mangrove bird fauna in the world. As many as twenty species of bird are confined or largely confined to the mangroves in this area, and many other species frequently visit mangroves to feed, nest or shelter. By comparison, in Borneo Smythies (1968) lists two species, *Pachycephala cinerea* and *Zosterops chloris* as the only birds common in mangroves; in Malaysia, Macnae (1968) mentions only two species *Parus major* and *Muscicapa rufigastra*, that appear to be restricted to mangroves; and only three species *Myiagra ruficollis*, *Eopsaltria pulverulenta* and *Myzomela erythrocephala*, are confined to the vast tracts of mangroves in New Guinea (Rand and Gilliard 1967).

Despite the richness of the mangrove avifauna in Western Australia little was known of the birds and of their habitat prior to this study. The most notable of previous workers was J.P. Rogers who collected mangrove birds in King Sound and around Wyndham between 1902 and 1910. His collections were reported on by Hall (1902), Hall and Rogers (1908) and Mathews (1909).

This study is based on surveys carried out between 1973 and 1982, of eighty-three different blocks of mangroves from Cambridge Gulf to Shark Bay (Figures 2, 4, 14, 18 and 23).

An estimate of size of each mangrove block, as well as details of vegetation and substrate colour taken at each site are given in the first part of this paper. Many sites were selected because of their accessibility, and although most were visited only once or twice, some, such as Walsh Point, were visited as many as six times. Within each block of mangroves an effort was made to sample all habitat types by transects from land to sea through

the vegetation and by following creeks and tidal channels. Bird specimens were collected opportunistically, but in many cases only after observing them feeding. Distribution maps are given for each species and many sites on these are cross-referenced with the vegetation descriptions in part one of this paper. Under food, for each species the number of stomach contents examined, and in most cases the total number of prey items for particular foods is listed. This was not possible with Lepidoptera because their soft nature made it difficult to count them in some stomachs. An indication of prey size is also given for most species. In order to assess the taxonomic status of some birds, specimens were borrowed from other parts of Australia and New Guinea, from the Queensland Museum, Australian Museum, Museum of Victoria, South Australian Museum and the National Wildlife Collection. Measurements of specimens were taken as follows: length of bill from tip to base of skull; width of bill across the middle of the nares; length of wing as a flattened chord; length of tail from base of central rectrix; and length of tarsus from the heel to the last full scale on the front of the tarsus. Breeding season is defined as the months in which eggs are laid. Unless otherwise stated all data on food, breeding and colours of unfeathered parts is from Western Australian birds.

THE MANGROVES

Mangrove plant communities, termed mangal by Macnae (1968), are found around the coasts of all mainland states of Australia. In both species richness and area mangals are best developed in the tropics where in Australia over 27 species of mangrove belonging to 14 families have been recorded Saenger *et al.* (1977). In the subtropics there are fewer species and the communities are not as extensive. In temperate regions only one species occurs in small pockets. In New Guinea mangrove vegetation is even richer than Australia, with about 40 species, and forests reaching 30 m or more are common (Macnae 1968).

In Western Australia there is a reduction in the number of mangrove species and in the structural complexity of the mangal from north to south (Semeniuk *et al* 1978). The most diverse mangals occur along the north and north-west Kimberley coasts where 16 species have been recorded. In south-west Kimberley there are 12 species, in the Pilbara 8 species and in the Carnarvon region one species. Kimberley mangals are often closed forests 10-14 m tall, whereas in the Pilbara they are not as tall and usually form low closed forests 5-10 m tall. Further south in the Carnarvon region the trees become more widely spaced and at best form low open forests and woodlands to 5 m.

In contrast with the mangal, tidal salt-marsh vegetation (samphires etc.) becomes more complex in structure and contain more species from north to south. Eight salt-marsh plant species have been recorded in the Kimberley, 14 in the Pilbara and 29 in the south-west of Western Australia (Saenger *et al.* 1977).

The floristics and ecology of Western Australian mangroves have been described in some detail by Semeniuk, Kenneally and Wilson (1978). They recognize four broad biogeographic regions: tropical subhumid (north and north-west Kimberley), tropical semiarid (Cambridge Gulf and south-west Kimberley), tropical arid (Pilbara), and subtropical arid to humid (Carnarvon to Bunbury). I largely follow their regional

classification, but differ in two respects. First, I treat Cambridge Gulf as a region of its own, because of the richness of its mangal and mangrove birds. Second I restrict their southernmost region to the Carnarvon area, because the mangals of Houtman Abrolhos and Bunbury support no mangrove birds. Figure 1 shows the five regions used in this paper namely: A north-east Kimberley (Cambridge Gulf); B north-west Kimberley; C south-west Kimberley; D Pilbara; and E Carnarvon-Shark Bay.

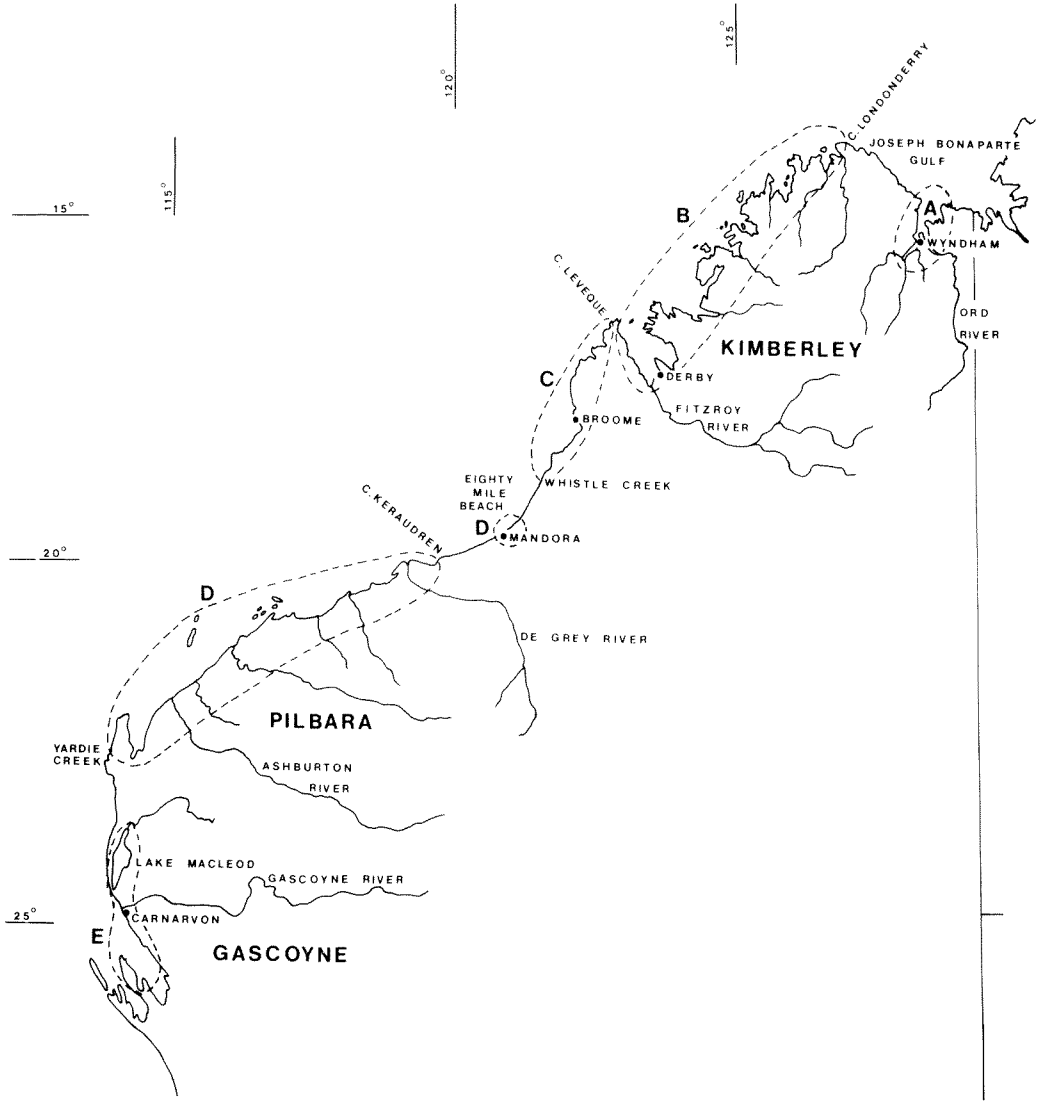

Figure 1 Map of northern Western Australia, showing the five mangrove regions: A north-east Kimberley (Cambridge Gulf); B north-west Kimberley; C south-west Kimberley; D Pilbara; E Carnarvon – Shark Bay.

Many blocks of mangal along the north and north-west Kimberley coasts have marked zonation, with the various mangrove species growing in distinct bands. The main factors that contribute to this zonation are frequency of flooding by tidal waters, soil type, soil salinity, drainage, plant interactions, and animal interactions (Semeniuk *et al.* 1978). In the Kimberley (regions A, B and C) most mangals exhibit the following zonation from sea to land; (1) *Sonneratia alba* or *Avicennia marina* or both, (2) *Avicennia* or *Avicennia* and *Bruguiera parviflora*, (3) *Rhizophora stylosa*, (4) *Ceriops tagal*, and (5) *Avicennia marina* (Semeniuk *et al.* 1978). In the Pilbara (region D) the mangals are less clearly zoned, and in the Carnarvon region *Avicennia* is the sole mangrove.

Variations in the micro-habitats are apparent in all regions and affect the structure of the mangal, so that even stunted communities can be found in the tropics. In the Pilbara for example, some stands of mangal are more extensive and luxuriant than many in south-west Kimberley.

Coastal hydrology is probably the single most important aspect affecting mangrove zonation. Tidal range and rhythm exert a strong influence on water supply, aeration, salinity and temperature of the soils. Along with tides, wave action, currents, rainfall and fresh water input from rivers, creeks and seepage, have a major effect on the vegetation. For example sheltered areas in the tropics subjected to regular inundation and aeration and having a good input of fresh water will support rich stands of mangroves. Unprotected areas in more arid environments with little fresh water input and high salinity will have more open, depauperate mangroves.

The five biogeographic regions are described together with the sites studied within each of them.

A. NORTH-EAST KIMBERLEY (CAMBRIDGE GULF)

The broad expanse of water constituting Cambridge Gulf is located within a deep embayment between sandstone ridges. These rocks outcrop predominantly on the western side of the Gulf, but on the eastern side of the outer estuary the Ord has built up a large deltaic plain with extensive mangal. The inner estuary contains the mouths of the Forrest, King and Pentecost Rivers, all with large stands of mangroves. One interesting aspect of the Gulf is the lack of *Rhizophora* forests in the inner estuary.

The tidal range is 8 m. There is a distinct wet season from December to March. Mean annual rainfall is 680 mm at Wyndham.

Fifteen species of mangrove are recorded from this region: *Acanthus ebracteatus* (only known from King River), *Avicennia marina*, *Camptostemon schultzii*, *Lumnitzera racemosa*, *Excoecaria agallocha*, *Pemphis acidula*, *Xylocarpus australasicus*, *Aegiceras corniculatum*, *Osbornia octodonta*, *Aegialitis annulata*, *Bruguiera exaristata*, *Bruguiera parviflora*, *Ceriops tagal*, *Rhizophora stylosa* and *Sonneratia alba*.

Six sites were visited within the Gulf: three in the outer estuary (Black Cliff Point, 7 km NNE of Mount Connection and Still Bay) and three in the inner estuary (Parry Creek, Wyndham and the mouth of the King River) (Figures 1 and 2).

Figure 2 Map of region A, north-east Kimberley (Cambridge Gulf), showing the areas visited: A1 Black Cliff Point; A2 7 km NNE of Mt Connection; A3 Still Bay; A4 Parry Creek; A5 Wyndham; A6 King River.

A1. Black Cliff Point 15°02'S, 128°06'E; area of mangal 250-300 ha.

The mangal here has three distinct zones, seaward, central and landward. The seaward zone (20-60 m wide) is an open woodland of thick-trunked *Sonneratia* (to 5 m) grading into mixed woodlands (to 9 m) of *Sonneratia, Avicennia, Aegiceras* and scattered trees of *Xylocarpus*. The central zone (up to 100 m wide) is a low closed *Rhizophora* forest 7-12 m high; there is no understory and few seedlings. The landward edge of the *Rhizophora* forest is sharp and contains many dead trees. The landward zone (30-60 m wide) is mainly woodland and thickets (4-5 m high) of stunted *Avicennia* and *Aegiceras* with pockets of *Ceriops* and scattered *Excoecaria*.

The substrate is dark grey mud, and the mangal is backed by mudflats and rocky slopes.

Figure 3 *Sonneratia-Avicennia* woodland, seaward edge, Black Cliff Point (A1).

A2. 7 km NNE of Mount Connection 15°10'S, 128°17'E; area of mangal 100 sq. km.

This area contains numerous shelving mudbanks and tidal creeks. Vegetation along the creeks ranges from 10 to 50 m wide and consists of low *Aegialitis, Camptostemon* and scattered *Avicennia*, backed by thickets of *Aegiceras* (to 3 m) on creek banks. These give way to a closed forest of *Avicennia* and *Rhizophora* (to 10 m). Scattered pure stands of *Bruguiera parviflora* (to 10 m) occur on some creeks, and there are scattered trees of *Xylocarpus* (to 7 m). The landward zone varies from open *Avicennia* woodland and shrubland to thickets of *Ceriops, Avicennia* and *Aegiceras*.

The substrate is dark grey mud. The mangal is backed by saline mudflats with some low open samphire and more to landward grasslands of *Sporobolus virginicus*.

A3. Still Bay 15°12'S, 128°07'E; area of mangal 50 ha.

Here the seaward zone is low branching *Rhizophora* (to 5 m) and *Avicennia* woodland, often with an understory of low *Aegialitis*, and further to landward an understory of taller *Aegiceras* (to 2 m). Scattered small pockets of *Rhizophora* forest occur in protected areas and along small creeks. The landward zone is mainly open *Avicennia*, with sparse samphire.

The substrate is dark grey mud, and the mangal is backed by bare saline mudflats.

A4. Parry Creek 15°25'S, 128°10'E; area of mangal 20 sq. km.

This is a small tidal creek running into Cambridge Gulf 14 km north of Wyndham. The banks are mainly vegetated with low thickets and shrubland of mixed *Avicennia*, *Ceriops*, *Aegiceras* and scattered *Excoecaria*.

The substrate is grey mud. A narrow belt of samphire fringes the mangal, which in turn is backed by bare saline mudflats.

A5. Wyndham 15°29'S, 128°07'E; area of mangal 180 ha.

The mangal consists mainly of open copses of *Avicennia* shrubland with low thickets of *Ceriops* and scattered small trees of *Excoecaria*. Taller *Avicennia* woodland with a ground cover of *Aegialitis* occurs along some tidal creeks. There is a thick belt of samphire on the landward side of the mangal and along the headwaters of some tidal creeks.

The substrate is dark grey mud, and the mangal is backed mainly by bare saline mudflats.

A6. King River 15°36'S, 128°07'E; area of mangal 30 sq. km.

The mouth of the King River contains many large shelving mudbanks. The river edge has relatively thin belts of mangal. The seaward zone is tall *Avicennia* (to 5 m) over low *Aegialitis*. Scattered trees of *Bruguiera*, *Lumnitzera* and *Excoecaria* also occur, and thickets of *Ceriops* and open *Avicennia* shrubland are found on the landward edge. Several large muddy islands are vegetated with *Avicennia* woodland with a dense ground cover of *Acanthus*. The drier tops of these islands have some samphire and stunted *Melaleuca*.

The substrate is dark grey mud. The mangal is backed by mudflats with scattered patches of samphire, and in some areas along the river edge by *Melaleuca*.

B. NORTH-WEST KIMBERLEY

This region extends from Cape Londonderry to King Sound (Figures 1 and 4). Here the most diverse and luxuriant blocks of mangal are found at the mouths of the larger rivers e.g. the Drysdale, Lawley, Hunter, Roe, Prince Regent, Glenelg and Fitzroy. Most of these tropical mangroves are backed by woodlands and saltflats, and in a few places by semi-deciduous vine forests. There is a gap of about 160 km between Cape Dussejour and Cape Londonderry where mangroves only occur in small isolated pockets mostly of less than 10 ha. (Figures 1 and 4).

There is a distinct wet season from December to March when almost all the annual rainfall is received and humidity is high. Mean annual rainfall at Drysdale River is 1189 mm, Lawley River 1583 mm, Prince Regent River 1400 mm and Derby 547 mm.

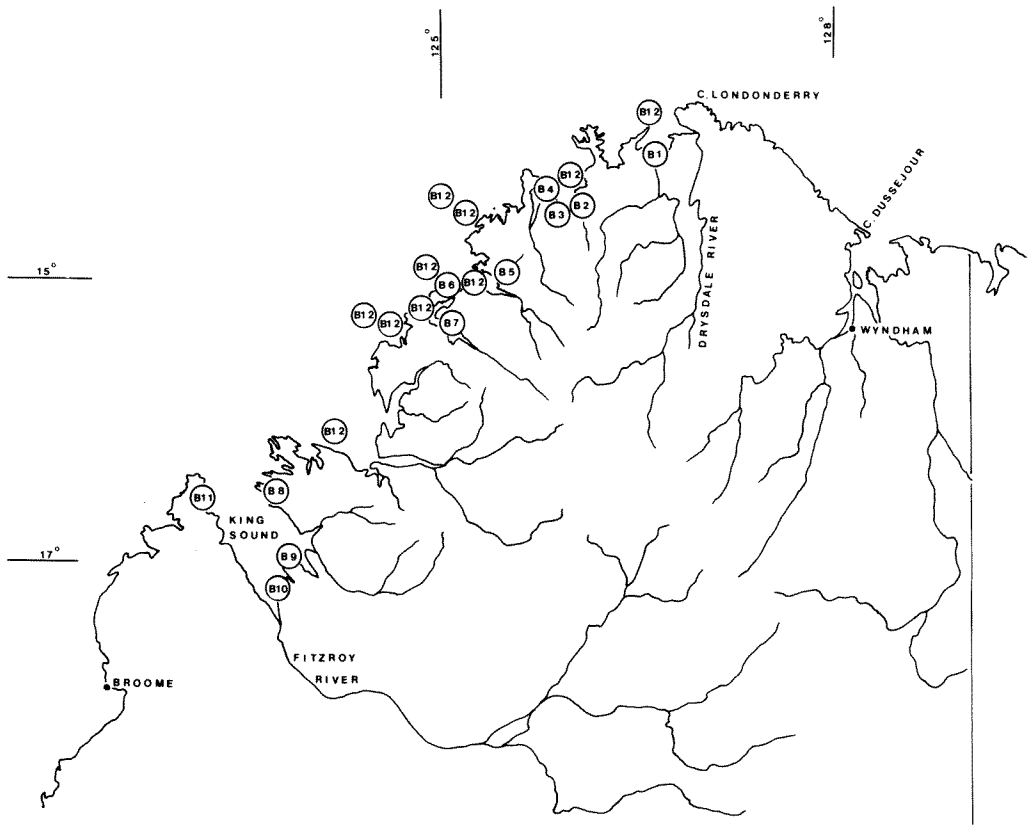

Figure 4 Map of region B, north-west Kimberley, showing the areas visited: B1 Napier Broome Bay; B2 Lawley River delta (Rail Creek); B3 Walsh Point, Port Warrender; B4 Crystal Creek; B5 mouth of Hunter River; B6 Careening Bay; B7 St George Basin; B8 mouth of Trent River; B9 Point Torment; B10 Derby; B11 Cygnet Bay; B12 Kimberley islands (Sir Graham Moore, Borda, Middle Osborn, South West Osborn, Carlia, Bigge, South Maret, Boongaree, Coronation, Uwins, Augustus, Darcy, Byam Martin and Kingfisher).

Fifteen species of mangrove are recorded from this region: *Avicennia marina, Camptostemon schultzii, Lumnitzera racemosa, Excoecaria agallocha, Pemphis acidula, Xylocarpus australasicus, Aegiceras corniculatum, Osbornia octodonta, Aegialitis annulata, Bruguiera exaristata, Bruguiera parviflora, Ceriops tagal, Rhizophora stylosa, Scyphiphora hydrophylacea* (only known from Cape Londonderry), and *Sonneratia alba.*

The twenty-six mangrove areas visited in this region are mapped (Figure 4) and described below.

B1. Napier Broome Bay 14°08'S, 126°43'E; area of mangal 10 ha.

Here the mangal is at the mouth of a small creek flowing into Mission Bay. The seaward zone consists of a thin belt of *Sonneratia* (to 7 m). The creekside vegetation is mainly *Rhizophora* forest (to 5 m) and low *Aegialitis*, and scattered trees of *Bruguiera exaristata* and *Avicennia*. The landward zone is mainly *Avicennia*, thickets of *Ceriops* (to 3 m), and open stands of *Osbornia*.

The substrate is mostly white sand with a few small areas of rock. The mangal is backed by open eucalypt woodland, and tall *Melaleuca* along the creek.

B2. Lawley River Delta (Rail Creek) 14°41'S, 125°52'E; area of mangal 12 sq. km.

The mangal at Rail Creek on the western side of the Lawley River delta is not well zoned but is richer floristically than other areas in Port Warrender, owing to the more

Figure 5 Aerial view of mangal, Rail Creek, Lawley River delta (B2).

Figure 6 Landward edge of mangal, Rail Creek (B2).

varied physiography: extensive shelving mudbanks, numerous small creeks running into the mangal, and sandy, muddy and rocky substrates. The dominant creek pioneer vegetation is mixed low closed forest (5-10 m) of *Avicennia, Sonneratia, Camptostemon, Xylocarpus, Rhizophora, Bruguiera exaristata, B. parviflora, Aegiceras,* and low *Aegialitis.* The landward areas are vegetated with dense stands of *Ceriops* and *Excoecaria.* Tall pure stands of *Bruguiera parviflora* occur on the upper reaches of Rail Creek, and whipstick thickets of *Aegiceras* often grow in the seaward zone among *Rhizophora* etc. Scattered shrubs of *Osbornia* and *Lumnitzera* occur on the landward edge.

The substrate is mainly dark grey mud. The mangal is backed by savannah woodland and in some areas by saline mudflats devoid of vegetation or with a few samphires.

B3. Walsh Point, Port Warrender 14°30'S, 125°50'E; area of mangal 180 ha.

Port Warrender has a high tidal range of 8.3 m and includes many broad shallow bays which contain extensive stands of mangroves. The mangal worked here, just south of Walsh Point, has distinct zonation (see Figure 7). It consists of a seaward zone of *Avicennia* and *Sonneratia* (trees 7-8 m and canopy cover 70%), a middle zone of low

Figure 7 Walsh Point, Port Warrender (B3) showing zonation of mangrove species. A seaward edge of *Sonneratia-Avicennia,* a central *Rhizophora* zone, then a mixed zone and to landward clumps of *Ceriops.*

closed forest of *Rhizophora* and *Camptostemon* (trees 7-10 m and canopy cover > 80%), and a landward zone of *Bruguiera exaristata, Ceriops* and *Avicennia*. A few small areas of *Aegialitis* and *Aegiceras* occur in the seaward zone as do odd trees of *Xylocarpus*. More to landward are found scattered *Osbornia* and *Excoecaria*.

The substrate is grey mud, and the mangal is backed by a saline mudflat.

B4. Crystal Creek 14°29'S, 125°48'E; area of mangal 50 ha.

The vegetation at the mouth of the creek is mainly a mixed low closed forest (5-7 m) of *Sonneratia, Avicennia, Rhizophora, Camptostemon, Bruguiera exaristata* and *Ceriops*.

The substrate is grey mud and rock, and the mangal is backed by a rocky slope.

B5. Mouth of Hunter River 15°01'S, 125°25'E; area of mangal 7.5 sq.km.

The river flows into the north-east corner of Prince Frederick Harbour. The pioneer mangrove *Sonneratia* forms groves on mudbanks, often with an understory of *Aegialitis*. In some areas a mixed community of *Sonneratia, Camptostemon* and *Avicennia* occur. Behind this pioneer fringe is low closed forest of *Rhizophora*. The landward zone is mainly *Ceriops*.

The substrate is dark grey mud. In many places semi-deciduous vine forests grow between the mangal and high cliffs.

B6. Careening Bay, Port Nelson 15°06'S, 125°01'E; area of mangal 3 ha.

The small block of mangroves at the northern end of the bay consists principally of *Avicennia, Rhizophora* and *Ceriops*, with trees of *Camptostemon* on the landward side, and small shrubs of *Aegialitis* on the seaward side.

The substrate is greyish-white sand, and the mangal is backed by open woodland.

B7. Saint George Basin 15°17'S, 125°06'E; area of mangal 142 sq. km.

There is a large mangrove-lined inlet on each side of the Prince Regent River mouth. The northern inlet contains about 70 sq. km. of mangal and the southern about 72 sq. km. Each inlet is broken into a number of channels or creeks which are further divided into side channels. These mangals constitute two of the largest blocks in Western Australia. The seaward zone is a low closed forest of *Sonneratia, Camptostemon* and *Avicennia*, behind which *Rhizophora* forms either a distinct band or large patches of low closed forest. The landward zone consists commonly of mixed thickets of *Ceriops, Avicennia* and *Excoecaria. Aegiceras* occurs along some of the tidal creeks, and tall (7-10 m) pure stands of *Bruguiera parviflora* grow in some landward areas near Mt Trafalgar.

The substrate is mainly grey mud, and the mangal is backed by open savannah woodland or bare saline mudflats.

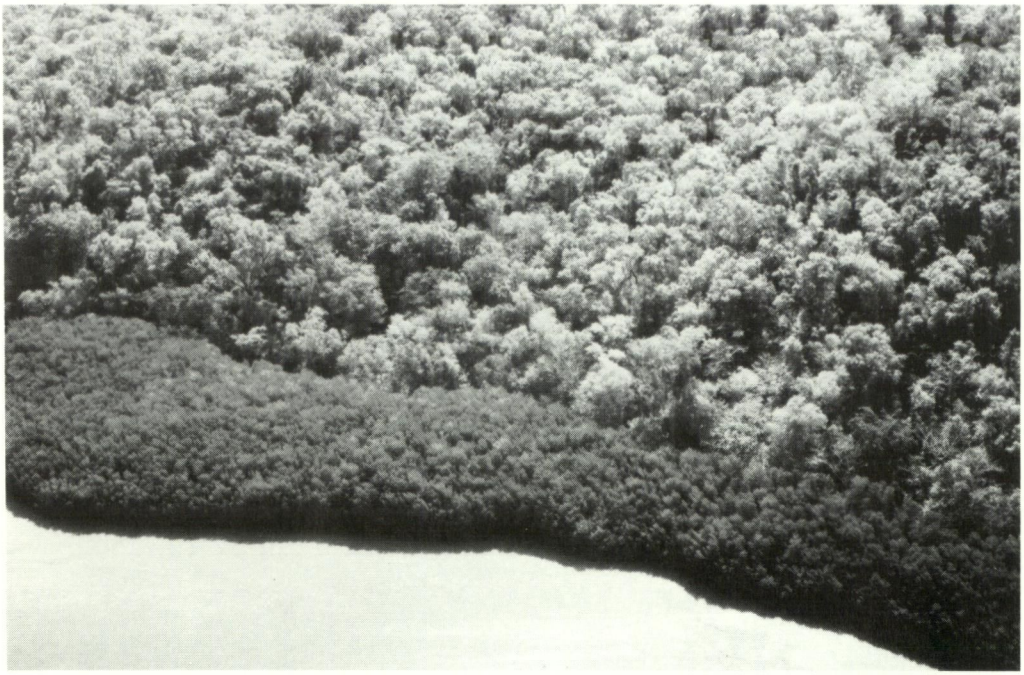

Figure 8 Mangal backed by vine forest, Saint George Basin.

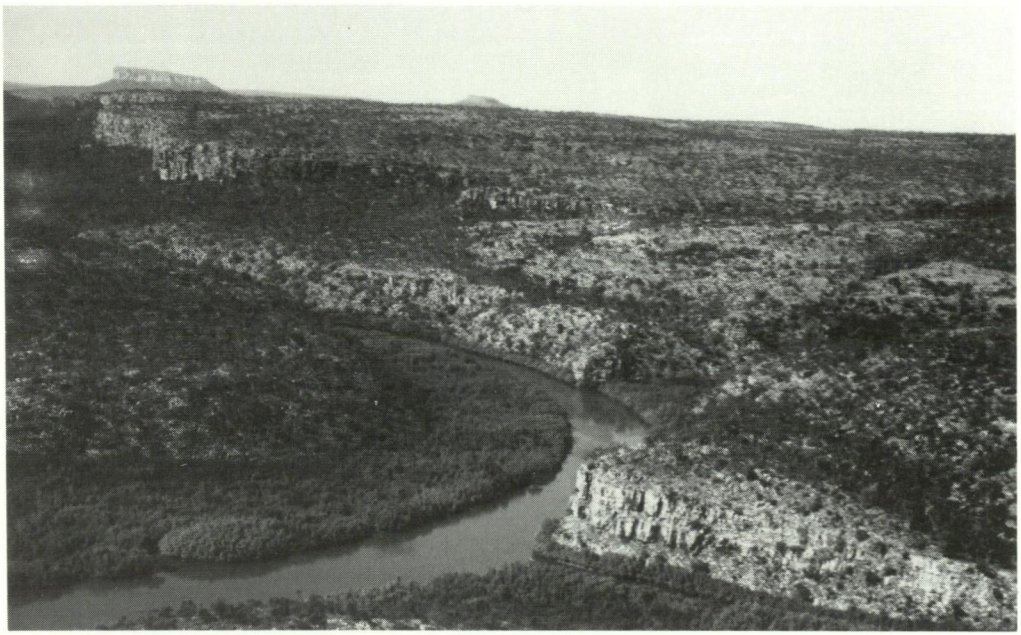

Figure 9 Mangal backed by open eucalypt woodland on tidal creek, Saint George Basin.

Figure 10 *Bruguiera* forest, landward edge, Saint George Basin (B7).

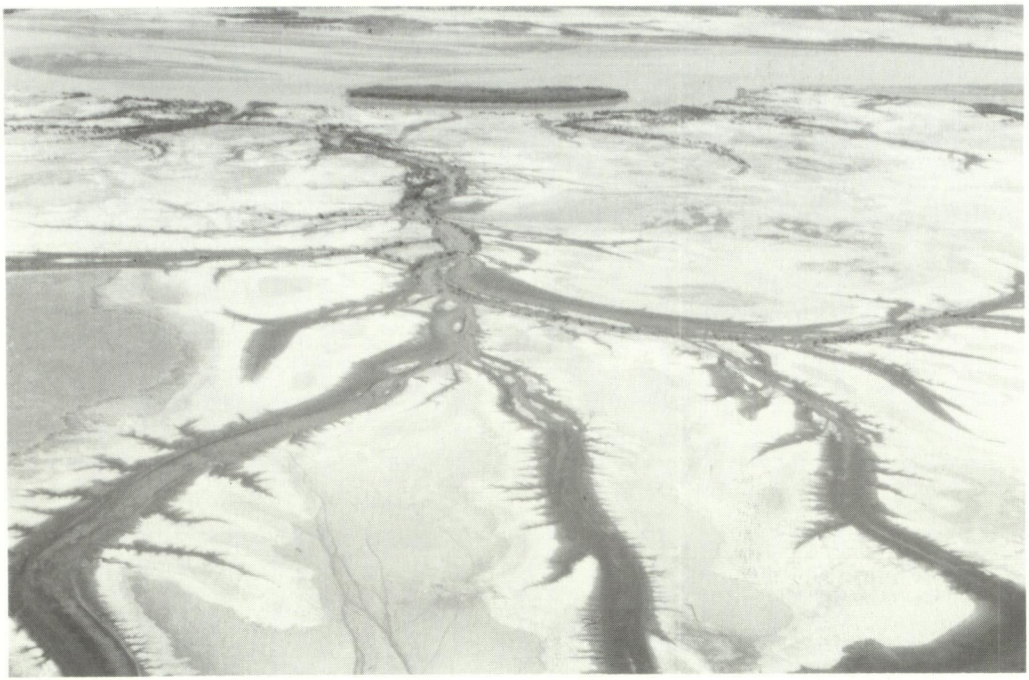

Figure 11 Tidal saltflats, Walcott Inlet.

B8. Mouth of Trent River 16°34'S, 123°07'E; area of mangal 480 ha.

The river flows into a large inlet near Port Usborne at the northern entrance to King Sound. The mangroves along the Trent are dissected with many channels and deep shelving mudbanks. The seaward zone consists of low closed forest of *Rhizophora, Avicennia, Camptostemon, Bruguiera parviflora* and *B. exaristata,* with an understory of *Aegiceras* and some *Aegialitis* growing in deep mud along creeks. The *Rhizophora* and *Bruguiera parviflora* often form pure stands, the latter 10-12 m high. A few scattered *Xylocarpus* also occur in this zone. The central zone is mainly forest and woodland of *Avicennia, Camptostemon* and tall *Bruguiera* with a dense understory of *Aegiceras* (to 6 m). The landward zone is mostly thickets of *Ceriops* and taller stands of *Excoecaria* (8-10 m), and a few trees of *Lumnitzera.*

The substrate is dark grey mud. The mangal is backed by bare saline mudflats, which are fringed by samphire, *Sporobolus* and *Melaleuca.*

B9. Point Torment 17°02'S, 123°35'E; area of mangal 60 sq. km.

The mangroves studied at Point Torment were on the north-eastern (Stokes Bay) side of the peninsula. Here they form a wide belt with fairly good zonation, parallel to the coast and dissected by many small creeks. The main creeks have the most complex marginal vegetation towards the seaward side. To landward the major creeks become shallower,

tributaries more numerous, and their marginal vegetation less diverse. The sources of the creeks could be discerned on the mudflats as mere gutters. The seaward zone is low closed forest of *Rhizophora, Camptostemon* (along creeks), *Bruguiera exaristata, Avicennia* and *Aegiceras.* The central zone is mainly *Avicennia* and *Bruguiera with some Ceriops, Camptostemon* and *Rhizophora.* The landward zone is mostly scattered *Avicennia, Excoecaria* and *Osbornia,* and open to dense thickets of *Ceriops.*

The substrate is dark grey mud. The mangal is backed by samphire flats with *Sporobolus virginicus,* further to landward there is a thin belt of *Melaleuca acacioides.*

B10. Derby 17°18'S, 123°37'E; area of mangal 40 sq. km.

Derby has a high tidal range of 11 m. Here the mangroves grow on a long, gently sloping mudbank, which has allowed the trees to form good zonal belts. There is a thin seaward belt of *Avicennia* followed by a belt of *Camptostemon, Aegialitis, Aegiceras* and *Rhizophora,* frequently mixed but in some areas *Rhizophora* forms pure stands, and a landward zone of mainly *Ceriops* and *Avicennia.*

The substrate is grey mud, and the mangal is backed by saline mudflats.

Figure 12 Aerial view of mangal and saltflats, mouth of Fitzroy River.

B11. Cygnet Bay 16°34'S, 123°00'E; area of mangal 240 ha.

On the north-east Dampier Land coast mangroves are found on tidal mudflats in sheltered bays and estuaries. At Cygnet Bay there is a pioneer zone of *Sonneratia* (one

Figure 13 *Rhizophora* forest, Cygnet Bay (B11), photographed by K.F. Kenneally.

or two trees deep and up to 10 m high). It is backed by low to tall forest of *Rhizophora* (to 14 m with a canopy cover of 60-100%) and mixed *Rhizophora* and *Avicennia* (to 15 m) forest (with a canopy cover of 40-80%. The landward zone consists of thickets of *Ceriops* (to 4 m, with a canopy cover of 80-100%) and scattered trees and shrubs of *Avicennia* and *Osbornia.*

The substrate is grey mud and rock, and the mangal is backed by open eucalypt woodland.

B12. Kimberley islands

There are small blocks of mangroves on many islands in the Bonaparte and Buccaneer Archipelagoes; most of them are limited to narrow strips in sheltered areas. Mangrove areas were studied on fifteen islands (see Figure 4). The richest are on Carlia, South-west Osborn, Boongaree, Coronation, and Darcy Islands. The more extensive stands have a seaward zone of *Sonneratia,* a central zone of low closed forest of *Rhizophora, Avicennia, Bruguiera exaristata, Aegiceras* and low *Aegialitis,* and a landward zone of *Ceriops, Avicennia* and scattered *Lumnitzera.*

C. SOUTH-WEST KIMBERLEY

This region extends from Cape Leveque, near the northern tip of Dampier Land, south to Whistle Creek, at the northern end of the Eighty Mile Beach (Figures 1 and 14). Here the most extensive mangrove communities are found at the mouths of creeks, in lagoons behind barrier dunes and in sheltered bays. There are no large watercourses. The climate is drier than region B, with a distinct wet season from December to March during which almost all the annual rainfall is received. Mean annual rainfall for Cape Leveque is 718 mm and Broome 541 mm.

Full zonation of mangrove species is still well developed within this region, but four species are absent: *Bruguiera parviflora, Acanthus ebracteatus, Xylocarpus australasicus* and *Scyphiphora hydrophylacea.* One of the features of this region is the scarcity of tall *Rhizophora* forest and of stands of *Sonneratia,* the latter only occurring at Packer Island in the north of the region and at Cape Bossut in the south. Saltmarshes and mudflats which support the samphire *Halosarcia halocnemoides,* are fairly extensive behind many of the coastal dunes; they are often fringed by a paperbark *Melaleuca acacioides.*

Twelve species of mangrove are recorded from this region namely: *Avicennia marina, Camptostemon schultzii, Lumnitzera racemosa, Excoecaria agallocha, Pemphis acidula, Aegiceras corniculatum, Osbornia octodonta, Aegialitis annulata, Bruguiera exaristata, Ceriops tagal, Rhizophora stylosa* and *Sonneratia alba.*

Nine blocks of mangal were visited (Figure 14).

C1. Packer Island 16°35'S, 122°47'E; area of mangal 300 ha.

The mangroves here grow at the mouth of Tilbata Creek on the south end of Packer Island. The seaward zone consists of *Sonneratia* (to 10 m but only one tree wide), giving

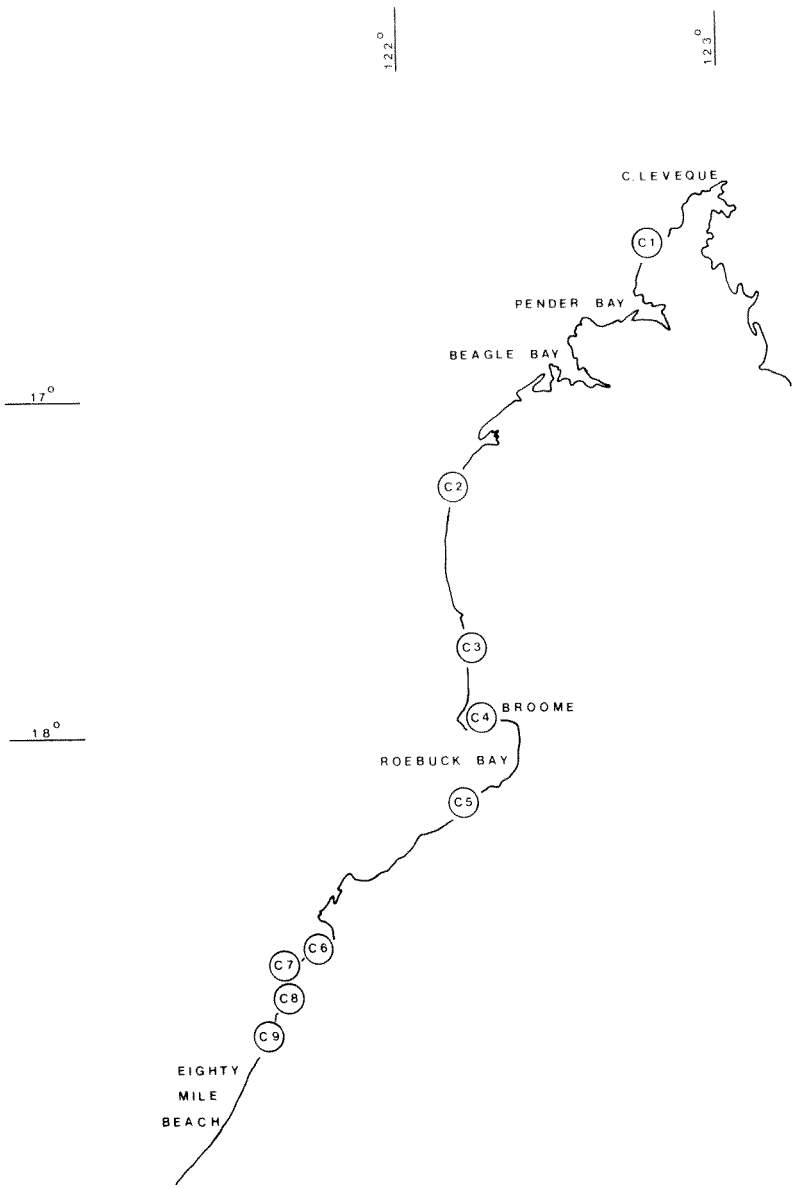

Figure 14 Map of region C, south-west Kimberley, showing the areas visited: C1 Packer Island; C2 3 km S of Cape Bertholet; C3 Willie Creek; C4 Broome; C5 Thangoo; C6 Lagrange Bay; C7 Cape Bossut; C8 Rocky Creek; C9 Whistle Creek.

way to *Avicennia* with a ground cover of *Aegialitis*, or in some areas to *Camptostemon* and *Aegiceras*. There is a broad central zone of low closed forest of *Avicennia* and *Rhizophora* (pure or mixed stands), followed by tall (14-16 m) woodland of *Camptostemon* and *Avicennia*

with an understory of *Aegiceras* growing on deep mud. The landward zone comprises *Ceriops, Camptostemon, Bruguiera, Osbornia,* with some *Lumnitzera* in sheltered areas.

The substrate is mainly whitish sand and grey mud. The mangal is backed by bare mudflats, which are fringed to landward by low samphire.

C2. 3 km S of Cape Bertholet 17°16'S, 122°10'E; area of mangal 130 ha.

This mangal grows in a large lagoon behind a barrier dune. There is a small island at the mouth of the lagoon with a narrow tidal creek each end. The seaward fringe is *Avicennia* woodland, succeeded by tall mixed woodland of *Bruguiera* (many dead trees) and *Avicennia. Camptostemon* (to 12 m) with an understory of *Aegiceras* (to 5 m) and scattered *Aegialitis* fringe tidal creeks. The landward zone is mainly thickets of *Ceriops* (to 3.5 m) and/or *Avicennia,* with scattered trees and shrubs of *Osbornia, Excoecaria* and *Lumnitzera.*

The substrate is white sand. The mangal is backed by mudflats fringed by belts of samphire, which in turn are fringed by thickets of *Melaleuca acacioides.*

Figure 15 Mangal behind barrier dune near Cape Bertholet (C2).

C3. Willie Creek 17°46'S, 122°13'E; area of mangal 800 ha.

This is a wide tidal creek, rocky on the northern side and at the mouth and muddy on the southern side. The seaward belt of mangal is low closed forest of *Avicennia*

(3-4 m), *Bruguiera*, and *Rhizophora* (5-8 m) and scattered *Aegiceras* (to 5 m). Tall *Camptostemon* (9-11 m) grows along some creeks; this species and thickets of *Ceriops* (to 3.5 m) are dominant in the landward zone, which includes trees and shrubs of *Osbornia* and *Excoecaria*.

The substrate is mostly white sand and grey mud. The mangal is backed by bare mudflats, which have an outer fringe of samphire and *Melaleuca acacioides*.

C4. Broome 17°59'S, 122°23'E; area of mangal 640 ha.

Broome has a tidal range of 10 m. The main area studied was at Crab Creek, which empties into Roebuck Bay. The seaward zone of mangal consists of low open to closed *Avicennia*, *Aegiceras*, *Camptostemon* and *Rhizophora* with some *Aegialitis* understory. *Avicennia* is the most common species forming dense stands in the landward zone, with scattered trees and shrubs of *Excoecaria* on the outer fringe.

The substrate is grey mud and sand. The mangal is backed by bare mudflats and samphire flats with an outer belt of open *Melaleuca acacioides*.

C5. Thangoo 18°16'S, 122°10'E; area of mangal 200 ha.

This mangal grows in a large narrow-mouthed inlet which cuts back behind coastal barrier dunes. The seaward zone is open to closed *Avicennia* woodland (up to 5 m) with scattered large stout trees. This is succeeded by mixed woodland (to 5 m) of *Avicennia*, *Bruguiera*, *Osbornia* and *Camptostemon*, the latter favouring the banks of tidal creeks. The landward zone is mainly closed thickets of *Ceriops* (2-4 m) and areas of open large dome shrubs of *Excoecaria* (3-4 m).

The substrate is light grey mud. The mangal is backed by samphire flats with an outer landward belt of buffel grass and thickets of *Melaleuca acacioides*.

C6. Lagrange Bay 18°37'S, 121°46'E; area of mangal 15 ha.

A small stand of *Camptostemon* trees and shrubs (to 5 m) fringes a tidal creek. The substrate is light grey sand and mud, and the mangal is backed by mudflats and samphire flats.

C7. Cape Bossut 18°42'S, 121°37'E; area of mangal 140 ha.

This mangal fringes a small creek running out of a samphire flat; its mouth is protected by a rocky headland and coastal dunes. The seaward zone comprises a few scattered *Sonneratia* with *Camptostemon*, *Avicennia* and *Aegialitis*. The central zone is low closed forest of *Rhizophora* and in some areas mixed woodland of *Avicennia*, *Bruguiera* and *Rhizophora*. The landward zone contains stands of *Camptostemon* (to 5 m), low open *Avicennia* and thickets of *Ceriops* (to 3 m). A stunted line of *Avicennia* follows the main tidal creek back on to the mudflat. There is a small stand of about one hectare

Figure 16 Aerial view of mangal, Roebuck Bay (C4).

of pure whipstick *Ceriops* (1.5-2 m) growing nearly 1 km away from the main mangal on a bare mudflat.

The substrate is white sand and grey mud, and the mangroves are backed by a dune with *Spinifex longifolius* and mudflats and samphire flats.

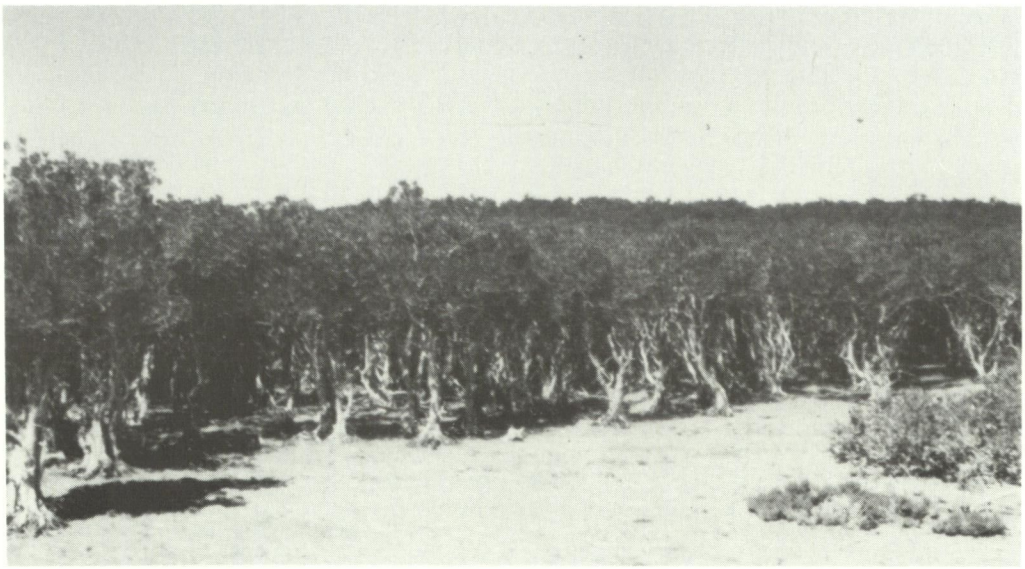

Figure 17 Low *Ceriops*, landward edge, Cape Bossut (C7).

C8. Rocky Creek 18°49'S, 121°39'E; area of mangal 240 ha.

This is a small J-shaped creek running back behind coastal dunes on Frazier Downs. The seaward mangal is tall open *Avicennia* woodland, mixed in some places with *Camptostemon*. The central zone is low, open to closed, *Rhizophora* forest, forming pure stands or mixed with *Avicennia* and/or *Camptostemon*. The landward zone is mainly thickets of *Ceriops* and scattered *Bruguiera*, and a line of stunted *Avicennia* follows the creek to its end.

The substrate is whitish-grey sand and grey mud. The mangal is flanked by dunes with *Acacia* and *Spinifex longifolius* and backed by mudflats and samphire flats.

C9. Whistle Creek 18°57'S, 121°35'E; area of mangal 50 ha.

Whistle Creek is a large-mouthed tidal creek running behind coastal dunes at the northern end of the Eighty Mile Beach. The seaward mangal is low *Avicennia*, backed by small areas of *Rhizophora*, and some *Camptostemon* along small creeks. The landward zone is mainly dense low thickets of *Ceriops*.

The substrate is grey mud and sand, and the mangal is backed by samphire flats which in turn are fringed by *Melaleuca acacioides*.

D. PILBARA

This region extends along the Pilbara coast from Cape Keraudren, at the southern end of the Eighty Mile Beach, to Yardie Creek on the western side of the North West Cape peninsula (Figures 1 and 18). The Eighty Mile Beach is almost devoid of mangroves due to the lack of creeks and reef sheltered bays. The exceptions are on Mandora Station where two small tidal creeks contain mangal (see below). There is also an inland stand of *Avicennia* along a creek running into a saltlake 40 km from the coast at 19°45'S, 121°20'E (Beard 1967). Along the Pilbara coast the biggest and most luxuriant blocks of mangal are found at the mouths of the larger creeks and rivers and in sheltered bays.

The climate of this region is arid. Mean annual rainfall at Port Hedland is 307 mm, Roebourne 321 mm, Dampier 361 mm, Onslow 267 mm, and Exmouth 325 mm. Most of it falls from January to April.

Compared with region C, there is more *Rhizophora* forest, no doubt due to the large number of creeks and rivers bringing down fresh water and depositing silt at their mouths. Four species of mangrove in region C are absent here: *Camptostemon schultzii, Lumnitzera racemosa, Pemphis acidula* and *Sonneratia alba.* Eight species of mangrove are recorded from the present region: *Avicennia marina, Excoecaria agallocha, Aegiceras corniculatum, Osbornia octodonta, Aegialitis annulata, Bruguiera exaristata, Ceriops tagal* and *Rhizophora stylosa.*

Twenty-nine blocks of mangal were visited (Figure 18).

D1. Mandora

Two tidal creeks were studied here, one 13 km NNE of Mandora (19°39'S, 120°56'E; area of mangal 50 ha.), and Mandora Creek (6 km N of Mandora; area of mangal 50 ha.). These are the only areas of mangal along the Eighty Mile Beach. Both creeks cut the coastal dunes and run back behind them parallel to the coast. The northern creek has a seaward zone of low thickets of pure *Avicennia* becoming open shrubland on the landward side. The landward zone contains many dead trees, and is being covered by dunes. The substrate is white sand, and the mangal is backed by dunes and samphire flats.

At Mandora Creek the mangal is mainly low thickets of whipstick *Avicennia,* with some small areas of taller *Avicennia* woodland (4-6 m), most trees with the mistletoe *Amyema.* Two shrubs of *Ceriops* were found about 1 km from the creek mouth on the east bank. The substrate is greyish white sand and sandy mud. The mangal is backed by samphire, some of which extends into the landward *Avicennia.*

D2. Cape Keraudren 19°58'S, 119°46'E; area of mangal 330 ha.

The mangroves here grow along a large creek that cuts the coast and runs behind rocky and sandy headlands. The creek divides into smaller channels and ends on a bare

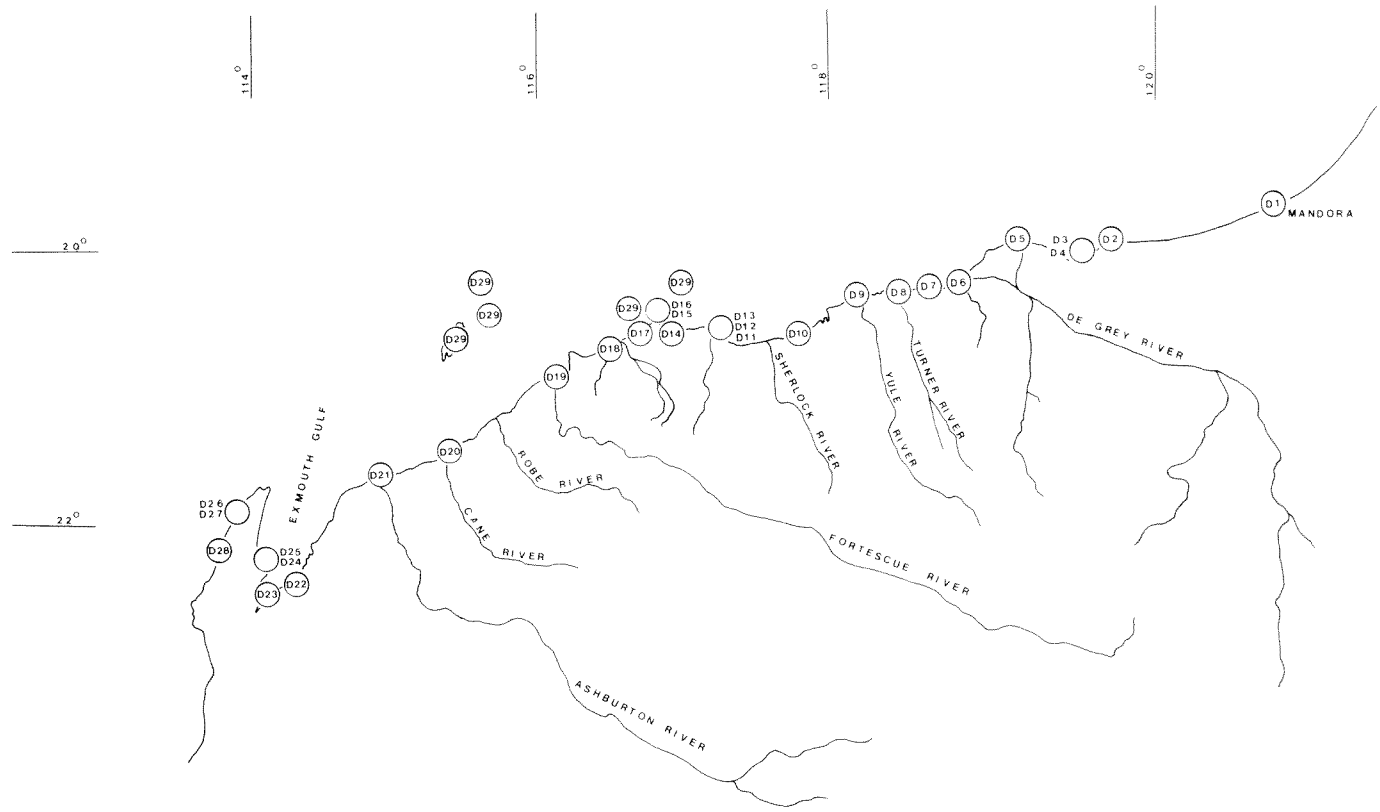

Figure 18 Map of region D, the Pilbara, showing the areas visited: D1 Mandora; D2 Cape Keraudren; D3 Mt Blaze; D4 Pardoo Creek; D5 mouth of De Grey River; D6 Leslie Salt; D7 Port Hedland; D8 mouth of Turner River; D9 Cowrie Creek; 10 km SSW of Cape Thouin; D10 Balla Balla Harbour; D11 Butcher Inlet, Cossack; D12 2 km SW of Point Samson; D13 Popes Nose Creek; D14 Nickol Bay; D15 Withnell Bay; D16 King Bay; D17 Dampier Salt; D18 mouth of Devil Creek; D19 mouth of Fortescue River; D20 mouth of Cane River; D21 mouth of Ashburton River; D22 Giralia Bay; D23 Gales Bay; D24 Bay of Rest; D25 near Learmonth; D26 Mangrove Bay; D27 Low Point; D28 Yardie Creek; D29 Pilbara islands (Dampier Archipelago, Montebello Islands; Lowendal Islands and Barrow Island).

mudflat. Low closed forest of *Rhizophora*, often with low *Aegialitis* understory, grows on the more seaward zone, and along the main creeks *Avicennia* and scattered trees of *Osbornia* and *Bruguiera* and shrubs of *Aegiceras* grow in the more landward areas, and thickets of *Ceriops* and *Rhizophora* abut the samphire flats and mudflats.

The substrate is grey mud and rock.

Figure 19 Low *Rhizophora* and *Avicennia* on tidal creek, Cape Keraudren (D2).

D3. Mt Blaze 20°01'S, 119°41'E; area of mangal 100 ha.

The mangal here just south of Mt Blaze follows two small creeks into a sheltered bay. It is mainly *Avicennia* woodland (to 3 m) with many dead trees. The substrate is grey mud and rock, and the mangal is backed by bare mudflats and dunes with *Acacia*.

D4. Pardoo Creek 20°04'S, 119°34'E; area of mangal 100 ha.

Pardoo Creek (4 km NW of Pardoo HS) is a deep tidal creek running back through a bare mudflat. Large dome-shaped *Avicennia* (to 4 m) are the dominant mangrove in both the landward and seaward zones. Scattered trees of *Rhizophora* (2-3 m) grow along tidal tributaries, and thickets of *Ceriops* (1-2 m) and scattered trees of *Excoecaria* occur on the landward fringe.

The substrate is grey mud, and the mangal is backed by mudflats, samphire flats and dunes.

D5. Mouth of De Grey River 19°59'S, 119°09'E; area of mangal 14 sq. km.

The mangal here is almost exclusively low *Avicennia* (to 3 m). It is broken by areas of bare mud and in some places by low dunes with *Sporobolus* and samphire. Some drainage channels have taller *Avicennia* shrubland. A few stunted *Rhizophora* occur near the river mouth. Many of the smaller creeks and channels with sandy soil support scattered trees of *Excoecaria* (3-4 m).

The substrate is mainly grey mud and sand, and the mangal is backed by mudflats and by dunes with *Triodia* and *Crotalaria*.

D6. Leslie Salt 20°15'S, 118°52'E; area of mangal 160 ha.

The mangroves fringe a tidal creek running back 5 km on to coastal flats. *Avicennia* is dominant in both the landward and seaward zones. Small areas of *Rhizophora* occur along tributary creeks.

The substrate is grey mud, and the mangal is backed by mudflats with scattered samphire.

D7. Port Hedland 20°20'S, 118°37'E; area of mangal 20 ha.

Port Hedland has a tidal range of 8 m. A small area of pure *Avicennia* shrubland was visited near the town at Stingray Creek. It is backed by bare, grey, mudflats.

D8. Mouth of Turner River 20°21'S, 118°29'E; area of mangal 230 ha.

Figure 20 *Avicennia* woodland, mouth of Turner River (D8).

This mangal has a broad seaward zone of mature closed forest of thick-trunked, well spaced *Avicennia* (to 6 m). This is succeeded by low open *Avicennia* woodland (trees and shrubs), grading into open *Avicennia* shrubland in the landward zone.

The substrate is grey mud, and the mangal is backed by samphire flats and by low dunes with *Spinifex longifolius*.

D9. Cowrie Creek, 10 km SSW of Cape Thouin 20°24'S, 118°06'E; area of mangal 80 ha.

The mangroves here grow in a small inlet and along creeks running back behind large coastal dunes. At the seaward edge of the creeks, on mudbanks and muddy islands, are mature closed forests of *Rhizophora* and *Avicennia* with an understory of *Aegialitis*. The smaller creeks are vegetated with *Avicennia* forest (thick-trunked trees to 5 m), backed by open whipstick *Avicennia* (to 4 m). There are some low thickets of *Ceriops* on the landward side.

The substrate is grey mud, and the mangal is backed by samphire flats, and dunes with *Acacia* spp., *Scaevola spinescens* and *Spinifex longifolius*.

D10. Balla Balla Harbour 20°40'S, 117°45'E; area of mangal 50 ha.

This contains the mouth of Balla Balla River and has several large tidal creeks running back on to coastal flats. There is a seaward zone of mature closed forest of *Rhizophora* (dominant) and scattered, thick-trunked *Avicennia* (4-6 m); on muddy banks the understory is *Aegialitis*. There are several large areas of low open forest of *Avicennia* just landward of the *Rhizophora* zone, and some small thickets of *Aegiceras* occur throughout. The landward zone is mainly thickets of *Ceriops* and/or *Avicennia*.

The substrate is grey mud, and the mangal is backed by mudflats and samphire flats.

D11. Butcher Inlet, Cossack 20°41'S, 117°11'E; area of mangal 400 ha.

This consists of the mouth of the Harding River and numerous tidal creeks. It contains the most luxuriant mangal in the Pilbara. The seaward zone is mainly a low closed forest of *Rhizophora* in pure stands or mixed with trees and shrubs of *Avicennia* and (on mudbanks) low *Aegialitis*. The larger mudbanks have pure stands of *Bruguiera* (4-6 m). The landward zone is mainly thickets of *Ceriops*, low shrubs of *Osbornia* and *Aegiceras* and trees and shrubs of *Avicennia*.

The substrate is mainly grey mud, and the mangal is backed by dunes with spinifex, rocky headlands and open samphire flats.

D12. 2 km SW of Point Samson 20°39'S, 117°10'E; area of mangal 130 ha.

Point Samson has a tidal range of 6 m. The mangroves studied here are in a large V-shaped embayment that opens into Port Walcott and is protected on each side by rocky headlands. The seaward zone is mainly mature, low closed forest of *Rhizophora*

(to 4 m) and in some areas mixed *Rhizophora* and *Avicennia* forest with low *Aegialitis* on mudbanks. This is succeeded by open woodland and forest of mature *Avicennia* with many large-trunked trees. More to landward are areas of mixed woodland and thickets of *Avicennia* and *Ceriops*, and the outer landward zone is mainly thickets of *Ceriops* and *Aegiceras*, the former species favouring the sandy areas.

The substrate is grey mud and whitish grey sand. The mangal is backed by samphire flats and rocky headlands.

D13. Popes Nose Creek 20°38'S, 117°10'E; area of mangal 220 ha.

This is a large tidal creek flowing into the north end of Port Walcott at Point Samson. There is a seaward zone of mature low closed forest of *Rhizophora* (to 4 m), mixed in some areas with *Avicennia* (4-5 m) and replaced in others by small pockets of *Avicennia* woodland. The landward zone is mainly thickets of *Avicennia*, *Ceriops* and *Aegiceras*.

The substrate is dull grey mud and greyish sand. The mangal is backed by low dunes with *Acacia*.

D14. Nickol Bay 20°40'S, 116°50'E; area of mangal 720 ha.

The mangroves along a small tidal creek 5 km south of Hearson Cove are almost exclusively stunted *Avicennia* with wide mudflats and samphire flats on the landward side. The substrate is grey mud.

D15. Withnell Bay 20°35'S, 116°47'E; area of mangal 20 ha.

The mangroves here grow in a narrow fringe around the Bay. It is mostly *Avicennia* and *Ceriops*. The substrate is grey mud, shell or muddy sand.

D16. King Bay 20°38'S, 116°45'E; area of mangal 30 ha.

The seaward zone is low forest of *Rhizophora* and *Avicennia* in pure or mixed stands, succeeded by tall *Bruguiera* forest (3-5 m) with an understory of *Bruguiera* saplings. Thickets of *Ceriops* and *Avicennia* dominate the landward zone.

The substrate is greyish-white sand, mud, shell grit, or muddy sand. The mangal is backed by low *Acacia*.

D17. Dampier Salt 20°43'S, 116°37'E; area of mangal 540 ha.

Dampier has a tidal range of 4.3 m. The mangroves studied here were opposite West Intercourse Island. They consist of a seaward *Avicennia* fringe, followed by a zone of *Rhizophora* forest (to 8 m, with saplings to 1.5 m) and scattered trees or small stands of *Avicennia* (to about 5 m). Mixed forests of *Rhizophora*/*Bruguiera* and *Bruguiera*/*Avicennia* occur in the sandy central zone. More to landward the *Avicennia* forms low forest grading into open scrub and often mixing with stunted thickets of *Ceriops*. There are also scattered trees and shrubs of *Aegiceras* in the landward zone.

The substrate is grey sand and mud, and the mangal is backed by salt ponds.

D18. Mouth of Devil Creek 20°50'S, 116°26'E; area of mangal 130 ha.

The mangal is mainly low closed forest of *Rhizophora* (to 4 m) growing on the muddy creek banks. This is backed by domed *Avicennia* (to 3 m, with scattered taller trees reaching 5 m), which grades on the landward side into low *Avicennia* thickets with scattered *Ceriops*.

The substrate is reddish-brown mud and sand, and the mangal is flanked by dunes with *Acacia coriacea*.

D19. Mouth of Fortescue River 21°00'S, 116°06'E; area of mangal 80 ha.

The mangal is predominantly *Avicennia*, mostly open shrubland but with some trees up to 4 m along the river edge. There are a few scattered low trees of *Rhizophora* and several small areas of immature *Rhizophora* (to 2 m).

The substrate is red mud, and the mangal is backed by open grassy flats.

D20. Yardie Landing, mouth of Cane River 21°33'S, 115°23'E; area of mangal 350 ha.

The most extensive mangal grows on the northern side of the river near its mouth. It consists of mature *Rhizophora* forest (to 8 m) backed by tall mature *Avicennia* forest and woodland. Further upstream on the northern bank the *Rhizophora* is lower (5-6 m) and is often mixed with *Avicennia*. Some *Ceriops* and low *Avicennia* grow in

Figure 21 *Rhizophora* forest, mouth of Cane River (D20).

the landward zone. Thickets of low closed *Ceriops* and *Aegiceras* grow on sandy islands where the river divides into channels. On the southern sandy bank of the river there are three mature *Bruguiera* trees, and further upstream on the same side open *Avicennia* woodland surrounds a small area of *Rhizophora* forest.

The substrate is bright red mud and sand. The mangal is backed by open samphire flats and by dunes with *Acacia* and *Spinifex longifolius*.

D21. Mouth of Ashburton River 21°42'S, 114°56'E; area of mangal 80 ha.

This area has a tidal range of 2.6 m. The mangal consists almost entirely of *Avicennia*, mainly as low open forest, thickets and open shrubland. There are several small areas of immature *Rhizophora* along some side channels. Still smaller channels have low thickets of *Aegiceras* and *Ceriops*.

The substrate is red mud, and the mangal is backed by bare mudflats and samphire flats.

D22. Giralia Bay 22°28'S, 114°23'E; area of mangal 14 sq. km.

This mangal has a seaward zone of *Avicennia* woodland, mainly thick-trunked trees to 4 m. This gives way to a zone of low closed forest (2 m) of immature *Avicennia* and scattered immature *Rhizophora*. The landward zone consists of open *Avicennia* woodland and stunted thickets.

The substrate is greyish-brown mud and white sand, and the mangal is backed by samphire flats.

D23. Gales Bay 22°27'S, 114°04'E; area of mangal 9 sq. km.

This is a broad U-shaped bay just west of Giralia Bay at the base of Exmouth Gulf. It has a seaward zone of low closed forest of mature *Rhizophora* (4-5 m), succeeded by a central zone of mature *Avicennia* forest and woodland and in some areas mixed *Rhizophora* and *Avicennia*. To landward the central zone grades into *Avicennia* thickets and in some places low thickets of *Ceriops*. A few *Bruguiera* grow on the sandy shore.

The substrate is greyish-brown mud and grey sand, and the mangal is backed by samphire flats.

D24. Bay of Rest 22°19'S, 114°08'E; area of mangal 250 ha.

This bay has a seaward zone of low open *Avicennia* woodland or less frequently a thin zone of low, open to closed *Rhizophora* (to 3 m), mainly of immature trees mixed with scattered thick-trunked *Avicennia*. The *Rhizophora* is not very extensive and the canopy is fairly open. There is a broad landward zone of *Avicennia* woodland and shrubland.

The substrate is grey-brown mud, and the mangal is backed by low dunes and limestone ridges.

Figure 22 *Rhizophora* forest, Bay of Rest (D24).

D25. Near Learmonth 22°14'S, 114°07'E; area of mangal 35 ha.

This area has a tidal range of 3 m. The mangroves grow along two small creeks that run back on to coastal mudflats. The mangal consists of a thin seaward zone of *Avicennia* woodland, backed by low *Avicennia* shrubland. This is the northernmost block of mangroves on the western shore of Exmouth Gulf.

The substrate is greyish-brown mud.

D26. Mangrove Bay 21°58'S, 113°57'E; area of mangal 55 ha.

Mangrove Bay lies to the north of Low Point on the west side of the North West Cape Peninsula. It contains a small but fairly well developed mangrove system. The mangal follows Tantabiddy Creek, a small inlet running back behind coastal dunes and disappearing on samphire flats. Small channels connect the sea with several open-water lagoons. Tall 5-6 m *Avicennia* forest fringes the main lagoons. In 1980, 17 *Rhizophora* trees were growing around the main lagoon. Further back the vegetation was open *Avicennia* woodland and thickets (to 4 m) thinning out to low *Avicennia* shrubland and heath (1-2.5 m). The *Avicennia* then tailed off across a samphire flat and became smaller and more stunted. There was a large area of mostly (60%) dead *Avicennia* on the NW side of the mangal, with only a few seedlings; further out all the trees were dead and there were no seedlings. At the mouth of the creek were several patches of huge dome-shaped *Avicennia;* one *Bruguiera* tree with several seedlings beneath it was found growing in sandy soil.

The substrate is greyish brown mud and sand, and the mangal is backed by samphire flats. This is the southern limit for *Bruguiera* (excluding those in Exmouth Gulf). In the past *Rhizophora* was evidently much more plentiful (see discussion).

D27. Low Point 21°59'S, 113°56'E; area of mangal 30 ha.

The mangroves grow in a small bay protected by a sandy point. There is a seaward zone of low open *Avicennia* woodland grading back to low stunted *Avicennia.*

The substrate is greyish white sand and mud, and the mangal is backed by samphire flats.

D28. Yardie Creek 22°19'S, 113°49'E; area of mangal 0.5 ha.

The mouth of Yardie Creek contains a small area of *Avicennia* and several *Rhizophora,* mainly low stunted trees and a few large dome-shaped shrubs. This is the southern limit for *Rhizophora* (excluding those in Exmouth Gulf).

D29. Pilbara islands

Small blocks of mangal occur on many islands in the Dampier Archipelago including Legendre, West Lewis, Enderby and West Intercourse, and on the Montebello and Lowendal Islands, and Barrow Island. Most blocks are in sheltered bays, and the dominant species

are *Avicennia, Rhizophora, Bruguiera* and *Ceriops*. On West Lewis Island there is a seaward belt of *Rhizophora*, backed by *Avicennia* and *Ceriops*. On Hermite Island the largest stand of mangroves is in a lagoon near the north end of the island. There is a seaward zone of dense *Bruguiera* backed by a varying width of *Avicennia* (tall mature trees) and scattered *Ceriops*. Small areas of *Rhizophora* also occur.

E. CARNARVON - SHARK BAY

This region extends down the mid-west coast from Miaboolia Beach (north of Carnarvon) to Peron Peninsula (see Figures 1 and 23). There is a 350 km break in the mangroves between Yardie Creek and Miaboolia Beach (the mid-western gap, see Figure 1) where the coast is mainly rocky. There are however, two inland blocks of mangal between these areas on Lake MacLeod (see below). The climate is arid with Carnarvon receiving a mean annual rainfall of 232 mm and Denham 227 mm. Only one species of mangrove (*Avicennia marina*) occurs in this region, and most stands are backed by extensive samphire flats. Throughout the region there is a lack of thick-trunked *Avicennia* trees and there is a sharp decline south of Carnarvon in the ground fauna, especially of crabs and mudskippers.

Twelve blocks of mangal were visited (Figure 23).

E1. Lake MacLeod

Lake MacLeod is a large saltlake about 30-140 km N of Carnarvon. There are two blocks of mangroves on the lake, one at North Cygnet Pond (23 km ENE of Gnaraloo 23°48'S, 113°45'E; area of mangal 7.5 ha.) and the other at South Cygnet Pond (18 km SE of Gnaraloo 23°55'S, 113°40'E; area of mangal 15 ha.); both are about 20 km from the sea. At North Cygnet Pond the mangroves grow around several circular lagoons. The fringing vegetation is tall 3-4 m *Avicennia* woodland of dome-shaped trees with fairly large trunks and tall pneumatophores and a dense understory of samphire. This is backed successively by *Avicennia* thickets along narrow creeks and open *Avicennia* shrubland. In 1980 there were quite extensive areas of dead trees.

South Cygnet Pond is a series of lagoons (up to 3 ha) fed by upwelling. Here the *Avicennia* ranges from 2 to 7 m high. The width of the mangal fringing the lagoons varies from 0-12 m, and ranges from tall dome-shaped trees and whipstick thickets, to low open shrubland with an understory of dense samphire.

The substrate in both areas is grey mud, and the mangal is backed by samphire flats and bare mudflats.

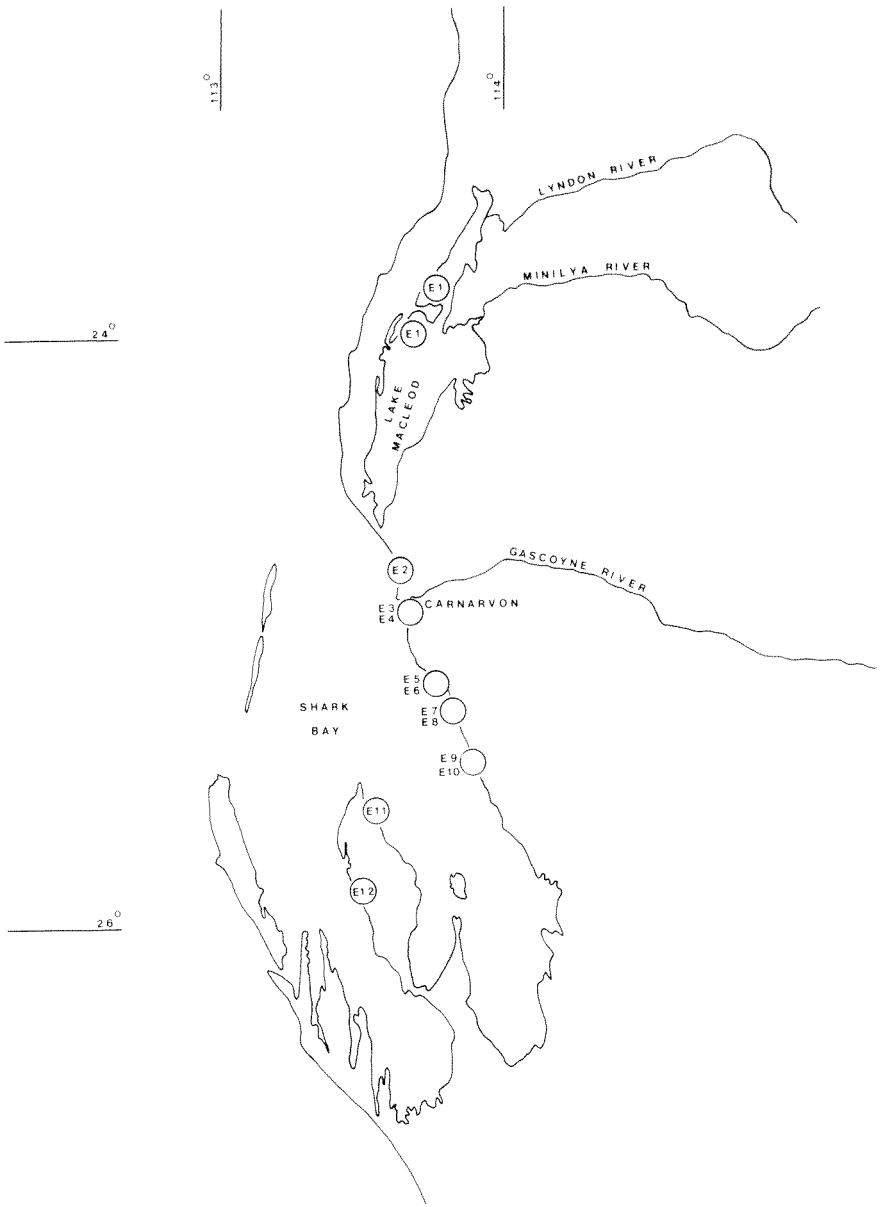

Figure 23 Map of Region E, Carnarvon-Shark Bay, showing the areas visited: E1 Lake MacLeod; E2 Miaboolia Beach; E3 Oyster Creek; E4 Mangrove Point (6 km SSE of Carnarvon); E5 Bush Bay; E6 New Bay; E7 Greenough Point near Denham Hummock; E8 5 km SSE of Denham Hummock; E9 7-8 km NNW of Long Point; E10 Long Point; E11 Guichenault Point; E12 Little Lagoon.

Figure 24 *Avicennia* thickets, Lake MacLeod (E1).

E2. Miaboolia Beach 24°48'S, 113°38'E; area of mangal 60 ha.

The mangroves fringe a small creek that has cut back behind coastal dunes. The vegetation is mainly low, open to closed *Avicennia* shrubland (3 m at their highest), in most places only a few trees wide.

E3. Oyster Creek 24°55'S, 113°40'E; area of mangal 15 ha.

This is a small inlet about 3 km SE of Carnarvon, where the tidal range is 1.5 m. It runs back into saline coastal flats. The creekside vegetation is open *Avicennia* woodland (trees 3-4 m high with small trunks), grading into thickets and low stunted shrubland.

The substrate is greyish sand and mud, and the mangal is backed by samphire flats and bare mudflats.

E4. Mangrove Point (6 km SSE of Carnarvon) 24°56'S, 113°41'E; area of mangal 600 ha.

A broad seaward belt of *Avicennia* woodland (trees 3-4 m with small trunks), is backed by thickets and shrubland with many bare interspaces on the landward side. There is an understory of samphire along some channels.

The substrate is grey mud and sand, and the mangal is backed by mudflats and samphire flats.

E5. Bush Bay 25°11'S, 113°50'E; area of mangal 300 ha.

Bush Bay has a seaward zone of tall whipstick *Avicennia* (3-5m) with a closed canopy; landwards the trees become well-spaced and the ground is covered with deep leaf litter. The landward zone is open stunted *Avicennia*.

The substrate is greyish-white grit and sand, and the mangal is backed by extensive samphire flats.

E6. New Bay 25°13'S, 113°51'E; area of mangal 100 ha.

A seaward zone of open low stunted *Avicennia* (mainly dome-shaped trees with thin trunks), is backed by open shrubland. There are many bare interspaces throughout this mangal.

The substrate is grey sand, and the mangal is backed by dense samphire.

E7. Greenough Point near Denham Hummock 25°15'S, 113°51'E; area of mangal 340 ha.

Here there is a radical change in the structure of the mangroves. The *Avicennia* trees do not form a solid continuous mass, but an open shrubland on a sandy substrate, highest (2-3 m) on the seaward side, the remainder 1-2 m.

The mangal is backed by samphire flats.

Figure 25 *Avicennia* shrubland, Greenough Point (E7).

E8. 5 km SSE of Denham Hummock 25°18'S, 113°53'E; area of mangal 160 ha.

This mangal grows behind a small sandy point that forms a V-shaped bay. The vegetation is similar to Greenough Point, being open *Avicennia* shrubland.

The substrate is greyish-white sand, and the mangal is backed by samphire flats.

E9. 7-8 km NNW of Long Point 25°24'S, 113°55'E; area of mangal 50 ha.

The mangroves grow along a small inlet that is protected by a sandy point. The vegetation is low *Avicennia* shrubland.

The substrate is grey sand, and the mangal is backed by bare mudflats.

E10. Long Point 25°28'S, 113°55'E; area of mangal 1 ha.

This mangal consists of a thin line of *Avicennia* trees (2-3 m), growing around the edge of a circular tidal inlet with deep mud at the tip of the point. These trees are backed by about 1 ha of low (25 cm) *Avicennia* growing as a ground cover. An isolated line of *Avicennia* shrubs growing 100-200 m out to sea from the tip of Long Point would be completely submerged by high tides.

The substrate is greyish-white sand and mud, and the mangal is backed by low bushes of *Nitraria* and dense samphire. This is the last block of mangroves on the mainland side of Shark Bay.

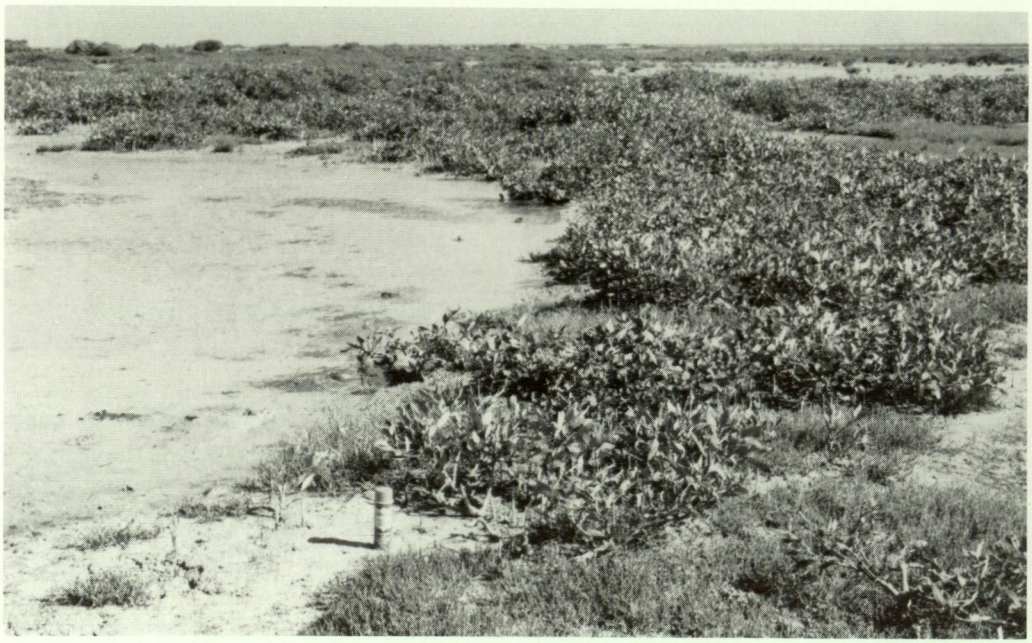

Figure 26 Samphire and low stunted *Avicennia*, Long Point (E10).

E11. Guichenault Point, Herald Bight 25°38'S, 113°34'E; area of mangal 100 ha.

Guichenault Point is about 2.5 km long by 0.5 km wide. Most of the point is covered in mangal, one of the largest blocks south of Carnarvon. There is a seaward zone of *Avicennia* woodland, most trees 3-4 m high with small trunks. This is backed by open shrubland, and a few stunted trees fringe the sandy bay to the west for about 1 km.

The substrate is greyish-white sand, and the mangal is backed by dunes with *Spinifex longifolius*.

E12. Little Lagoon 25°54'S, 113°32'E; area of mangal 1 ha.

Little Lagoon has a narrow neck of water connecting the lagoon with the sea. Part of the inlet is fringed by tall (4-5 m) *Avicennia* trees with moderate-sized trunks and a continuous canopy. The rest of the mangal is only 3 to 4 trees wide and grades sharply to low shrubland.

The substrate is greyish-white sand, and the mangal is backed by dunes with *Spinifex longifolius*.

Ardea sumatrana Raffles **Great-billed Heron**

Distribution

From south-east Asia to New Guinea and northern Australia (Payne 1979). In Western Australia: the Kimberley from Cambridge Gulf around north and west coasts nearly to Broome (Storr 1980 and Figure 27).

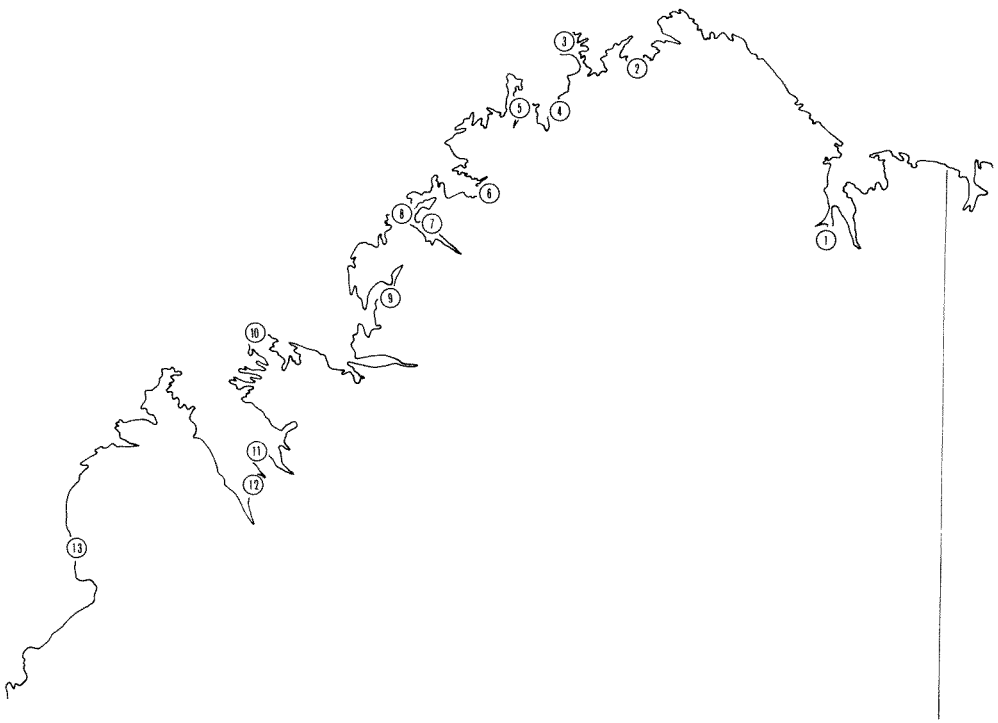

Figure 27 Map of Kimberley, Western Australia, locating records of *Ardea sumatrana*: 1 Wyndham (A5); 2 Napier Broome Bay (B1); 3 Parry Harbour; 4 Lawley River delta (B2); 5 mouth of Mitchell River; 6 mouth of Hunter River (B5) and mouth of Roe River; 7 Saint George Basin (B7); 8 Uwins Island (B12); 9 Gibson Creek; 10 Wotjulum; 11 Point Torment (B9); 12 Derby (B10); 13 Barred Creek.

Status and Ecology

Moderately common in ones and twos in some of the larger estuaries, namely Lawley, Mitchell, Hunter and Roe Rivers and St George Basin; elsewhere scarce. In Kimberley confined to mangroves, especially tidal creeks overhung by tall dense *Rhizophora, Bruguiera, Avicennia, Aegiceras* and *Camptostemon*. Shy, difficult to approach, and most often seen at edge of tidal creeks and pools, searching for food.

Voice

I attributed occasional loud roaring calls in west Kimberley mangroves to this species.

Food

A specimen collected by J.P. Rogers at Point Torment had fish and reptiles in its stomach.

Breeding

A fresh empty nest was found by I.C. Carnaby 2 m up in a mangrove near Wyndham in May 1966. I saw two birds near a large, empty, stick nest 18 m up on a horizontal branch of a *Melaleuca* at the edge of mangroves on Uwins Island on 7 July 1973. A nest with one large young was found by K. Coate, 3 m up on a horizontal branch of a mangrove, on Gibson Creek, on 8 May 1986. Storr (1977, 1984b) gives the breeding season for this species in the Northern Territory and Queensland as December and January, and August to May respectively. Rand and Gilliard (1965) mention that there are no breeding records from New Guinea. There is however a clutch of 2 eggs in the Western Australian Museum collected on the Strickland branch of the Fly River by Dr Wohlmann on 28 January 1911, from a large stick nest 12 m up in a tree on the river bank. These eggs are light greenish-blue in colour and measure 64.5 x 45.5 mm and 61.3 x 45.5 mm. Another clutch of 2 was taken from the same nest earlier in the month.

Unfeathered Parts

An immature collected by J.P. Rogers at Point Torment on 23 March 1911 had iris yellow, feet black, and bill black with yellow under the tip.

Butorides striatus (Linnaeus) **Mangrove Heron or Green Heron**

Distribution

Most tropical and subtropical coasts throughout the world. In Australia from north-western Western Australia around northern and eastern coasts to Victoria. In Western Australia all five mangrove regions from Cambridge Gulf to Shark Bay (see Figure 28).

Status and Ecology

Although fairly secretive, commonly seen throughout range in Western Australia, in a wide variety of habitats in or near mangal, including tidal creeks and estuaries, rocky, sandy and muddy tidal flats, and inshore reefs. Occasionally visit salt ponds and freshwater streams. Sometimes seen well away from mangroves, e.g. Kimberley specimen collected in *Ficus* thicket on near-coastal ridge. Mainly solitary but small parties of up to ten occasionally roost fairly close together or gather at concentrations of food. Feed by day and night, depending in most localities on the tide. When feeding, uses the stand-and-wait technique: crouching low at the waters edge with head drawn into the shoulders until prey comes within reach of thrust-out bill. Most food is captured from edge of

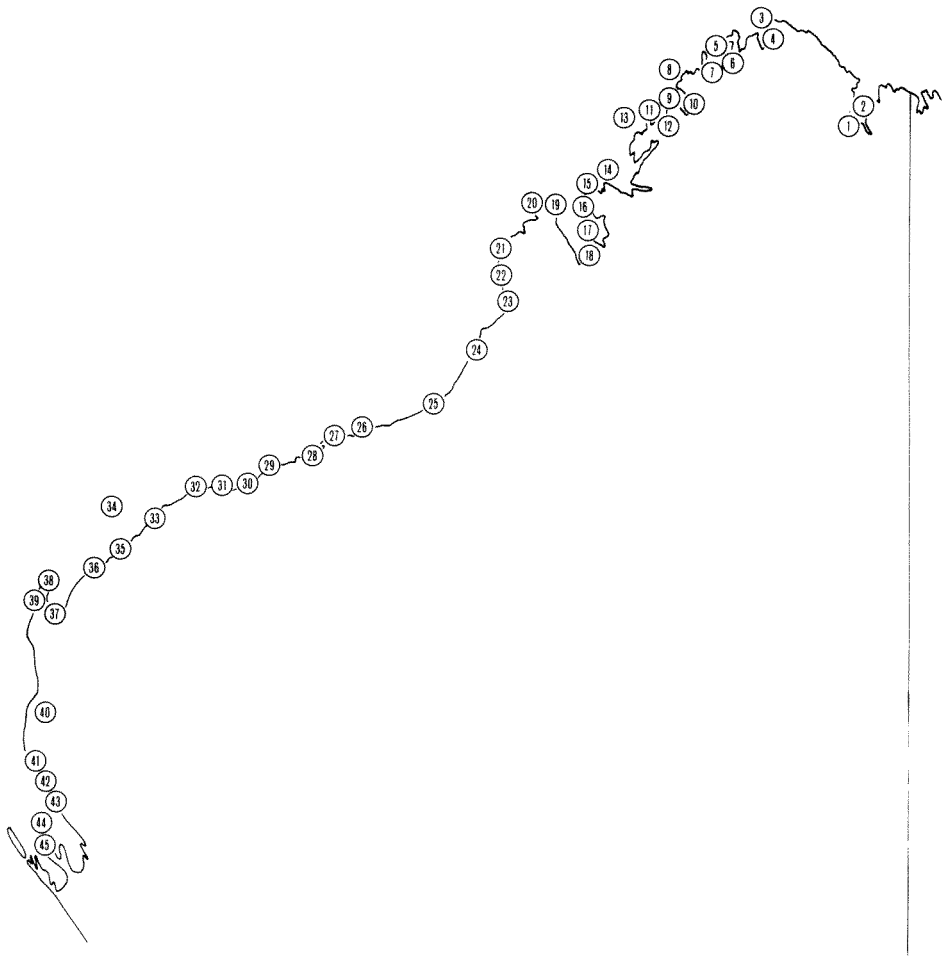

Figure 28 Map of northern Western Australia, locating records of *Butorides striatus*: 1 Wyndham (A5) and mouth of King River (A6); 2 7 km NNE of Mount Connection (A2), mouth of Ord River and Parry Creek (A4); 3 Sir Graham Moore Islands (B12); 4 Napier Broome Bay (B1); 5 Borda Island and Osborn Islands (B12); 6 Lawley River delta (B2); 7 Walsh Point Port Warrender (B3), and Crystal Creek (B4); 8 South Maret and Bigge Islands (B12); 9 Boongaree Island (B12); 10 mouth of Roe River; 11 Uwins Island (B12); 12 Saint George Basin (B7); 13 North Heywood and Byam Martin Islands (B12); 14 South Wood Island (B12); 15 Wotjulum; 16 Kimbolton; 17 Point Torment (B9); 18 Derby (B10); 19 Cygnet Bay (B11); 20 Packer Island (C1); 21 Cape Bertholet (C2); 22 Barred Creek; 23 Broome and Crab Creek (C4); 24 Cape Bossut (C7), Rocky Creek (C8) and Whistle Creek (C9); 25 Mandora Creek (D1); 26 Cape Keraudren (D2) and Pardoo Creek (D4); 27 mouth of De Grey River (D5); 28 Leslie Salt (D6); 29 Cowrie Creek 10 km SSW of Cape Thouin (D9); 30 Balla Balla (D10); 31 Butcher Inlet Cossack (D11), Point Samson (D12) and Popes Nose Creek (D13); 32 Nickol Bay (D14), Withnell Bay (D15), Dampier, Dampier Salt (D17) and Dolphin Island (D29); 33 mouth of Fortescue River (D19); 34 Barrow Island; 35 mouth of Cane River (D20); 36 mouth of Ashburton

River (D21); 37 Gales Bay (D23), Bay of Rest (D24) and near Learmonth (D25); 38 North West Cape; 39 Mangrove Bay (D26) and Yardie Creek (D28); 40 Lake MacLeod (E1); 41 Miaboolia Beach (E2); 42 Carnarvon and Oyster Creek (E3); 43 Mangrove Point (E4), Bush Bay (E5), New Bay (E6), Greenough Point (E7) and 7-8 km NNW of Long Point (E9); 44 Guichenault Point (E11); 45 Little Lagoon (E12).

pools formed by advancing or retreating tide, or from exposed tidal flats. Sometimes wade into water and stand motionless with neck extended or withdrawn; occasionally perch almost parallel to water, on prop roots or rocks.

Excellent swimmers. Frequently climb up through canopy of mangroves before taking off. Alarm note a loud 'sceow', or 'keyow' or 'cherk' and contact calls are a softer 'chk chk'.

Food

Of 20 WA specimens, 17 contained a total of 80 fishes ranging in size from 3-95 mm, mostly mud-skippers (11 specimens), also hardyheads (Atherinidae), bearded goby *Scartelaos histiophorus*, yellowtail trumpeter *Amniataba caudavittatus* and trumpeter whiting *Sillago maculata*. Next in importance were crustaceans, mainly fiddler crabs *Uca* spp. (in 7 specimens), also marsh crabs *Sesarma* spp., and less frequently shrimps and prawns. Minor items included molluscs, spiders, beetles and ants, and in one specimen 2 large winged insects.

Breeding

In south Kimberley in December, and in the Pilbara and Carnarvon regions from August to October. Nests are platforms of sticks placed on horizontal forks well above water, mostly in *Avicennia* and *Rhizophora*. A nest from Balla Balla was 25 cm wide and 20 cm deep and one from Exmouth Gulf 30 cm wide and 6 cm deep. Only two and three egg clutches are recorded from Western Australia. Eggs pale bluish-green, often partly smeared with lime or mud from sitting bird. A clutch of two from Exmouth Gulf measured 39.2 x 28.7 mm and 38.2 x 28.8 mm and another from Lake MacLeod 40.5 x 31.6 mm and 41.1 x 31.0 mm, and a clutch of three from Miaboolia Beach 42.7 x 31.3 mm, 41.2 x 30.5 mm and 40.8 x 31.5 mm.

Unfeathered Parts (WA birds only)

Iris yellow or bright yellow. Facial skin greenish-yellow or yellowish-green (N13) or light green (N1). Upper mandible black (occasionally with yellowish-green cutting edge). Lower mandible greenish-yellow with black cutting edge. Mouth pink (N4), pale yellow to greenish-yellow (N3) or green (N1). Legs and feet greenish-yellow (N10), yellow (N4), light green (N4), or bright yellow (N1). Juveniles. Facial skin green. Bill yellowish-brown or greenish-yellow. Legs green. Bare skin under wings lime green.

Geographic Variation

Populations in Australia and New Guinea vary considerably in colour pattern and size. Although poorly represented in collections much attention has been paid to subspecies.

Table 1 Comparison of substrate colour and colour variation in *Butorides striatus* specimens from Western Australia.

WAM No	Locality	Sex	Substrate	Neck	Back & Wings	Edging to Back Feathers & Wing Coverts	Throat	Breast & Belly
A17598	Cambridge Gulf	♀	dark grey	grey, tinged with buff	dark grey	buff	grey, tinged buff	grey, tinged buff
A7726	Wotjulum	♂	dark grey	pale grey	mid grey	buff & white	pale grey	pale grey
A14199	Kimbolton	♀	dark grey	pale grey	mid grey	buff & white	grey	mid grey
A14759	Crab Creek	♂	whitish-grey	pale grey	pale grey	buff & white	grey	pale grey
A16653 & A16655	10 km SSW of Cape Thouin	♂,♂	grey	pale grey, tinged buff	dark grey	reddish-brown buff & white	buffy grey	grey, tinged buff
A16654	10 km SSW of Cape Thouin	♀	grey	reddish-buff	dark grey	reddish-brown	reddish-brown	buff, tinged reddish-brown
A16657	Balla Balla	♀	grey	grey, tinged buff	dark grey	buff	pale grey, tinged buff	grey, tinged buff
A14429 & A14430	Onslow	♂,♀	red	pale reddish-brown	grey, tinged reddish-brown	broadly reddish-brown	pale reddish-brown	pale reddish-buff
A15422 & A15423	Gales Bay	♂,♀	greyish-brown	grey, tinged reddish-buff	dark grey	chestnut & reddish-brown	buff, tinged reddish-brown	reddish-brown, tinged grey
A15153	Exmouth Gulf	♀	greyish-brown	pale reddish-brown	mid grey	reddish-brown	pale reddish-brown	reddish-brown, tinged grey
A15424	Yardie Creek	♀	greyish-white	grey, tinged buff	mid grey	buff	buffy grey	grey, tinged buff
A16658 & A17654	Lake MacLeod	♂,♂	grey	pale grey, tinged buff	pale grey	reddish-brown & buff	pale grey, tinged buff	pale grey, tinged buff
A16659	Lake MacLeod	♀	grey	reddish-brown tinged buff	pale grey, tinged reddish-brown & buff	reddish-brown, buff & white	buffy-grey & reddish-brown	grey, tinged buff & reddish-brown
A17656	6 km SE of Carnarvon	♂	grey	pale grey, tinged buff	mid grey	pale reddish-brown, buff & white	pale grey	pale grey, tinged buff
A17657	Little Lagoon	♀	greyish-white	pale grey, tinged buff	mid grey	pale reddish-brown, buff & white	pale grey	pale grey, tinged buff

Table 2 Measurements (mm) and weight (g) of *Butorides striatus*, with means in parentheses.

Population	N	Wing	Tail	Tarsus	Bill length	Weight
Carnarvon-Shark Bay	6	167-188 (180.6)	55-64 (58.6)	47-52 (49.1)	73.5-86.0 (80.5)	240-250 (247)
Pilbara	11	177-189 (184.4)	58-66 (61.3)	43-54 (49.2)	78.0-89.5 (82.1)	202-290 (249)
Kimberley	5	172-189 (181.8)	58-61 (59.0)	48-53 (49.6)	78.5-89.0 (83.5)	250-260 (253)
Northern Territory	22	172-184 (177.6)	52-72 (58.7)	44-53 (48.1)	71.0-83.5 (77.5)	208-280 (246)
North Queensland	9	171-196 (185.6)	56-72 (62.6)	47-50 (49.1)	76.5-87.0 (83.0)	250
South Queesland	8	189-200 (194.1)	62-68 (65.1)	45-52 (49.5)	79.0-85.0(82.0)	183-260 (233)
New South Wales	7	184-201 (192.0)	63-70 (65.5)	49.54 (51.5)	73.0-86.0 (82.8)	270,290

Mayr (1943) and Condon (1975) recognized seven in Australia. Schodde *et al.* (1980) reduced these to two, namely *Butorides striatus stagnatilis* Gould from the south-west of the Gulf of Carpentaria to Shark Bay, and *B. s. macrorhynchus* Gould from the south-east of the Gulf of Carpentaria to Victoria.

The occurrence of reddish birds on the mid-west coast of Australia from Devil Creek south to Exmouth Gulf has puzzled some reviewers. Mathews (1912), Hartert (1920) and Peters (1931) treated these reddish birds as a separate species *B. rogersi;* Mayr (1943) and Payne (1979), as the subspecies *B.s. rogersi;* Hancock and Elliott (1978), as an erythristic phase of *stagnatilis;* and Schodde *et al.* (1980), as morphs.

The term morph is inappropriate because *all* birds from Devil Creek to Exmouth Gulf are reddish. The problem is further compounded by the fact that birds from north and south of *rogersi* are grey and buffy-grey respectively. The present study and a larger series have permitted a better understanding of geographic variation within this region.

In Western Australia colour variation can be correlated with substrate colour (see Table 1); dark birds occur on dark grey substrates, pale-grey birds on whitish-grey substrates and reddish birds on reddish substrates. In the Pilbara reddish muds occur from Devil Creek to Giralia Bay (Exmouth Gulf); the reddest are in the centre of this area at the mouths of the Fortescue, Cane and Ashburton Rivers. Beyond this area substrates grade from reddish through greyish-brown to greyish-white (see descriptions). As expected, the striking red muds of the Fortescue, Cane and Ashburton Rivers are where the reddest birds occur. They are grey tinged with reddish-brown dorsally, and have broad reddish-brown fringes to the back plumes and wings, and are pale reddish-buff ventrally. Birds in this area were observed to be well camouflaged on the bright red muds. Camouflage would no doubt protect them from aerial predators. More importantly it would reduce detection by their prey.

North of the Fortescue, from Dampier to Cape Keraudren, both the substrates and the birds are much greyer. Specimens from Balla Balla and near Cape Thouin are similar to those from Cambridge Gulf, being dark grey dorsally with fine buff edging to the back plumes and wings, and grey tinged with buff ventrally. There is one exception, an adult female from Cape Thouin is redder than two males from the same location; although not as red as birds from the Fortescue, Cane and Ashburton Rivers, it matches well with specimens from Exmouth Gulf. Between the Ashburton and Exmouth Gulf substrates change from bright red to greyish-brown. Birds from Exmouth have the back grey with reddish-brown fringes to the back plumes and wings, and are reddish-brown tinged with grey ventrally. On the western side of the North West Cape peninsula substrates grade from greyish-brown in the north at Low Point to greyish-white in the south at Yardie Creek. The only specimen from the western side of the peninsula is from Yardie Creek and it is slightly paler than birds from Exmouth Gulf, matching best with specimens from further south at Lake MacLeod and Carnarvon. Substrates from the latter areas are grey and most birds here are pale grey dorsally with buff fringes to the back plumes and wings, and are grey tinged with buff ventrally. The exception is an adult breeding female WAM A16659 from Lake MacLeod that is much redder than other birds from the same location. It has broad rufous fringes to the back plumes, broad buff fringes

to the wing coverts and extensive buff on the underparts. Despite breeding, it still has traces of juvenile plumage (a pale streaked cap and extensive white on the throat).

At Little Lagoon on Peron Peninsula, substrates are greyish-white, and specimens are slightly paler than Carnarvon birds, being overall a paler grey only faintly tinged with buff. They are very similar to birds from south Kimberley (Crab Creek, Roebuck Bay) which are ash-grey or pale grey on the upper and under parts and the palest birds from this State (the substrate at Crab Creek is whitish grey).

Another example of substrate and plumage matching is provided by the Horsfield Bushlark *Mirafra javanica*. In northern Western Australia this species is common on flats adjacent to the coast, and the various "subspecies" from here are no more than local adaptions to soil colour. Mees (1962) graded Western Australian *Mirafra* into four colour types; the palest (whitest) birds coming from south of Broome (Roebuck Plains to Anna Plains) and the reddest birds from the mid-west, especially the Onslow, Cane River area, with paler birds to the north and south. This is an exact parallel to the Mangrove Heron.

The Mangrove Heron figured on plate 33 in Hancock and Elliott (1978) depicts the race *sundevalli* of the Galapagos Islands as an almost black bird on black rocks.

Variation in Northern Territory, Queensland and New South Wales

Variation in northern and eastern Australia is far less complex than in Western Australia. I examined 22 Northern Territory, 17 Queensland and 6 New South Wales specimens. None of these is as red as Fortescue, Cane and Ashburton birds. Most Northern Territory specimens could be matched with dark grey specimens from north Kimberley or pale grey specimens from south Kimberley. Most south Queensland and New South Wales specimens are large and very dark and have the back and wings more iridescent and the breast and belly dark brownish-grey. The exceptions are much paler, e.g. female WAM A18735 from Port Hacking, New South Wales, which is very similar to female WAM A17598 from Cambridge Gulf. Some north Queensland birds with a strong reddish tone to the underparts are most like dark Northern Territory specimens, e.g. a female from the Watson River is similar to a male from the McArthur River. Apparently the zone of intergradation between *Butorides striatus stagnatilis* and *B. s. macrorhynchus* in the Gulf of Carpenteria is very wide. More material may indicate that these subspecies are not worth recognizing.

Accipiter novaehollandiae (Gmelin) **Grey or White Goshawk**

Distribution

From the Lesser Sundas, Moluccas and New Guinea to the Solomons and northern and eastern Australia. In Western Australia confined to the Kimberley: Ord River from Wyndham south to the lower Behn River, and along the north-west coast from Admiralty Gulf south-west to Port Usborne; see Storr (1980) and Figure 29.

Figure 29 Map of Kimberley, Western Australia, locating records of *Accipiter novaehollandiae*: 1 Negri River (Northern Territory); 2 Behn River; 3 Ivanhoe Station; 4 Parry Creek; 5 Kalumburu; 6 Lawley River delta (B2); 7 Crystal Creek (B4); 8 mouth of Mitchell River; 9 mouth of Hunter River (B5); 10 Wotjulum; 11 Port Usborne.

Status and Ecology

Scarce or uncommon, most sightings being of single birds. In north-east Kimberley favouring tall riverside forests and white phase greatly outnumbering grey. In north-west Kimberley nearly always in or near mangroves (mostly extensive blocks with forest) and grey phase outnumbering white. Difficult to approach, and little is known of their habits in this State. When a grey bird glided low over mangal at Rail Creek and perched in a tall *Avicennia* most of the small birds in the vicinity stopped calling.

Food

Recorded feeding on lizards, snakes and small freshwater crabs.

Breeding

No records from Western Australia. In Northern Territory breeding in May (Storr 1977).

Unfeathered Parts

Adults. Iris red or orange red. Bill black. Cere and mouth at gape orange. Legs and feet orange. An immature from Port Usborne. Iris orange. Bill and mouth black. Cere, gape and orbital ring yellow. Legs greenish-yellow.

Eulabeornis castaneoventris Gould — **Chestnut Rail**

Distribution

Aru Islands and northern Australia from King Sound, Western Australia to the Smithburne River, Queensland. In Western Australia, along northern and north-western coasts from Cambridge Gulf to Derby. See Figure 30.

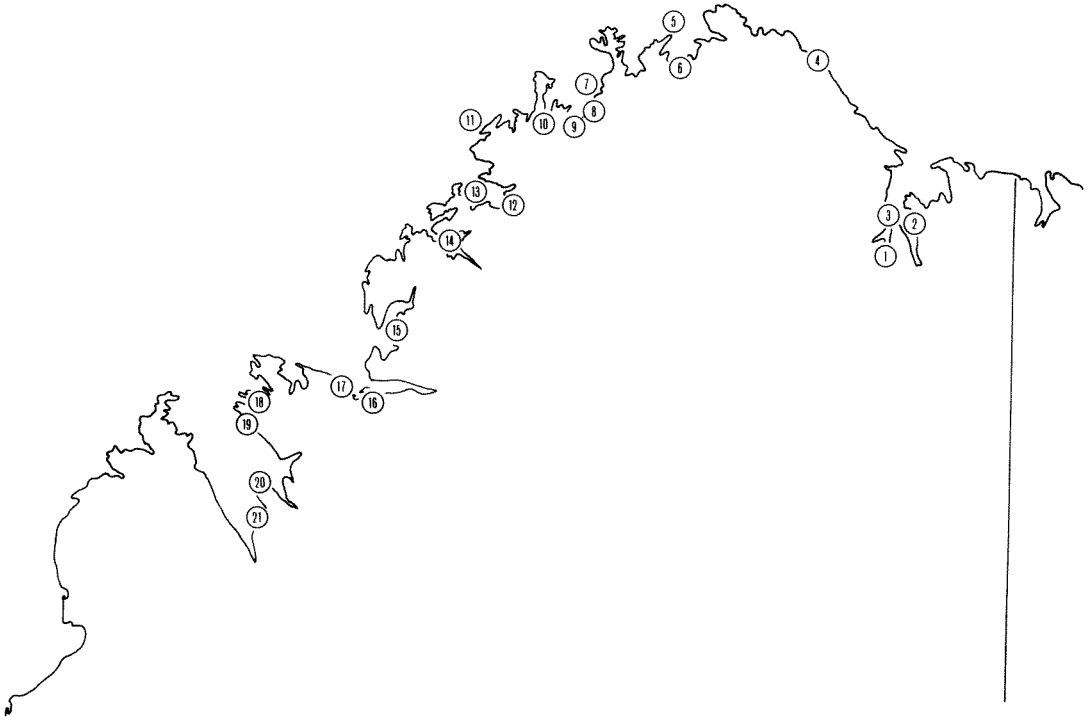

Figure 30 Map of Kimberley, Western Australia, locating records of *Eulabeornis castaneoventris*: 1 Wyndham (A5); 2 7 km NNE of Mount Connection (A2); 3 Still Bay (A3); 4 near Cape Bernier; 5 Sir Graham Moore Islands (B12); 6 Napier Broome Bay (B1); 7 Osborn Islands (B12); 8 Lawley River delta (B2); 9 Walsh Point Port Warrender (B3); 10 mouth of Mitchell River; 11 Bigge Island (B12); 12 mouth of Roe River; 13 Boongaree Island (B12); 14 Saint George Basin (B7); 15 mouth of Sale River; 16 Secure Bay; 17 Collier Bay; 18 mouth of Trent River (B8); 19 Port Usborne; 20 Point Torment (B9); 21 Derby (B10).

Status, Ecology etc.

In Western Australia common to moderately common in largest blocks of mangal, namely in Cambridge Gulf, Lawley River estuary, St George Basin, and Stokes Bay; elsewhere uncommon. Density in Lawley River estuary about 8 birds per sq. km. In St George Basin 10 single birds counted on a 3 km run up a tidal creek on 26 May 1972.

Extremely shy and alert and more often heard than seen. A quiet approach from the sea at low tide or sitting in the densest stands of mangroves are the best ways to observe it. Favours seaward mudflats, seaward zones of mangal (especially *Sonneratia*, mixed *Rhizophora-Bruguiera* forest and whipstick *Aegiceras*), and tidal creeks and channels with shelving mudbanks. When feeding moves slowly, often flicking tail and occasionally running a few short steps to pursue crabs or other prey. Frequently probes crab burrows, often with bill in mud or water up to eyes. Most food taken from ground, but birds also peck at base of trees and take molluscs from prop roots of *Rhizophora*. One feeding among prop roots of *Rhizophora* in Port Warrender caught small red fiddler crabs and tapped them against a prop root before eating them. Feeds by day and night. When alarmed runs at great speed into or through mangal for 20-30 m before feeding again. Pairs often feed close together. Contact note a loud 'chuuk chuuk' or chek chek' with occasional grunts like drumming of Emu. Song begins with a deep drumming, followed by loud squealing notes (like those of a half-grown pig); it lasts for about 10-15 seconds and is often followed by a few grunts. Song mostly uttered during morning and is answered by neighbouring birds.

In October 1976 I observed two birds fighting at the edge of a small tidal creek. They faced each other and began grunting, leaping up and striking each other with their feet. The combat lasted for about 4 minutes, when one bird retreated.

They moult in February-March and, judging from specimens, would be flightless in that period, e.g. one collected at Fannie Bay, Northern Territory, on 7 February had dropped all the primaries in one wing and had only one worn primary in the other.

Food

Crabs (mostly fiddler crabs *Uca* spp., but also marsh crabs *Sesarma* spp. and ghost crabs *Ocypode* spp.) found in all 7 W.A. stomachs examined, and made up about 90% of diet. Small molluscs recorded in 4 stomachs, and insects (including beetles) in 3 stomachs.

Breeding

A nest found by P.S. Stone on the King River on 19 February 1971 was built on a fallen, leaning dead mangrove where it was supported on a live mangrove trunk. The nest was a rough platform of sticks 2.8 m above the mud and 40 m from the river. It contained 3 fresh eggs. These eggs are light pinkish-buff with scattered reddish-brown spots and small blotches and have underlying spotting of dull purplish-grey. They measure 52.6 x 35.9 mm, 51.8 x 35.8 mm and 53.7 x 35.7 mm.

Two nests were found in Cambridge Gulf in October 1983 in dense *Rhizophora* forest with scattered *Xylocarpus* and *Bruguiera parviflora*. Both were empty, but freshly

constructed, and an adult was flushed twice from one. The nests were circular platforms of sticks and twigs, about 40 cm wide and placed between vertical branches of *Rhizophora* trees 1.5 m from the ground. Both had a gangway of sticks running up over the prop roots from the ground to the edge of the nest. This was used by the adult bird when leaving and returning to the nest.

Unfeathered Parts

Ten W.A. specimens. Iris bright red or red. Bill light green or yellowish-green with whitish tip. Legs yellow (N6) or yellowish-green (N3).

Taxonomic Notes

Peters (1934) recognized the subspecies *sharpei* for the Aru Islands and placed all Australian populations in nominate *castaneoventris*. The type of *sharpei* (in the AMNH), three *sharpei* in the British Museum and three in Museum Zoologicum Bogoriense are reddish-brown on the back, wings, and tail. Most Northern Territory birds are dark olive-green on the back, wings, and tail, but a specimen from Melville Island is dorsally olive-brown with odd chestnut feathers among the light brown. The single Cape York specimen has the back, wings, and tail chestnut, matching well with *sharpei*. All ten Western Australian specimens have the back, wings and tail olive-green or light olive-grey. Two specimens have one or two reddish-brown feathers on the back, but I have observed many birds in the Kimberley and none has had reddish-brown upperparts.

In coloration Aru birds do not differ from some Northern Territory and Queensland specimens; however they have deep heavy bills with a pronounced ramicorn, and four of the six specimens had red on the bill (described on labels as green base, yellow tip, red about the nostrils; and green with blue base, yellow tip, red midway). The red is still quite obvious on some specimens. Red on the bill has not been noted on any Australian specimen.

I would tentatively recognize *sharpei* on bill shape and coloration. Ford (1983), however, merges it with the Australian race.

Table 3 Measurements (mm) and Weight (g) of *Eulabeornis castaneoventris*, with means in parentheses.

Population	Sex	N	Wing	Tail	Bill length	Bill depth	Tarsus	Middle toe and claw	Weight
Western Australia	♂	3	218-244 (227)	117,144	59.0-66.0 (63.0)	15.6, 18.5	68-69 (68.5)	61-67 (64.0)	626-910 (752)
	♀	7	202-222 (211)	117-127 (122)	56.0-65.0 (60.4)	14.2-17.7 (15.7)	60-67 (63.4)	55-68 (60.0)	550-710 (628)
Northern Territory	♂	2	219	51-117	64.0, 65.0		65,67		723,750
	o	1	219	119	59.0		69		
Queensland	o	1	220	130	62.5		68		
Aru Islands	♂	1	224	129	62.5	17.8	68		
	♀	4	209-218 (213)	115-122 (118)	50.0-62.0 (56.7)	17.0-17.5 (17.1)	66-78 (71.0)	50.61	
	o	1	208	114	59.0	17.0	72	65	

Distribution

Southern New Guinea and north-western, northern and eastern Australia. In Western Australia, confined to the Kimberley and coastal Pilbara. See Storr (1980, 1984a) and Figure 31.

Figure 31 Map of northern Western Australia, locating records of *Geopelia humeralis*: 1 Negri River; 2 Lake Argyle and Behn River; 3 Kununurra and Ivanhoe; 4 Parry Lagoons; 5 Pentecost River; 6 King River (A6), Wyndham (A5) and Parry Creek (A4); 7 7 km NNE of Mount Connection (A2); 8 near Cape Bernier; 9 lower Drysdale River; 10 Morgan Falls; 11 Theda and Carson Escarpment; 12 Carson River; 13 Kalumburu and Pago (B1); 14 Sir Graham Moore Islands (B12); 15 Mount Connor; 16 Parry Harbour; 17 Fenelon Island and Osborn Islands (B12); 18 Lawley River delta (B2); 19 Crystal

Creek (B4); 20 Walsh Point Port Warrender (B3) and Mitchell Plateau; 21 Mitchell River; 22 Maret and Bigge Islands (B12); 23 York Sound, Prince Frederick Harbour and Careening Bay (B6); 24 Coronation Islands (B12); 25 Saint George Basin (B7); 26 Uwins, Augustus, Heywood, Champagny and Byam Martin Islands (B12) and Kunmunya; 27 George Water; 28 mouth of Sale River; 29 Walcott Inlet; 30 Secure Bay and near Mt Humbert; 31 Kingfisher Island (B12); 32 Cockatoo Island; 33 Wotjulum; 34 mouth of Trent River (B8); 35 Kimbolton; 36 Point Torment (B9); 37 Derby (B10) and Langey Crossing; 38 Meda; 39 Lennard River; 40 Napier Downs; 41 Mount Bell; 42 Beverley Springs; 43 Mount Elizabeth; 44 Mount Barnett; 45 Mount House; 46 Lake Gladstone; 47 Landsdowne; 48 Black Elvire River; 49 Mary River; 50 Christmas Creek; 51 Fitzroy Crossing, Geikie Gorge and junction of Fitzroy and Margaret Rivers; 52 Cherrabun; 53 Noonkanbah; 54 Windjana Gorge and Tunnel Creek; 55 Liveringa; 56 Mount Anderson; 57 Cygnet Bay (B11); 58 Sunday Island (B12), One Arm Point and Cape Leveque; 59 Lombadina and Cape Borda; 60 Pender Bay and Beagle Bay; 61 Coulomb Point; 62 Barred Creek and Willie Creek (C3); 63 Broome (C4); 64 Thangoo (C5); 65 Injudinah Swamp; 66 Cape Bossut (C7), Frazier Downs and Whistle Creek (C9); 67 Nita Downs; 68 17 km SSW of Anna Plains; 69 Cape Keraudren (D2); 70 mouth of De Grey River (D5); 71 Port Hedland (D7); 72 Cowrie Creek (D9); 73 Cossack (D11), near Point Samson (D12), Popes Nose Creek (D13) and Wickham; 74 Legendre and Dolphin Islands (D29); 75 Nickol Bay (D14), Withnell Bay (D15) and King Bay (D16); 76 West Lewis and Enderby Islands (D29); 77 Dampier Salt (D17) and Devil Creek (D18); 78 Montebello Islands (D29); 79 Barrow, Pascoe and Double Islands and Lowendal Islands (D29); 80 North Sandy Island (D29); 81 mouth of Cane River (D20); 82 Onslow and mouth of Ashburton River (D21); 83 near Learmonth (D25); 84 Mangrove Bay (D26).

In May 1908 F.L. Whitlock recorded this dove on the upper Coongan River near Marble Bar. However his description of their call as 'olly wattle' leaves no doubt that they were Peaceful Doves *Geopelia striata*. Because of this error many texts on Australian birds, e.g. Pizzey (1980) and Frith (1982), wrongly include the Hamersley region in the distribution of this species.

Status and Ecology

In Kimberley, common to very common on coasts and coastal plains, common to moderately common along largest rivers, but uncommon, scarce or absent in much of interior (Storr 1980). On Pilbara coasts, common, usually in ones, twos or small parties up to 8, but scarce in far south of region.

In north-west Kimberley, favours semi-deciduous vine forests, thickets and scrubs, dense vegetation along watercourses, *Melaleuca* swamps, closed evergreen woodlands of *Ficus* and *Terminalia* at foot of cliffs and in gullies, and mangal. Vine forests range in size from 1 ha to 100 ha, and are irregular in height, with canopy closed about 3-10 m above ground. Emergents (mostly deciduous) rise to 15 m and include *Bombax ceiba, Brachychiton paradoxum, Albizia lebbek, Garuga floribunda, Terminalia* spp. and *Syzygium* spp. Lower storeys consist of slender trees and shrubs including *Celtis philippensis, Randia cochinchinensis, Zizyphus quadrilocularis, Diospyros nitens, Vitex glabrata, Ficus* spp., *Terminalia* spp. and vines. They nest and roost in these forests and often feed on ground in forest and around its edges.

In south and east Kimberley, confined to larger rivers especially Fitzroy, Mary, Negri and Ord. Here vegetation is dense and of varying composition, but stands of *Melaleuca leucadendron* and *M. argentea* are common; other trees and shrubs include *Pandanus, Eucalyptus, Eugenia, Ficus, Terminalia* and *Barringtonia*.

In south-west Kimberley, favours depauperate vine forests of *Melaleuca, Celtis, Ficus, Terminalia, Diospyros, Mimusops* and *Cassine*; and found frequently in near-coastal thickets of *Melaleuca acacioides* and in mangal.

In the Pilbara, mainly in mangal and adjacent *Acacia* scrubs on coastal dunes. Within mangal prefer closed forests of *Rhizophora* and *Bruguiera*. Often observed feeding in landward ecotone between mangal and dry-land vegetation. Mangal provides nesting and roosting sites, from which the birds must venture out into other habitats to feed and drink. On a late afternoon in October at Popes Nose Creek, about 40 were emerging from mangroves in ones, twos and threes to feed beneath *Acacia coriacea* trees. In the Pilbara riverine vegetation is generally too open for this species which is thus largely confined to mangal, the only closed forest in region. Lower temperatures within the mangal may also provide a refuge from heat. Probably colonised the Pilbara via a previous mangrove connection along Eighty Mile Beach.

Usually seen foraging on ground or perched in dense cover. When flushed fly low and fast directly to cover. Prefer to feed on bare ground or in short grass. Drink in broad daylight.

Voice

Calls are loud and clear and carry for some distance. Most are short 'cook-a-wook' or 'zo-cocoo'. A series of the latter notes sometimes ending abruptly with 'cook'.

Food

In Kimberley, seeds of sedges and grasses including *Sporobolus* and *Sorghum*, and in the Pilbara seeds of *Euphorbia* spp., *Cleome viscosa, Amaranthus, Cucumis* and *Acacia* spp., especially *A. coriacea*, and leaves and seeds of *Scaevola spinescens*. Length of seeds range from 1.2 to 6.4 mm.

Breeding

In Kimberley, from September to May with peak in April. Forty-eight 2-egg clutches recorded for Kimberley in following months: January (6), February (4), March (2), April (20), May (4), September (4), October (2), November (3) and December (3). It appears this species can breed throughout much of year but prefers the period immediately following wet season, when food most abundant. In Kimberley nests in *Barringtonia, Ficus, Pandanus, Hakea*, mangroves and creepers.

In the Pilbara, from July to October with peak in August. Most nests in mangroves, but one in a *Brachychiton*, and on Barrow Island nests in rock crevices and caves.

Nests are typically flimsy platforms about 15 cm wide, made of twigs and placed on horizontal forks or among dense foliage about 2 m from ground. Two white, slightly

glossy eggs form the clutch. Three two egg clutches from near Kununurra measured 27.5 x 20.1 mm and 27.6 x 20.4 mm, 29.7 x 21.7 mm and 29.5 x 20.8 mm, and 28.1 x 21.2 mm and 27.4 x 21.6 mm and two eggs from south Kimberley 29.6 x 21.5 mm and 28.3 x 20.7 mm.

Unfeathered Parts

Tweny-four W.A. specimens. Iris yellow or cream. Orbital ring reddish-purple or bluish-grey. Bill grey or blue-grey. Mouth grey, pink or whitish. Legs pink or reddish-grey.

Geographic Variation

The range of this species is continuous in eastern and northern Australia. The only break in its mainland range is in Western Australia between Anna Plains and Cape Keraudren. Most of the variation is clinal. Specimens from New South Wales, Queensland and New Guinea are large and dark (New South Wales birds being slightly larger and darker than those from Queensland and New Guinea). They have the cap bluish-grey, nape grey (each feather with a whitish or greyish-white bar near the tip), mantle reddish-brown barred black, back, wings and upper-tail coverts dark brownish-grey barred black, throat and breast grey, belly mostly white with pinkish-brown towards breast and on flanks, undertail coverts white. Compared to south Queensland and New South Wales birds most New Guinea specimens have less pinkish-brown on the belly and have the faint blackish barring on the breast a little more conspicuous; many of them can be matched with specimens from Cape York Peninsula.

In their description of the New Guinea race *gregalis* Bangs and Peters (1926) state that it is similar to nominate *humeralis* from Australia, but darker above, especially the hind neck which is nearly mikado-brown instead of vinaceous-cinnamon or orange-cinnamon. The ten specimens that I studied from south-west New Guinea show no difference in the colour of the hind neck or mantle from Northern Territory, Queensland and New South Wales birds. It would appear that the Bar-shouldered Dove has only recently colonized New Guinea from Australia, as have many other Australian woodland savanna birds such as the Whistling Kite *Haliastur sphenurus*, Australian Bustard *Otis australis* and Australian Magpie *Cracticus tibicen*.

Coastal populations of the Bar-shouldered Dove from the Northern Territory, Kimberley and the Pilbara show a distinct cline in size and coloration. Northern Territory and north-east Kimberley birds are slightly darker on the upperparts than birds from elsewhere in the Kimberley. They have little or no white on the nape feathers, the pale terminal bar on these feathers is greyish-white or bluish-grey; and the upperparts are dark greyish-brown, barred black. Many north Queensland and Northern Territory specimens are more chestnut on the mantle than Kimberley birds, but this character undergoes considerable individual variation. A specimen from Mitchell Plateau and one from Ivanhoe (east Kimberley) have faint barring on the breast like many Northern Territory specimens.

Specimens from north-west Kimberley have the head dark bluish-grey, the nape feathers with greyish-white bars, the mantle reddish-brown, and the rest of the upperparts greyish-brown with black barring. Birds from coastal south-west Kimberley (Yampi Peninsula

to Dampier Land) are paler on the upperparts than more northerly birds, and the amount of white barring on the nape increases slightly.

Birds from the south-west and interior of the Kimberley (Broome, Fitzroy River drainage and upper Pentecost River) are very pale, being similar to southern Pilbara specimens, they are also larger than other Kimberley birds. They have the cap pale bluish-grey; nape pale greyish-brown barred black, with only a trace of a pale terminal bar on these feathers; mantle and upper back pale reddish-brown barred black (paler than all other Kimberley birds). One specimen from the Pentecost River is the palest of all birds I have seen, being sandy brown or light reddish-brown on the wings and back.

Pilbara birds are small and pale. The head is pale bluish-grey, the nape feathers have a distinct white subterminal bar, the mantle is pale reddish-brown, and the back, wings and tail are light brownish-grey. In the Pilbara (especially the south) there are fewer black-edged feathers and the black edging is narrower. Specimens from Barrow and Hermite Islands are the palest (most sandy) from the Pilbara, whereas birds from West Lewis and Dolphin Islands are the darkest.

In summary, Pilbara birds are small and pale and have pure white subterminal bars on the nape feathers. Kimberley birds are larger and become progressively darker northward around the coast, and the subterminal bars on the nape feathers become greyish-white. The Fitzroy and Pentecost River populations in the interior are of interest because they are extremely pale and semi-isolated having contact with the main coastal populations (if at all) only at the river mouths. Although rainfall is higher here than on the Pilbara coast, the relative humidity is much lower, e.g. at Fitzroy Crossing the daily mean at 3 p.m. ranges from 16% in October to 40% in February, compared to 47-56% at Onslow. This may explain their pale coloration.

Overall there are only slight differences in colour and size between all populations. I would not recognise any subspecies in Australia or New Guinea.

Table 4 Measurements (mm) and weight (g) of *Geopelia humeralis*, with means in parentheses.

Population	Sex	N	Wing	Tail	Bill length	Tarsus	Weight
Pilbara	♂	2	122, 138	110, 137	23.0, 24.0	21.5, 24.5	
	♀	7	125-130 (126.7)	112-124 (118.0)	21.0-24.0 (22.4)	21.0-23.0 (21.9)	98, 108
Kimberley	♂	10	130-147 (137.2)	110-142 (127.1)	22.0-25.0 (24.0)	21.0-24.0 (21.9)	104-140
	♀	7	126-149 (139.4)	119-156 (133.8)	21.0-24.0 (22.2)	20.0-23.5 (21.9)	
Northern Territory	♂	12	130-146 (138.4)	103-155 (131.1)	20.5-25.0 (22.5)	21.0-24.0 (22.4)	114
	♀	7	131-135 (132.7)	112-131 (119.5)	20.5-23.5 (21.8)	19.0-22.0 (20.5)	
Queensland	♂	32	133-146 (140.3)	115-150 (132.3)	20.5-25.0 (22.4)	20.0-26.0 (22.3)	112-145 (132)
	♀	21	131-143 (136.7)	117-134 (125.5)	20.5-24.0 (22.3)	19.0-24.0 (21.8)	115-137 (128)
New Guinea	♂	5	126-136 (131.6)	124-131 (128.0)	21.0-23.0 (22.2)	22.0-25.0 (23.6)	
	♀	5	129-132 (130.2)	119-130 (124.0)	21.0-22.5 (21.5)	22.0-25.0 (23.2)	
New South Wales	♂	6	138-145 (142.3)	128-143 (138.6)	21.5-23.5 (22.7)	21.0-25.0 (22.9)	125-140 (131)
	♀	3	136-141 (138.3)	128-144 (133.6)	21.0-23.5 (22.0)	21.0-23.0 (22.0)	100-141 (119)

Distribution

From the Red Sea through southern Asia, the Philippines, the Malay Archipelago, New Guinea and northern Australia to Samoa. In Australia, northern coastal mangroves,

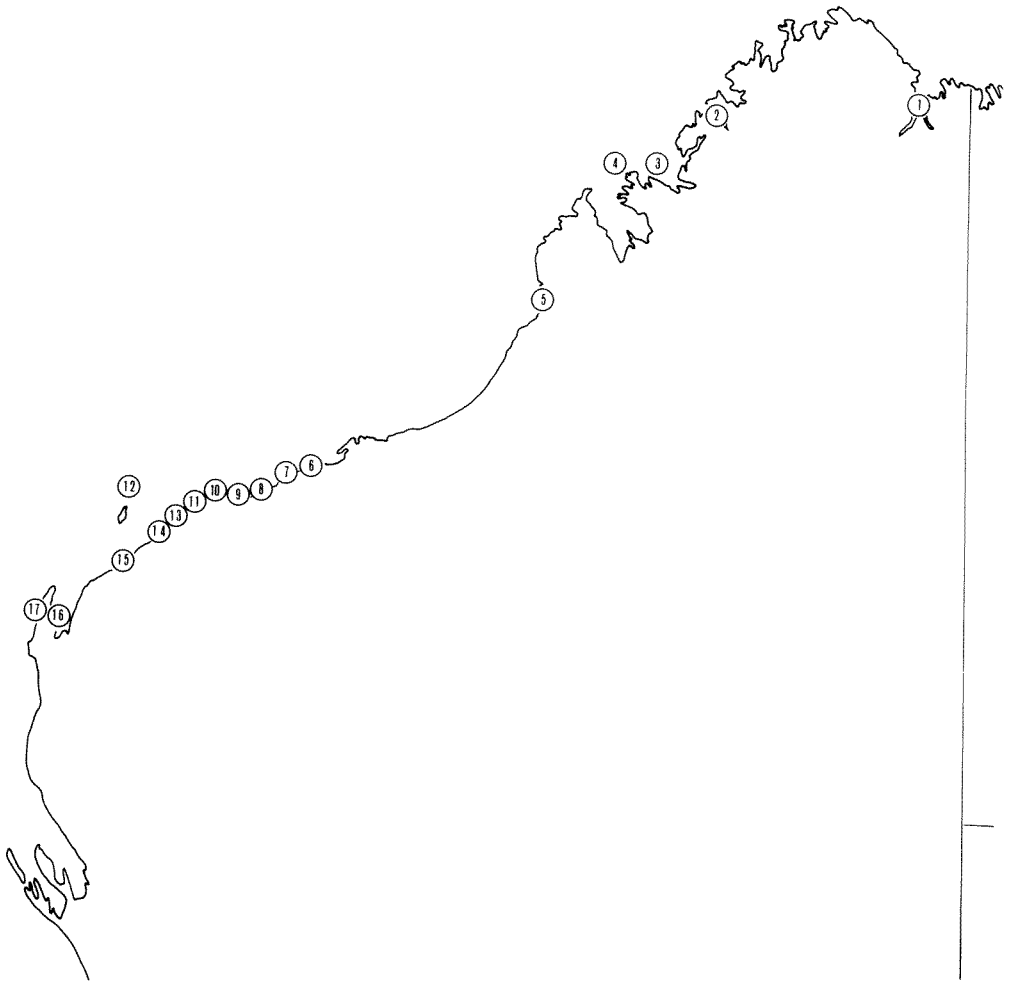

Figure 32 Map of northern Western Australia locating records of *Halcyon chloris sordida* 1-5 and *H. c. pilbara* 6-17: 1 7 km NNE of Mount Connection (A2), Black Cliff Point (A1) and Hardman Point; 2 Saint George Basin (B7); 3 Kingfisher Island (B12); 4 Sir Frederick Island; 5 Crab Creek (C4); 6 mouth of Turner River (D8); 7 Cowrie Creek (D9); 8 Balla Balla (D10); 9 Cossack (D11), 2 km SW of Point Samson (D12) and Popes Nose Creek (D13); 10 Nickol Bay (D14) and King Bay (D16); 11 Dampier Salt (D17); 12 Hermite Island (D29); 13 mouth of Devil Creek (D18); 14 mouth of Fortescue River (D19); 15 mouth of Cane River (D20); 16 Bay of Rest (D24); 17 Mangrove Bay (D26).

south in the east to the Tweed River (northern New South Wales) and in the west to Exmouth Gulf (probably further south in the past). Range in Western Australia fragmented, with apparently isolated populations in Cambridge Gulf, west Kimberley and the Pilbara. See Figure 32.

Status and Ecology

Common in Cambridge Gulf, rare in west Kimberley and moderately common to common in the Pilbara.

In Cambridge Gulf it favours *Rhizophora* forest, mixed *Rhizophora-Sonneratia* forest and woodland, and less frequently mixed *Avicennia-Rhizophora* and *Rhizophora-Bruguiera* forests.

Only three specimens have been collected in north-west Kimberley, two from dense mangal (St George Basin and Sir Frederick Island), and one from Kingfisher Island that flew from mangroves into eucalypt woodland. The only south-west Kimberley specimen is from Crab Creek where the vegetation is mainly low open to closed *Avicennia, Aegiceras, Camptostemon* and *Rhizophora, Avicennia* being the most common species.

In the Pilbara, they are confined to blocks of mangal with *Avicennia* forest or woodland. When feeding they venture into other habitats including forests and woodlands of *Rhizophora* and mixed *Rhizophora-Avicennia. Avicennia* is the only mangrove in this region large enough to produce nesting hollows. Mangrove Kingfishers are absent from mangrove blocks between Cape Keraudren and Port Hedland, all of which lack thick-trunked mature *Avicennia* forest. Montague (1914) collected two immature Mangrove Kingfishers on Hermite Island (Montebellos) in 1912. He described the mangroves there as mostly *Avicennia* on the landward side, growing to a considerable size, and *Bruguiera* on the seaward side. Hill (1955) also recorded Mangrove Kingfishers in the Montebello Islands in 1952. Between 1952 and 1955 the islands were used as a site for testing nuclear weapons and no doubt much of the habitat was destroyed. At any rate there are no recent reports of the kingfishers from these islands.

The southernmost records are from Exmouth Gulf. However it appears that they formerly occurred at Yardie Creek or perhaps Mangrove Bay on the western side of the North West Cape peninsula. Three specimens collected by T. Carter between 1889 and 1901 and labelled Point Cloates, certainly did not come from that location (see Johnstone 1983), and must have been collected at Yardie Creek or Mangrove Bay. The mangal at both Yardie Creek and Mangrove Bay is now inadequate for this species. So too is the mangal at Carnarvon, and records of Mangrove Kingfishers in this area in Blakers *et al.* (1984) would be based on the smaller Sacred Kingfisher (*H. sancta*) which also frequents mangroves.

Feed mostly along seaward fringe of mangal, darting from a perch to pick up food from ground or water and eating it on the same or another perch. Often seen or heard tapping crabs or other prey against branches to kill them. Some feeding perches are used for a considerable time and hollows may even be used for storing food. At Dampier in 1980 several worn spouts of *Avicennia* trees on seaward side of mangal, were full

of remains of numerous fiddler crabs. The top-most remains were fresh crippled crabs, some only partly eaten.

Voice

Main call is a high-pitched 'ek ek' or 'kick it', second syllable higher-pitched. A churring 'keer' is also uttered.

Food

Stomach contents of 21 W.A. specimens were examined. Crabs, mostly fiddler crabs *Uca* spp., also swimming crabs *Thalamita* spp., and ghost crabs *Ocypoda* spp., were found in 20 specimens and so are by far the most important food. One Cambridge Gulf specimen contained a fiddler crab and a large mud-skipper 110 mm long. The single specimen that did not contain crabs had 11 or 12 Lepidoptera larva in its stomach.

Breeding

Two females collected in Cambridge Gulf in early October 1982 had enlarged gonads; the ovary in one measured 16 x 12 mm and had two developing follicles, and in the other 20 x 15 mm with four developing follicles. Judging from their behaviour and gonads they were preparing to breed. In the Pilbara most specimens collected in October 1980 and October 1982 had enlarged gonads. On 12 October 1980 a nest was found 38 cm down a hollow log wedged in branches of an *Avicennia* at the mouth of the Cane River. The hollow was 10 cm wide, and the entrance was 2 m above the ground. A male was flushed from the nest and returned within a few minutes. The nest contained three pure white, slightly glossy eggs; they measured 32.0 x 25.3 mm, 30.9 x 24.9 mm and 30.5 x 25.6 mm.

Unfeathered Parts

Iris dark brown. Bill black except for base of lower mandible, which is whitish. Mouth pink. Legs pale brown, blue grey or grey.

Table 5 Measurements (mm) and weight (g) of *Halcyon chloris* with sample size and means in parentheses.

Population		Wing	Bill length	Bill depth	Tail	Tarsus	Total length	Weight	Mean Bill/ Wing%
Pilbara	(N20)	91-104 (97.5)	54.0-61.0 (57.9)	10.7-12.0 (11.3)	65-71 (67.8)	15-18 (15.8)	225-257 (248)	50-70 (62)	59.1
West Kimberley WA	(N 4)	105-107 (106)	57.0-66.5 (61.6)	13.6-13.7 (13.6)	71-76 (73)	15-17 (16.0)	260, 268	70-87 (76)	58.1
Cambridge Gulf WA	(N 8)	100-105 (102)	55.0-58.5 (56.9)	11.7-13.3 (12.1)	66-74 (70)	15-17 (16.0)	250-270 (260)	61-92 (71)	55.7
Northern Territory	(N16)	98-106 (101)	54.0-62.0 (57.2)	12.5-14.0 (13.0)	64-72 (68)	14-19 (15.5)		57-90 (69)	56.6
Queensland	(N15)	97-114 (105)	49.0-59.0 (54.6)		63-70 (67)	14-19 (17.0)	242, 260, 266	62,92	52.0
New Guinea	(N 2)	99, 109	55.0, 53.5	11.6	62, 70	15, 16	242	85	52.1

Taxonomic Notes

Two subspecies are recognised in Western Australia, *Halcyon chloris sordida* Gould from the Kimberley and *H. c. pilbara* Johnstone from the Pilbara (Johnstone 1983).

Chrysococcyx minutillus Gould **Little Bronze Cuckoo**

Distribution

New Guinea, also northern Australia from Kimberley, Western Australia to north-eastern New South Wales. In Western Australia confined to Kimberley, around northern and western coasts from Cambridge Gulf to Barred Creek. See Storr (1980) and Figure 33.

Figure 33 Map of Kimberley, Western Australia locating records of *Chrysococcyx minutillus*: 1 25 km E of Shakespeare Hill; 2 Wyndham (A5) and Parry Creek (A4); 3 Kalumburu; 4 Lawley River delta (B2); 5 Port Warrender (B3); 6 mouth of Glenelg River; 7 Secure Bay; 8 mouth of Trent River (B8); 9 Kimbolton; 10 Point Torment (B9); 11 Derby (B10); 12 Cygnet Bay (B11); 13 3 km S of Cape Bertholet (C2); 14 Coulomb Point; 15 Barred Creek.

Status and Ecology

Scarce in Cambridge Gulf and north-west Kimberley, but moderately common in south-west Kimberley from Kimbolton to Barred Creek. Found in mangal, dense riverine vegetation, melaleuca thickets (especially *M. acacioides*), and coastal vine scrubs. Within mangal favour forest areas especially of *Rhizophora, Avicennia* and tall *Ceriops*. Most observations are of single birds high up in canopy, either calling or foraging among small branches. Feed mainly by snatching insects from vegetation. Like most cuckoos, shy and difficult to locate. Their call is a single 'chew' repeated at same pitch. Also a high-pitched trill, sometimes descending.

Food

Hemiptera were recorded in all 5 stomachs examined and totalled 69 items. Next in importance were Lepidoptera (3 stomachs) and Coleoptera (8 in 2 stomachs). Minor items include spiders, wasps and insect larvae. Largest item 10 mm long.

Breeding

In September, December and March. Recorded parasitizing *Gerygone levigaster, G. olivacea* and *G. magnirostris*. At Rail Creek on 19 October 1976 an immature was being fed by two *Gerygone magnirostris* in canopy of large *Avicennia*. It was calling 'seep seep' with mouth open and wings flapping.

Immatures have less gloss on upperparts than adults, are more greyish-brown on head, back and wings and have no barring on underparts (throat and breast being light grey and rest of underparts white).

Eggs are dark olive-brown. One collected by R. Mason in a *Gerygone magnirostris* nest in Northern Territory measured 18.0 x 12.9 mm.

Unfeathered Parts

Adults. Iris brown or dark brown (N3), red or reddish-brown (N4). Orbital ring red to orange. Bill black or slate grey. Mouth black or grey. Legs black or grey. One immature. Iris grey-brown. Orbital ring light grey. Bill tip black (rest light pink). Gape yellow. Legs grey.

Geographic variation

Ford (1981a) discusses hybridization and migration in Australian populations of the Little and Rufous-breasted Bronze Cuckoos. Parker (1981) has shown that *malayanus* cannot be used for this species.

Table 6 Measurements (mm) and weight (g) of *Chrysococcyx minutillus* from Western Australia. Sample size and means in parentheses.

Population	Sex	Wing	Bill length	Bill width	Tail	Tarsus	Total length	Weight
Kimberley	♂ (5)	92-96 (93.2)	17.0-19.0 (17.5)	4.9-6.0 (5.4)	53-59 (55)	14.0-17.0 (15.4)	140-149 (145)	14.5-17.0 (15.1)
WA	♀ (2)	79, 93	18.0	5.5, 5.7	56, 58	9, 12	140, 156	15.4, 17.0

Distribution

The subspecies *M. f. tormenti* Mathews inhabits coastal mangroves in Western Australia from Cambridge Gulf, around northern and western Kimberley coasts to Barred Creek (40 km north of Broome) and on continental islands, viz. Bigge, Boongaree, Augustus and Hidden. See Johnstone (1984) and Figure 34. The subspecies *M. f. flavigaster* occurs in far north-east at Ningbing, in Cambridge Gulf (where it interbreeds with *M. f. tormenti)* and on lower reaches of Ord River. See Figure 34.

Figure 34 Map of Kimberley, Western Australia locating records of *Microeca flavigaster flavigaster* (1-4), intermediate specimens (5-7) and *M.f. tormenti* (8-25): 1 Ningbing; 2 Ivanhoe, 3 60 km SE of Wyndham; 4 Parry Creek (23 km SE of Wyndham); 5 7 km NNE of Mount Connection (A12); 6 Hardman Point; 7 Black Cliff Point (A1); 8 Napier Broome Bay (B1); 9 Anjo Peninsula; 10 Lawley River delta (B2); 11 Walsh Point Port Warrender (B3); 12 Bigge Island (B12); 13 Boongaree Island (B12); 14 Saint George Basin (B7); 15 Augustus Island (B12); 16 Wotjulum; 17 Hidden Island; 18 Port Usborne; 19 Point Torment (B9); 20 Cygnet Bay (B11); 21 One Arm Point; 22 Packer Island (C1); 23 Cape Baskerville; 24 3 km S of Cape Bertholet (C2); 25 Barred Creek.

Status and Ecology

Throughout its west Kimberley range from Napier Broome Bay to Barred Creek *M. f. tormenti* is uncommon, but in far north-east and Cambridge Gulf, *M.f. flavigaster* is moderately common. Usually solitary but occasionally pairs feed close together. Confined to extensive blocks of mangal, favouring forests, woodlands and thickets of pure and mixed stands of *Rhizophora, Bruguiera, Avicennia, Aegiceras* and *Ceriops*. Frequently in areas with scattered dead trees. In addition to these habitats the subspecies *M. f. flavigaster* is also found in closed waterside forest.

Forage in all levels of mangal: on ground, prop roots, pneumatophores, tree trunks and branches and in canopy. Most food captured by probing and pecking tree trunks etc. and by short flights from a perch to catch flying prey. Also observed taking insects from flowers of *Rhizophora* and often search dead and fallen trees for insects. Although foraging throughout a wide range of habitats and sometimes in open landward fringes, seldom leave cover of mangal.

Voice

Contact calls are a sharp 'k chip'. When breeding short 'peter peter' and 'treet treet' calls are made and a longer 'pa-treeter' repeated three or four times.

Food

Stomach contents of 10 W.A. specimens were examined. Ants, mostly *Polyrachis*, were by far most important food. A total of 77 ants recorded in 9 stomachs. Eleven Hymenoptera (bees and wasps) in 4 stomachs, and 7 Hemiptera in 2 stomachs. Minor items include Lepidoptera, Coleoptera and spiders. Prey size ranged from 1-18 mm long.

Breeding

A nest with one egg was found by G.F. Hill at Napier Broome Bay in November 1909. It was built in a dead mangrove tree 1.5 m above high-water mark, constructed of bark and spider web and covered externally with small pieces of leaf. This nest was a small shallow cup, externally 41 mm wide and 28 mm deep and internally 35 mm wide and 15 mm deep. Two empty nests found at Cape Bertholet were of similar construction; both placed on horizontal forks of dead mangrove trees. Specimens collected in Cambridge Gulf in early October 1982 were in full song and had enlarged gonads.

The single egg is dull greyish-green or greyish-blue, spotted and blotched with dull reddish-brown and lavender. An egg of nominate race collected at Humpty Doo in Northern Territory measured 19.7 x 14.1 mm.

Unfeathered Parts

Thirteen W.A. specimens, excluding Cambridge Gulf birds. Iris dark brown (N6), brown (N4), red-brown (N2) and grey-brown (N1). Upper mandible black or brown. Lower mandible pale horn or brown with a dark tip. Mouth yellow. Legs black (N10), brownish-black (N2) and dark grey (N1).

Geographic Variation

For notes on the intergradation between Lemon-breasted Flycatcher and Brown-tailed Flycatcher see Johnstone (1984).

Table 7 Measurements (mm) and weight (g) of *Microeca flavigaster* with means and sample size in parentheses.

Population	Sex	Wing	Bill length	Bill width	Tail	Tarsus	Total length	Weight
Microeca f. flavigaster WA and NT	♂ (N11)	71-76 (73.7)	12.0-14.5 (13.7)	5.3-5.8 (5.6)	49-54 (51.8)	14.0-15.0 (14.5)	130-135 (133)	10.0-12.5 (11.2)
	♀ (N7)	67-73 (69.6)	12.5-14.0 (13.1)	5.0-5.8 (5.4)	49-51 (49.6)	13.0-15.0 (14.1)	133	10.0-11.0 (10.7)
M. f. flavigaster x *f. tormenti* Cambridge Gulf WA	♂ (N4)	73-76 (74.2)	14.0-14.5 (14.1)	5.4-5.8 (5.6)	51-55 (52.7)	15.0-15.5 (15.1)	134-140 (136)	10.9-12.0 (11.6)
	♀ (N2)	72-73	14.0-14.5	5.5-5.9	51-53	14.5-15.0	135-137	11.0-11.5
M. f. tormenti WA	♂ (N7)	74-75 (74.4)	14.0-15.0 (14.5)	5.3-5.8 (5.5)	51-56 (53.8)	14.0-18.0 (15.7)	129-142 (135)	11.0-13.5 (11.6)
	♀ (N4)	70-74 (71.2)	14.0 (14.0)	5.4-5.7 (5.5)	50-54 (51.7)	13.0-16.0 (15.0)	130-135 (132)	10.0-12.3 (11.2)

Eopsaltria pulverulenta (Bonaparte) **Mangrove Robin**

Distribution

New Guinea and northern Australia from Exmouth Gulf, Western Australia, to Cardwell, Queensland. Range in Western Australia broken and patchy. Two isolated populations in the Kimberley: one in Cambridge Gulf; the other in west Kimberley from Napier Broome Bay to Cygnet Bay, including some continental islands. In the Pilbara range from Cape Keraudren south-west to Gales Bay, including some islands in the Dampier Archipelago. See Storr (1980, 1984a) and Figure 35. In the past also occurred at Mangrove Bay on the west coast of the North West Cape peninsula Carter (1903).

Status and Ecology

Much more common in some blocks of mangal than others. In Kimberley, common in Cambridge Gulf and Napier Broome Bay, scarce in mouth of Lawley River but common 12 km NNW at Walsh Point, and common at Point Torment and in Cygnet Bay. Absent from entire south-west Kimberley coast from One Arm Point to Whistle Creek. In the Pilbara, scarce or rare from Cape Keraudren to mouth of Turner River, common at Balla Balla, Cossack, Popes Nose Creek and Point Samson, scarce at Nickol Bay and common at Dampier Salt and mouth of Cane River and in Gales Bay.

This patchy distribution and variable abundance may be explained by its peculiar ecological requirements. In Western Australia Mangrove Robins only occur in stands of mangal with extensive *Rhizophora* forest, especially those on mud. In Cambridge Gulf it favours areas of tall *Rhizophora* forest. At present there are no records from the western side of the Joseph Bonaparte Gulf between Cape Dussejour and Cape Londonderry, where mangroves only occur in small isolated pockets. The scarcity of this robin in the Lawley River delta can be explained by the diverse physiography of

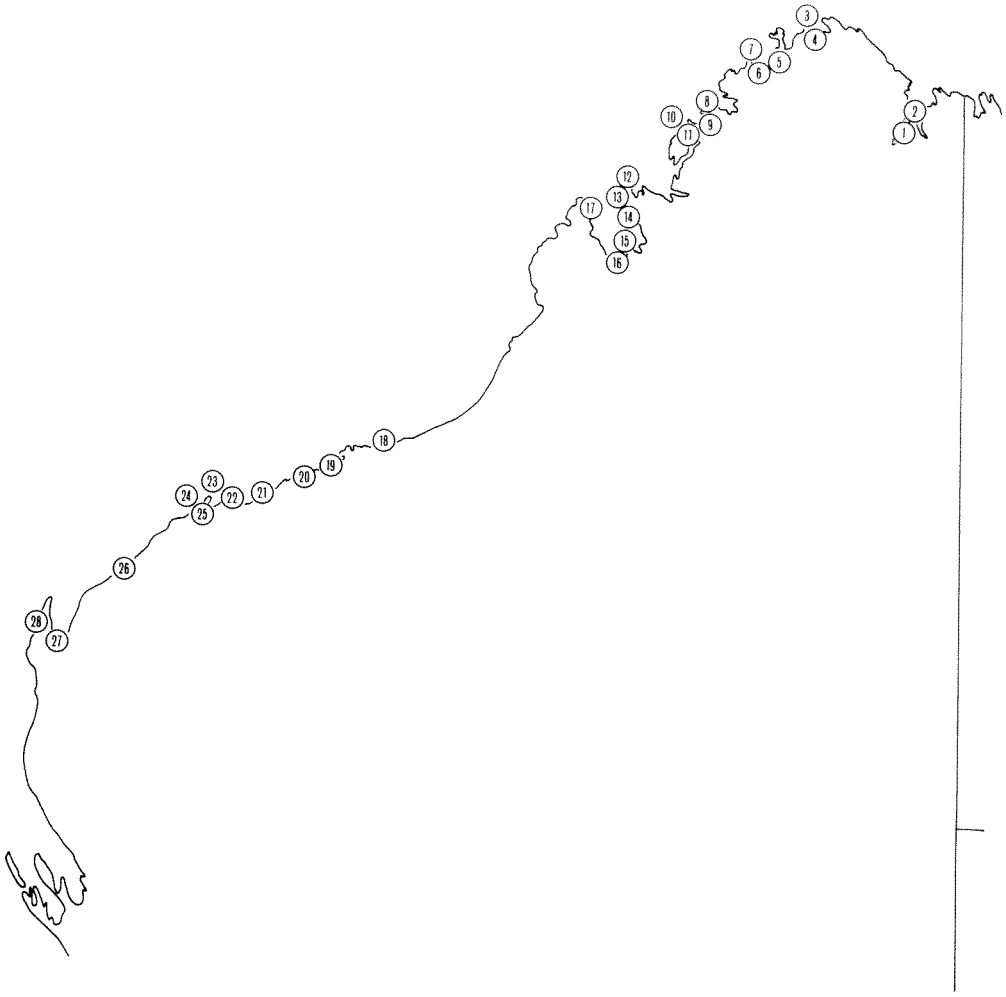

Figure 35 Map of northern Western Australia locating records of *Eopsaltria pulverulenta*: 1 Parry Creek (A4), Wyndham (A5) and King River (A6); 2 Black Cliff Point (A1), 7 km NNE of Mount Connection (A2) and Still Bay (A3); 3 Sir Graham Moore Islands (B12); 4 Napier Broome Bay (B1); 5 Lawley River delta (B2); 6 Walsh Point Port Warrender (B3); 7 Crystal Creek (B4); 8 Careening Bay (B6); 9 Saint George Basin (B7); 10 Augustus and Champagny Islands (B12); 11 Kunmunya and mouth of Glenelg River; 12 Wotjulum; 13 mouth of Trent River (B8); 14 Cascade Bay and Port Usborne; 15 Point Torment (B9); 16 Derby (B10) and mouth of Fitzroy River; 17 Cygnet Bay (B11); 18 Cape Keraudren (D2); 19 Leslie Salt (D6); 20 mouth of Turner River (D8); 21 Balla Balla Harbour (D10); 22 Cossack (D11), 2 km SW of Point Samson (D12) and Popes Nose Creek (D13); 23 Legendre Island (D29); 24 West Lewis and Enderby Islands (D29); 25 Dampier and Dampier Salt (D17); 26 mouth of Cane River (D20); 27 Gales Bay (D23); 28 Mangrove Bay (D26).

the mangal there. It is not well-zoned, and *Rhizophora* occurs throughout the mangal only in isolated patches. Nearby at Walsh Point where the Mangrove Robin is common, the mangal is well-zoned, and *Rhizophora* forest forms an extensive middle zone.

The absence of this robin from south-west Kimberley (region C) was puzzling until recently. There are many large blocks of mangal between One Arm Point and Whistle Creek, namely Packer Island, Cape Bertholet, Barred Creek, Willie Creek, Broome, Thangoo, Lagrange Bay, Cape Bossut and Rocky Creek that at first sight seemed suitable for Mangrove Robins. In these blocks, however, *Rhizophora* forest only occurs at Packer Island in the north and at Cape Bossut and Rocky Creek in the south, and in all three places the areas of *Rhizophora* are small and often low and open, and thus unsuitable for the robins.

The lack of extensive, mature *Rhizophora* forest in the northern Pilbara from Cape Keraudren to the mouth of the Turner River similarly explains the scarcity of the robin in this area. The populations in the Dampier Archipelago are slightly exceptional in that the stands of *Rhizophora* on these islands are small and in some cases fairly open. Mangrove Robins are, however, common on the opposite mainland from which could come some recruitment to island populations.

On 23 February 1902 T. Carter collected two Mangrove Robins at Mangrove Bay on the west coast of the North West Cape peninsula. Despite intensive fieldwork none have been subsequently recorded from this area. There are now only seventeen low *Rhizophora* trees remaining at Mangrove Bay, but it is evident from the large number of sub-fossil prop roots embedded in the sand and mud, that *Rhizophora* was much more extensive here in the past.

They feed in the lower levels of the mangal: on the ground, prop roots, pneumatophores, tree trunks and low branches. They often pounce from a low perch onto the ground after sighting prey, land near the item, pick it up and return to the perch. Most small prey is eaten where caught, but larger prey is often taken to a prop root or low branch and tapped against it before eating. When catching food on the ground the bill often becomes covered in mud and is frequently cleaned on prop roots.

Although the occurrence of *Rhizophora* is a prerequisite for this bird, they forage in surrounding vegetation such as pure and mixed forests and woodlands of *Bruguiera*, *Avicennia*, *Camptostemon* and *Sonneratia*, mixed forest of *Rhizophora-Aegiceras*, *Rhizophora-Camptostemon* and *Rhizophora-Avicennia* and in pure or mixed thickets of *Ceriops*, *Avicennia* and *Aegiceras*. The fact that Mangrove Robins feed and often nest in other mangrove habitats apart from *Rhizophora* forest, poses the question, why is this forest so important for it. There appears to be two main reasons. Firstly the prop roots of *Rhizophora* provide numerous low level perches, and secondly *Rhizophora* seems to contain a greater density of insects and other invertebrates than other mangroves.

Voice

Contact calls include soft 'chirps' and churring notes. Main song is a mournful two or three-noted whistle, reminiscent of that of the Little Grassbird *Megalurus gramineus*.

Indeed, an aural record of this robin from Carnarvon (*RAOU Newsl.*, December 1978) could only have been based on the Little Grassbird.

Food

In stomachs of 21 W.A. specimens ants, mostly *Polyrachis*, were by far most important food. Ninety-two ants recorded in 17 stomachs, and also present in unknown numbers in another 2 stomachs. Other major food items were small Coleoptera (beetles) and crustaceans (mostly small fiddler crabs). Seventeen beetles were recorded in 10 stomachs and 11 crabs in 10 stomachs. Minor food items included Lepidoptera, Hemiptera, wasps, spiders and insect larvae. Most prey was less than 15 mm long, but some insect larvae measured about 20 mm.

Breeding

In Kimberley in October, February and March, and in the Pilbara in August and September. Some autumn breeding also occurs in the Pilbara judging from a spotted immature, still begging for food, observed in Gales Bay on 5 June 1978. When breeding, both male and female birds defend the territory and will attack and drive off larger birds including White-breasted Whistlers *Pachycephala lanioides*.

Most nests are built in vertical or horizontal forks of mangroves. A nest found at Balla Balla on 4 October, was built 3 m up on a horizontal fork of an *Avicennia*. It was a small oval cup, constructed of thin strips of bark bound together with spider web, lined with fine pieces of *Triodia* and soft bark, and covered externally with squarish pieces of *Avicennia* bark. Outside measurements of the nest were 70 mm long, 55 mm wide and 35 mm deep and inside 58 mm long, 45 mm wide and 20 mm deep. Two eggs form the clutch. They are olive-green to olive-grey with small reddish-brown and purplish-brown spots and blotches on the larger end. A clutch from Balla Balla measured 22.6 x 14.8 mm and 21.0 x 15.1 mm, and two clutches from Point Samson 20.3 x 15.4 mm and 20.9 x 15.9 mm, and 19.9 x 16.0 mm and 19.6 x 16.0 mm and 19.6 x 16.2 mm.

Unfeathered Parts

Iris dark brown (N22), brown (N18), sepia (N8), black (N1), grey (N1) and greyish-brown (N1). Bill black. Legs black or blackish-grey. Mouth yellow or orange-yellow.

Geographic Variation

Despite considerable breaks in the range of this species there is very little geographic variation. See Ford (1983).

Table 8 Measurements (mm) and weight (g) of *Eopsaltria pulverulenta* from Western Australia. Means and sample size in parentheses.

Population	Sex	Wing	Bill length	Bill width	Tail	Tarsus	Total length	Weight
Kimberley	♂ (N14)	73-85 (82.2)	18.5-21.5 (20.2)	5.3-6.3 (5.6)	54-66 (60.2)	21.0-24.0 (22.2)	145-170 (155.8)	20.0-23.0 (21.2)
	♀ (N15)	75-83 (78.0)	17.5-20.0 (18.7)	5.0-6.0 (5.4)	52-63 (55.9)	19.0-24.0 (20.8)	146-155 (149.7)	15.0-19.5 (16.6)
Pilbara	♂ (N11)	80-84 (81.8)	20.0-22.5 (20.8)	5.2-5.9 (5.4)	57-63 (59.5)	22.0-24.0 (23.4)	158-167 (161.8)	20.5-23.5 (21.7)
	♀ (N8)	75-80 (77.6)	18.0-20.0 (19.0)	4.9-5.7 (5.3)	53-57 (55.5)	20.0-23.0 (21.3)	145-154 (150.0)	16.0-22.0 (18.6)

Distribution

Coastal northern Australia from Exmouth Gulf, W.A. to Mackay, Qld. See Storr (1977, 1980, 1984a, 1984b). Also on many islands in Torres Strait and the D'Entrecasteaux and Bismarck Archipelagos. See Diamond (1975). Range in Western Australia broken with a population in Kimberley and another in the Pilbara. See Figure 36.

Figure 36 Map of northern Western Australia, locating records of *Pachycephala melanura*: 1 King River (A6) and 16 km south of Wyndham; 2 Wyndham (A5), 9 km NW of Wyndham, 7 km NNE of Mount Connection (A2) and Still Bay (A3); 3 Black Cliff Point (A1); 4 near Cape St Lambert; 5 Sir Graham Moore Islands (B12); 6 Napier Broome Bay (B1); 7 Cape Bougainville, Parry Harbour and Hecla Island; 8 Osborn Islands (B12); 9 Lawley River delta (B2) and Walsh Point Port Warrender (B3); 10 Cape Voltaire

and Fenelon, East Montalivet and Katers Islands (B12); 11 Bigge Island (B12); 12 Prince Frederick Harbour including mouth of Hunter River (B5) and Naturalist and Boongaree Islands (B12); 13 Cape Brewster; 14 Coronation Islands (B12); 15 Uwins Island (B12); 16 Saint George Basin (B7); 17 Augustus Island (B12); 18 near Kunmunya; 19 Maitland Bay, George Water and mouth of Sale River; 20 Collier Bay; 21 Wotjulum; 22 mouth of Trent River (B8) and Port Usborne; 23 mouth of Townsend River; 24 Point Torment (B9); 25 Derby (B10) and mouth of Fitzroy River; 26 Cygnet Bay (B11); 27 Packer Island (C1), Cape Borda and Pender Bay; 28 Cape Baskerville; 29 Coulomb Point; 30 Barred Creek and Willie Creek (C3); 31 Broome (C4); 32 Rocky Creek (C8); 33 Cape Keraudren (D2) and Pardoo Creek (D4); 34 Cowrie Creek (D9); 35 Balla Balla (D10); 36 Cossack (D11) and Point Samson (D12); 37 Nickol Bay (D14) and King Bay (D16); 38 Dampier Salt (D17), mouth of Maitland River and West Lewis and Enderby Islands (D29); 39 mouth of Devil Creek (D18); 40 mouth of Cane River (D20); 41 mouth of Ashburton River (D21); 42 Gales Bay (D23) and Bay of Rest (D24); 43 Mangrove Bay (D26).

Status and Ecology

Common to moderately common in Kimberley and Pilbara mangals. Usually in ones and twos and favouring extensive blocks of mangal, especially those with forests and woodlands of *Rhizophora* and *Bruguiera*, pure and mixed thickets of *Ceriops* and *Aegiceras* and mixed *Avicennia* - *Camptostemon*. Overall has a strong preference for mangal with closed canopy. Canopy can vary in height from tall forests of *Rhizophora* to low thickets of *Ceriops*. This habitat preference may explain recent extinction of Mangrove Golden Whistler from Mangrove Bay, on west coast of North West Cape peninsula. Here in 1902 T. Carter collected Mangrove Robins and Mangrove Golden Whistlers, both of which favour *Rhizophora* forest. *Rhizophora* was much more extensive at Mangrove Bay in the past (see under Mangrove Robin), but mangal now is mostly open *Avicennia* woodland unsuitable for both species.

Feed mostly in canopy, hop gleaning and snatching insects from foliage and upper branches. Occasionally catch insects from tree trunks, prop roots and pneumatophores and less frequently on ground. In Kimberley these whistlers, especially immatures, often wander up to 10 km from mangroves into neighbouring vegetation including semi-deciduous vine forests and *Melaleuca* thickets; both of these habitats are very similar in structure to mangal. In the Pilbara more restricted to mangroves but occasionally immatures forage in *Acacia* thickets up to 200 m from mangroves.

Voice

Contact call is a loud rising 'wheep' or 'seep' and full song a loud melodious whistle often ending with a crack.

Food

Stomach contents of 36 W.A. specimens were examined. Most important foods were Coleoptera (beetles) 89, were found in 26 stomachs, 85 Hemiptera (bugs and cicadas) in 25 stomachs, 40 ants in 15 stomachs, 27 wasps in 12 stomachs and Lepidoptera (moths

and butterflies) were noted in 22 stomachs. Other foods included spiders, molluscs, Diptera, mantids, crickets and crabs.

Most items were 1-5 mm long but some weevils and bugs were 11 mm long.

Breeding

In Kimberley, from October to February. In the Pilbara nest building reported in mid-September, and many specimens collected in October had enlarged gonads. Nests cup-shaped, made of fine twigs, rootlets, pieces of samphire and grasses, and placed in vertical forks of mangroves. External measurements of one nest were 88 mm wide and 65 mm deep, internal measurements 50 mm wide and 35 mm deep. A clutch of two eggs from Point Torment measured 21x16 mm.

Unfeathered Parts

Adults. Iris dark brown, brown or reddish-brown. Bill black. Mouth black or blackish-grey. Legs black or dark grey. Immatures have mouth white, yellowish or pinkish.

Geographic Variation

Mayr (1954), Galbraith (1956, 1967) and Ford (1971, 1983) have described geographic variation in *Pachycephala melanura*. The most recent of these (Ford 1983) recognized two subspecies in Australia: *melanura* from Exmouth Gulf to Port Warrender, and *spinicauda* from Napier Broome Bay to Mackay. He pointed out that *melanura* and *spinicauda* intergrade between Port Warrender and Napier Broome Bay. I follow Ford, but would extend the zone of intergradation between these subspecies east to Cambridge Gulf.

Adult females of *spinicauda* differ from those of *melanura* in being yellow, rather than buffy-white tinged yellow, on the breast, abdomen and flanks; olive rather than dark grey tinged olive on the mantle; and more blackish, less olive on the tail. Specimens from Walsh Point, Port Warrender are typical *melanura*, but nearby in the Lawley River, females have the underparts more yellowish. The single Pago female is similar to Lawley River birds. Because female (WAM A9094) collected at Kalumburu by A.M. Douglas and G.F. Mees in June 1960 had a bright yellow abdomen, Ford believed that *spinicauda* extended to this area. However I believe that the specimen is in fact a young male; it has a bright olive back and several black throat feathers where the black bib of the male develops, and its skull was not fully ossified. In October 1982 I collected five females in Cambridge Gulf. They have stronger yellow on the breast, belly and flanks, than Pago birds, but are still less yellow than Northern Territory and Queensland specimens. They are also dark grey tinged with olive on the dorsum, more like Pago and Port Warrender specimens than Northern Territory birds, but they have more black on the tail than the former. Between Cambridge Gulf and Queensland the ventral yellow in females becomes brighter, the dorsum becomes more olive, the amount of black on the tail increases, and the upper neck or collar becomes buffy brown.

Table 9 Measurements (mm) and weight (g) of *Pachycephala melanura* from Western Australia, means in parentheses.

Population	Sex	N	Wing	Tail	Tarsus	Bill length	Weight	Total length
Pilbara, WA	♂	17	74-86 (82.5)	62-68 (64.7)	22-25 (23.5)	18.0-20.5 (18.9)	18.5-22.5 (20.3)	159-170 (164)
	♀	6	78-81 (79.6)	62-66 (63.8)	22-23 (22.5)	18.0-19.0 (18.5)	19.0-21.0 (20.0)	157-167 (163)
Kimberley, WA	♂	30	76-84 (80.3)	57-66 (61.1)	20-26 (21.9)	18.0-20.0 (18.9)	16.0-23.0 (19.1)	145-165 (159)
	♀	23	75-83 (78.2)	57-65 (60.2)	21-24 (22.1)	17.5-19.5 (18.3)	15.8-22.5 (19.2)	147-165 (157)

Pachycephala lanioides Gould **White-breasted Whistler**

Distribution

Northern Australia from Bush Bay, W.A., to the Norman River, Qld. See Storr (1977, 1980, 1984a, 1984b, 1985). Range in Western Australia broken with four isolated populations, two in the Kimberley, one in the Pilbara and another in the Carnarvon region. See Figure 37. In Kimberley, occurs in Cambridge Gulf and in north-west Kimberley from St George Basin to Whistle Creek. In the Pilbara, from Cape Keraudren south-west to Giralia Bay and Mangrove Bay, including islands in Dampier Archipelago. In the Carnarvon region from Carnarvon south-east to Bush Bay. There is a break in its range of about 450 km from Cambridge Gulf to St George Basin, a break along Eighty Mile Beach from Whistle Creek to Cape Keraudren (apart from one record from Mandora), and a break of 290 km from Mangrove Bay to Carnarvon.

Status and Ecology

In Cambridge Gulf, they are common to moderately common in the inner estuary at Parry Creek, Wyndham and King River, but uncommon in the outer estuary. Scarce or uncommon along the north-west Kimberley coast from St George Basin to Port Usborne, and common in south-west Kimberley from Point Torment to Whistle Creek. Only one record from Mandora on the Eighty Mile Beach and I would agree with Storr (1984a) that it is only a casual visitor to this mangal. In the Pilbara, common from Cape Keraudren to Mangrove Bay. Its status at Mangrove Bay is of interest because it was not recorded there by T. Carter in 1902. On 17 July 1980 I made a total of 13 sightings at Mangrove Bay, during transects through the mangal. I have little doubt that Carter would not have overlooked them. In the Carnarvon region they are moderately common in mangroves from Carnarvon south-east to Oyster Creek (6 km SE of Carnarvon), but between Oyster Creek and Bush Bay they are scarce.

Confined to mangroves and occurs in a wide range of habitats from dense mixed forests to low open stands of *Avicennia*. Overall has a strong preference for woodlands dominated by *Avicennia*. In Cambridge Gulf favour tall *Avicennia* woodland, and in St George Basin *Rhizophora-Bruguiera* forest. In south-west Kimberley mainly in pure and mixed woodlands of *Avicennia- Bruguiera*, low closed forest of *Camptostemon*, and pure and mixed thickets of *Ceriops*, *Avicennia* and *Aegiceras*. In the Pilbara most often in forests, woodlands and thickets of *Avicennia*, forests of *Avicennia-Rhizophora*, and thickets of *Ceriops*. In the Carnarvon region found in *Avicennia* woodland and thickets, especially those on mud.

Figure 37 Map of northern Western Australia, locating records of *Pachycephala lanioides*: 1 mouth of King River (A6); 2 Still Bay (A3); 16 km NNW of Wyndham, Parry Creek (A4) and Wyndham (A5); 3 Saint George Basin (B7); 4 Secure Bay; 5 Port Usborne; 6 Point Torment (B9); 7 Derby (B10); 8 Cygnet Bay (B11); 9 Cape Baskerville; 10 3 km south of Cape Bertholet (C2) and Coulomb Point; 11 Willie Creek (C3); 12 Roebuck Bay (C4); 13 Thangoo (C5); 14 Cape Bossut (C7) and Rocky Creek (C8); 15 Whistle Creek (C9); 16 Cape Keraudren (D2), Mount Blaze (D3) and Pardoo Creek (D4); 17 mouth of De Grey River (D5); 18 Leslie Salt (D6), Port Hedland (D7) and Finucane Island; 19 mouth of Turner River (D8); 20 Cowrie Creek (D9); 21 Balla Balla Harbour (D10); 22 Cossack (D11), Point Samson (D12) and Popes Nose Creek (D13); 23 Nickol Bay (D14), King Bay (D16) and Dampier Salt (D17); 24 Legendre, West Lewis and Enderby Islands (D29); 25 mouth of Maitland River; 26 mouth of Fortescue River (D19); 27 mouth of Cane River (D20); 28 mouth of Ashburton River (D21); 29 Exmouth Gulf, Giralia Bay (D22), Gales Bay (D23), Bay of Rest (D24) and near Learmonth (D25); 30 Mangrove Bay (D26); 31 Carnarvon, Oyster Creek (E3) and Mangrove Point (E4); 32 New Bay (E6).

South of Bush Bay there is a dramatic change in the structure of the mangal with *Avicennia* becoming more open and sand replacing mud. Most mangrove blocks south of Bush Bay are thus unsuitable for the White-breasted Whistler. However, the Guichenault Point mangal on Peron Peninsula with its extensive *Avicennia* woodland seems suitable, but the whistler has apparently been unable to cross Shark Bay.

Feed mostly at low levels in mangal: on ground, fallen logs, prop roots, pneumatophores, tree trunks and low branches and in canopy. In muddy areas bill and feet are often encrusted with mud. Compared to other Australian whistlers have a long, heavy and strongly hooked bill, which enables them to prize molluscs and crabs from cracks in logs and tree trunks. One observed at Dampier Salt cracking a small mollusc on a log.

The White-breasted Whistler is similar in size, bill-shape and feeding behaviour to the Little Shrike-thrush *Colluricincla megarhyncha,* which may explain the large break in the whistler's range between Cambridge Gulf and St George Basin. The shrike-thrush occurs in mangroves within this area. It appears to be more aggressive than the whistler. Furthermore stomachs of shrike-thrushes from west Kimberley mangals contained mostly Coleoptera, the main food of the whistler. Competition between these two species seems likely, however there may be other important factors such as climate. North-west Kimberley could be too wet for the White-breasted Whistler.

Voice

Contact calls are a loud 'wheet' or two-noted 'too wheee' and occasionally a churring sound. Song is a loud melodious whistle of up to six notes, usually uttered with crown feathers up and throat feathers puffed out and bird bobbing up and down on its perch.

Food

Stomach contents of 46 W.A. specimens were examined. Most important foods were Coleoptera (beetles) and Crustacea (crabs). Seventy-five beetles were recorded in 26 stomachs (also in unknown numbers in 2 more stomachs), and crabs in 25 stomachs. Other important foods were Lepidoptera (23 stomachs), Hymenoptera (48 ants in 15 stomachs, and 9 wasps in 5 stomachs), Hemiptera (10 in 9 stomachs), Araneida (5 in 4 stomachs) and molluscs (3 in 3 stomachs). Minor items were insect larvae, flies and mantids.

Most prey was between 5 and 20 mm long, one mantid was 30 mm long and one bird seen eating a large moth 40-50 mm long.

Breeding

From late August to October. I have only observed males defending the territory, and although not very aggressive they will threaten other males and honeyeaters. On 15 October 1980 in the Bay of Rest, a male was threatening a Singing Honeyeater *Meliphaga virescens.* The whistler held wings partly drooped and tail erect; it then rocked and bobbed up and down, jerking head back and forth. It worked its way to within 30 cm of honeyeater. The same male repeated this display to a male whistler shortly afterwards.

Male and female share in nest building, incubation and feeding of young. I have observed birds collecting nesting material from *Acacia* trees 200 m from mangal. Nest

is a small bowl, constructed of twigs (often of samphire) or rootlets, lined with spinifex or other grasses and placed in vertical fork of mangrove (usually *Avicennia*) 1.5-5 m above ground. A nest collected at Thangoo on 25 September 1975 was 130 mm wide and 60 mm deep externally, and 70 mm wide and 35 mm deep internally. A nest collected in Exmouth Gulf on 12 October 1978 measured 120 mm wide and 100 mm deep externally and 55 mm wide and 45 mm deep internally. The two eggs (rarely one) are dull cream in colour with brown and purplish spots and dashes on larger end. Two eggs from Thangoo measured 26.0x18.8 mm and 25.9x18.0 mm. Newly hatched chicks have black skin and white hairs.

Unfeathered Parts

Iris reddish-brown (N35), brown (13), dark brown (13), red (12), light brown (4), sepia brown (4), dull red (3), sepia (1), red hazel (1) and dark reddish-hazel (1). Bill: adult male black (noted on a few labels as dark grey or grey); immature male brownish-grey; adult female black, brownish-black, greyish-black or occasionally with upper mandible black and lower mandible brown; immature female brown. Legs dark grey, grey or black. Mouth of adults black or greyish-black; of immatures yellow or white.

Geographic Variation

Mayr (1954), Mees (1964), Galbraith (1974) and Ford (1983) recognized three subspecies in the White-breasted Whistler: *Pachycephala lanioides fretorum* from the mouth of the Norman River to east Kimberley, *P. l. lanioides* in west Kimberley, and *P. l. carnarvoni* in the Pilbara and Carnarvon regions. Table 10 shows that birds from Cambridge Gulf, the Northern Territory and Queensland are slightly smaller than other populations. In coloration males vary much less than females. One male from Cambridge Gulf and two from Point Torment have darker backs than other males; many of the back feathers are black, broadly fringed with grey. Males from Karumba have mostly grey tail coverts (some feathers with a central blackish streak), and the tail is tipped greyish-white. Males from Cambridge Gulf and Point Torment have mostly black tail coverts and little or no pale tip to the tail. Males from Cape Bertholet have mostly black tail coverts (some feathers fringed grey) and the tail is tipped greyish-white. Specimens from Frazier Downs, Cape Keraudren and the mouth of the De Grey River are similar to Cape Bertholet birds in that the tail coverts are mostly grey, but some lower coverts have blackish shaft streaks. Males from Popes Nose Creek have the upper-tail coverts grey and the lower coverts black fringed grey. Exmouth Gulf males have the upper-tail coverts grey with blackish centres, and the lower coverts black.

Variation in females is much more marked. Specimens from Karumba and Cambridge Gulf are similar with greyish-brown upperparts (including the tail coverts), light grey face, white orbital feathers, greyish-buff breast and whitish-buff belly. Females from Cape Bertholet are slightly paler. Those from Pardoo and the De Grey River have the head, back, rump and tail coverts greyish-brown; they are overall slightly browner and less grey than Cape Bertholet birds. They are however still more like Kimberley birds than those from the rest of the Pilbara. From Balla Balla south to the Fortescue there is

a drastic change in coloration of females. They become more brownish-grey on the upperparts, with the head, back and face often tinged with reddish-brown; the breast and belly are reddish-brown. Females from the mouth of the Fortescue and Cane Rivers have the upperparts dull grey tinged reddish-brown, the primaries and secondaries edged with reddish-brown, the face and forehead light reddish-brown, orbital feathers reddish-brown, the throat white streaked light brown, and the breast and belly reddish-brown (strongest on breast and flanks). It is of interest that these reddish females are from the area with bright red substrates. As in the Mangrove Heron, there could be some selection in the White-breasted Whistler for matching substrate colour. Female White-breasted Whistlers from Exmouth Gulf are much less red than Fortescue and Cane River specimens. They have the upperparts light brownish-grey, tail coverts grey and the breast and belly buff (strongest on breast and flanks). Carnarvon females are olive-grey on the upperparts including the tail coverts and whitish-buff on the breast and belly.

From this it can be seen that apart from the slight variation in size separating *P. l. fretorum* from other populations, there is no concordance of characters within any of the subspecies. In the tail coverts for example, Cambridge Gulf males are more like those from west Kimberley than those from Queensland, and specimens of nominate *lanioides* from south Kimberley are most like northern *carnarvoni* from Cape Keraudren. There is considerable variation in females of *carnarvoni*, with northern birds from Pardoo and the De Grey River most like the nominate subspecies from the Kimberley, reddish birds from the Fortescue and Cane Rivers, paler birds in Exmouth Gulf and paler birds still in the Carnarvon region.

Pachycephala lanioides fretorum is at best only weakly differentiated, but I would not recognize any subspecies.

Table 10 Measurements (mm) and weight (g) of *Pachycephala lanioides*, means in parentheses.

Population	Sex	N	Wing	Tail	Tarsus	Bill length	Weight
Carnarvon	♂	4	97-100 (98.2)	74-76 (74.7)	25-28 (26.7)	25.0-26.5 (25.6)	41-46 (42.6)
	♀	1	94	75	26	25.5	
Pilbara	♂	35	94-103 (98.5)	73-80 (76.7)	24-28 (25.9)	24.0-27.0 (25.4)	36-48 (40.9)
	♀	27	90-100 (95.4)	65-84 (74.8)	23-29 (26.1)	23.0-27.0 (25.2)	31-52 (41.0)
West Kimberley	♂	16	94-104 (99.3)	71-80 (76.4)	24-27 (25.6)	24.0-27.5 (25.6)	40-45 (42.8)
	♀	7	94-99 (97.0)	72-77 (74.8)	25-26 (25.5)	22.0-26.5 (24.8)	39-43 (40.6)
Cambridge Gulf	♂	5	91-96 (93.8)	71-77 (73.2)	22-25 (23.6)	23.0-25.0 (24.0)	33-39 (35.6)
	♀	3	91-93 (92.0)	70-73 (72.0)	26 (26.0)	23.0-24.0 (23.5)	39
Northern Territory	♂	7	91-101 (95.8)	70-77 (73.8)	21-26 (23.7)	22.5-25.5 (23.6)	33-44 (37.5)
	♀	3	92-97 (94.0)	73-75 (74.0)	25-26 (25.6)	23.0 (23.0)	35
Queensland	♂	3	95 (95.0)	71-75 (73.3)	24-25 (24.6)	23.0-24.0 (23.5)	37
	♀	1	93	72	24	24.5	

Rhipidura dryas Gould **Wood Fantail**

Distribution

Northern Australian coasts from the Watson River, Qld, to Yampi Peninsula, W.A. See Storr (1977, 1980, 1984b). Also southern New Guinea. In Western Australia confined

to Kimberley, from Cambridge Gulf around northern and western coasts to Wotjulum, and inland to Mitchell Plateau and on continental islands. See Figure 38.

Figure 38 Map of Kimberley, Western Australia, locating records of *Rhipidura dryas*: 1 25 km E of Shakespeare Hill; 2 mouth of King River (A6) and 30 km S of Wyndham; 3 Parry Creek (A4) and Wyndham (A5); 4 near Cape Bernier and near Evelyn Island; 5 Napier Broome Bay (B1) and Kalumburu; 6 near Davidson Point; 7 near September Point; 8 Osborn Islands (B12); 9 Walsh Point Port Warrender (B3); 10 Mitchell Plateau; 11 Katers Island (B12); 12 East Montalivet Island (B12); 13 Prince Frederick Harbour; 14 Boongaree Island (B12); 15 Careening Bay (B6), Cape Brewster and Coronation Islands; 16 Kunmunya; 17 Wotjulum.

Status and Ecology

In Western Australia uncommon, occurring in ones and twos. One of the rarer mangrove birds and has a rather patchy distribution. Not confined to mangroves and occurs in coastal semi-deciduous vine forests and closed riverine forests. Within mangal most often in *Rhizophora* forest. At mouth of King River favoured mixed *Bruguiera-Avicennia* and dense low *Acanthus*. Forage below canopy, hovering and hawking for flying insects and hopping about on vegetation and ground. Often flick wings and fan tail while searching for food but much less nimble than Mangrove Grey Fantail *Rhipidura phasiana*.

Voice

Contact calls are soft 'chip-it' or 'chip' and sometimes soft whispery notes. Song is a series of high pitched whistling notes, 'seep-seep-seeper seep-sep', or 'seep-seep chip-chip-chip'.

Food

Stomach contents of 7 W.A. specimens were examined. Most important foods were Hemiptera (mainly leafhoppers Fulgoroidea), Hymenoptera (ants and wasps), Lepidoptera (moths), Coleoptera (beetles) and Diptera (flies and mosquitoes). Other items included insect eggs and spiders. Prey ranged from 1 to 7 mm long.

Breeding

No breeding records for Western Australia. In Northern Territory breed from November to February. See Storr (1977).

Unfeathered Parts

In 11 Kimberley specimens. Iris dark brown or brown. Upper mandible black or greyish-brown. Lower mandible blackish-brown or greyish-brown with a whitish base. Legs horn, brown, black or grey. Mouth whitish, or pink.

Geographic Variation

Most recent workers including Galbraith (1974) and Ford (1983) have treated *R. dryas* as a race of the Rufous Fantail *R. rufifrons*. Ford showed that *rufifrons* and *dryas* do not intergrade in north Queensland and that the superficial resemblance of northern breeding populations of *rufifrons* to *dryas* was a case of convergence. Storr (1984) was the first to treat *dryas* and *rufifrons* as allospecies in view of their marked differences in habitat and morphology. Further work is needed to determine whether *streptophora* of southern New Guinea is separable from *R. dryas*.

Table 11 Measurements (mm) and weight (g) of *Rhipidura dryas* from Western Australia. Means in parentheses.

Population	Sex	N	Wing	Tail	Tarsus	Bill length	Bill width	Weight
Kimberley, WA	♂	9	65-72 (69.0)	80-90 (86.1)	18-20 (19.5)	12.5-15.0 (14.0)	4.3-5.5 (4.9)	8.0-10.0 (9.1)
	♀	4	63-72 (66.6)	81-89 (84.3)	19-20 (19.5)	14.0-14.5 (14.1)	4.5-5.5 (5.1)	8.4- 8.6 (8.5)

Rhipidura phasiana De Vis **Mangrove Grey Fantail**

Distribution

Coastal northern Australia from Shark Bay, W.A. to Norman River Qld, and southern New Guinea. See Storr (1977, 1980, 1983, 1984a, 1984b, 1985) and Heron (1975). In Western Australia, in all five mangrove regions. See Figure 39. In Kimberley, from far north-east and Cambridge Gulf around northern and western coasts to Whistle Creek and

Anna Plains. Not recorded from any Kimberley island. In the Pilbara, from Mandora Creek south-west to Giralia Bay and Mangrove Bay, and some islands in Dampier Archipelago. In the Carnarvon-Shark Bay region, at Lake MacLeod and along coasts from Miaboolia Beach to 8 km NNW of Long Point; also northern Peron Peninsula at Guichenault Point and Little Lagoon.

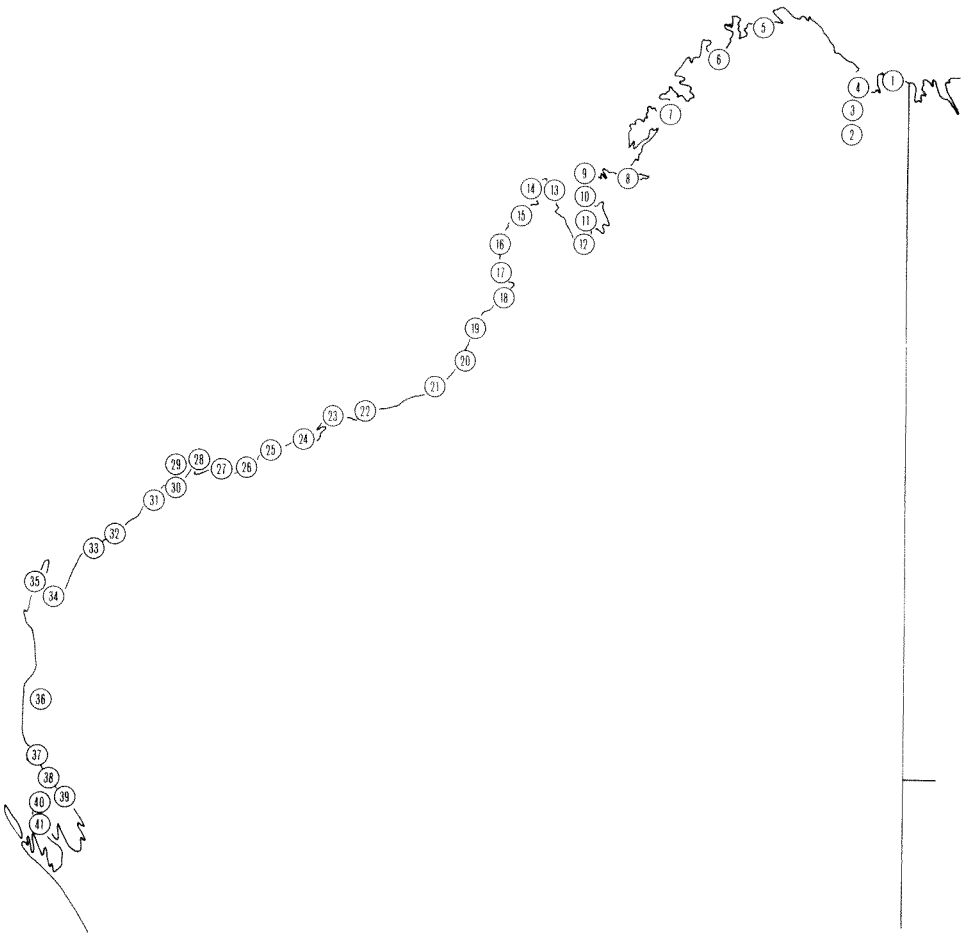

Figure 39 Map of northern Western Australia, locating records of *Rhipidura phasiana*: 1 25 km E of Shakespeare Hill; 2 16 km S of Wyndham and mouth of King River (A6); 3 Parry Creek (A4) and Wyndham (A5); 4 Black Cliff Point (A1), 7 km NNE of Mount Connection (A2) and Still Bay (A3); 5 Napier Broome Bay (B1); 6 Lawley River delta (B2) and Walsh Point Port Warrender (B3); 7 Saint George Basin (B7); 8 Secure Bay; 9 mouth of Trent River (B8); 10 12 km SW of Kimbolton and mouth of Townsend River; 11 Point Torment (B9); 12 Derby (B10); 13 Cygnet Bay (B11); 14 Packer Island (C1); 15 Beagle Bay; 16 Coulomb Point; 17 Barred Creek, Willie Creek (C3) and Broome (C4); 18 Thangoo (C5); 19 Cape Bossut (C7), Rocky Creek (C8) and Whistle Creek (C9); 20 Anna Plains; 21 Mandora (D1); 22 Cape Keraudren (D2) and Pardoo Creek (D4); 23 mouth of De Grey River (D5); 24 Leslie Salt (D6) and Port Hedland (D7);

25 Cowrie Creek (D9); 26 Balla Balla Harbour (D10) and Depuch Island; 27 Cossack (D11), Point Samson (D12) and Popes Nose Creek (D13); 28 Nicol Bay (D14), Withnell Bay (D15), King Bay (D16) and Legendre Island (D29); 29 West Lewis and Enderby Islands (D29); 30 mouth of Devil Creek (D18); 31 mouth of Fortescue River (D19); 32 mouth of Cane River (D20); 33 Onslow and mouth of Ashburton River (D21); 34 Giralia Bay (D22), Gales Bay (D23), Bay of Rest (D24) and near Learmonth (D25); 35 Mangrove Bay (D26) and Yardie Creek (D28); 36 Lake MacLeod (E1); 37 Miaboolia Beach (E2), Carnarvon and Oyster Creek (E3); 38 Bush Bay (E5), New Bay (E6); 39 Greenough Point (E7), 5 km SSE of Denham Hummock (E8) and 9 km N of Long Point (E9); 40 Guichenault Point (E11); 41 Little Lagoon (E12).

Status

Moderately common on northern and western Kimberley coasts from Cambridge Gulf to Point Torment. In south-west Kimberley, common; for example, nine counted on a transect through mangal at Cape Bossut on 11 April 1974, and five on a transect at Whistle Creek on 8 April 1974.

In the Pilbara, much more common in some blocks of mangal than others, e.g. uncommon at Mandora Creek, common at Cape Keraudren and Pardoo, very common at Cowrie Creek (30 recorded in mangal transect on 3 October 1980), common at Balla Balla Harbour, moderately common at Point Samson, common in mouth of Fortescue and Cane Rivers, and common to very common at Mangrove Bay (22 recorded around edge of mangal on 16 July 1981).

In Carnarvon-Shark Bay region, common at Lake MacLeod, Miaboolia Beach, Carnarvon and Bush Bay, and uncommon in mangal 7-8 km north of Long Point (only four recorded here on 14 November 1982). None found in small block of mangal at Long Point, the last mangroves on mainland side of Shark Bay. On Peron Peninsula, moderately common at Guichenault Point, but only three seen at Little Lagoon.

Ecology

In Kimberley, occurring in all mangal formations from dense mixed forests to open stunted *Avicennia*. In Cambridge Gulf and north-west Kimberley largely confined to mangal, but in south-west Kimberley also in other near-coastal vegetation, especially forests and thickets of *Melaleuca acacioides*. This melaleuca forms large stands often contiguous with mangal or separated by samphire and buffel grass flats. The melaleuca thickets and samphire flats are both rich in insects, and this may explain greater abundance of Mangrove Grey Fantail in south-west Kimberley than further north. North of Point Torment most mangals are backed by bare mudflats and open woodland that is unsuitable habitat for this species.

In the Pilbara, found in all mangal formations including forests of *Rhizophora*, and open stunted and even almost dead stands of *Avicennia*. Occasionally leaves mangal to forage in neighbouring samphire flats and *Acacia* scrubs.

In Carnarvon-Shark Bay region, confined to mangal occurring in most formations from *Avicennia* woodland to low stunted shrubland. Also forage in adjacent samphire flats.

Feed in all levels of mangal: in canopy of trees and shrubs and on branches, tree trunks, hanging roots, prop roots, pneumatophores, fallen logs and ground. Also frequently feed above canopy and around edges of mangal, hawking flying insects and returning to cover. Occasionally leaves mangal to forage out over samphire flats. In south-west Kimberley, often cross 2-3 km of samphire and buffel grass flats to belts of melaleuca. Within these melaleuca forests and thickets also feed in all strata from the canopy to the ground.

Insects are gleaned from vegetation while perched or hovering, and the constant movement and fanning of the tail flushes many small insects that are then caught in mid-air or followed and snapped up when they land. Extremely active and aerobatic. They hop about on the vegetation, often make short flights, and flutter, hover and turn in and out among the mangroves. Observed catching mosquitoes by hovering just above water. Often follow an observer through mangal catching disturbed insects. On many occasions I have had fantails catching mosquitoes and sand-flies that were attracted to me. The birds would hover and flutter to within about 20 cm and on several occasions even briefly land on me while catching insects. This feeding method would no doubt also be used with other large mammals, especially the kangaroos and wallabies that often shelter from the heat and drink within the mangal. Mangrove Grey Fantails often drink and bathe at freshwater springs in the mangroves.

Voice

Contact calls are short 'check chek' or 'dek dek' sounds similar to those of Grey Fantail *Rhipidura fuliginosa*. Song is a series of short twittering whistles, 'chit-chit chitty-chit', usually lasting 3-4 seconds, and easily distinguished from song of Grey Fantail.

Food

Stomach contents of 12 W.A. specimens were examined. Most important foods were Hymenoptera and Diptera. Eighty-seven Hymenoptera (mainly wasps) found in 7 stomachs, and 61 Diptera (flies and mosquitoes) in 8 stomachs. Other important foods were Hemiptera (15 in 6 stomachs), Coleoptera (8 in 6 stomachs), Lepidoptera (in 3 stomachs), Araneida (8 in 3 stomachs) and ants (3 in 2 stomachs). Other items included insect larvae and a cricket. Prey ranged from 2 to 12 mm long.

Breeding

In Kimberley and Pilbara from September to March (Storr 1980, 1984a), and in Carnarvon-Shark Bay region in spring and summer (Storr 1985). Sexes share in nest building and attending young out of nest. Nests shaped like small stemmed glass without a base. Made of fine strips of bark (usually *Avicennia*) tightly bound together with spider web and lined with fine rootlets and strips of bark. Nest tail or stem is made of thin strips of bark bound together with spider web. Most nests built from 1 to 3 m above high water, on thin horizontal branches of mangroves especially *Avicennia*. Nests have a light brown papier-mache look and camouflage well with pale bark of *Avicennia*.

Measurements (mm) of 4 W.A. nests are as follows: 1) external 53 wide x 50 deep, internally 36 wide and 23 deep, tail 50 long; 2) externally 54 wide x 45 deep, internally

42 wide x 30 deep, tail 30 long; 3) externally 52 wide x 40 deep, internally 40 wide x 25 deep, tail 55 long; and 4) externally 53 wide x 36 deep, internally 38 wide x 20 deep, tail 30 long. The tail of one nest found near Carnarvon was 160 mm long. One or two eggs form the clutch. They are creamy white with light brown spots and blotches forming a zone around the larger end. Two eggs from Carnarvon measured 15.6 x 12.0 mm and 15.5 x 12.4.mm

Immature birds have head, brow, back and wing coverts tinged with buff, and wing coverts broadly edged with white.

Unfeathered Parts

Iris brown (N24) or dark brown (23). Upper mandible black or dark brown. Lower mandible black with a white or greyish-white base. Legs black (sometimes grey). Mouth yellow.

Taxonomy

Ford (1981b) showed that *phasiana* was the most distinctive member of the *Rhipidura fuliginosa* complex. It differs from the other members of the group in song, ecology, clutch size and morphology. Compared to *fuliginosa, phasiana* is small, has a large bill and short tail, is paler on the upperparts (light brownish-grey rather than dark grey), has a small pale grey breast smudge rather than a blackish-grey band, is more buffy on the underparts and has little or no white edging to the secondaries. The song is also very different to that of *fuliginosa,* both on sonagrams and to the ear (Ford 1981). I therefore follow Storr (1984a) in treating *phasiana* as a full species.

Table 12 Measurements (mm) and weight (g) of *Rhipidura phasiana* from Western Australia, means in parentheses.

Population	N	Wing	Tail	Tarsus	Bill length	Bill width	Weight	Total length
Carnarvon-Shark Bay	13	62-70 (65.7)	68-75 (73.5)	15-17 (16.3)	12.0-14.0 (12.8)	4.0-5.1 (4.3)	6.4-7.6 (7.0)	139-151 (146)
Pilbara	31	64-70 (66.7)	73-80 (76.0)	15-17 (16.4)	11.5-14.0 (12.8)	3.1-4.5 (3.8)	4.0-7.8 (6.8)	140-158 (151)
Kimberley	21	63-68 (66.1)	70-79 (74.6)	15-18 (16.3)	11.5-14.5 (12.9)	3.5-4.7 (4.1)	5.0-7.5 (6.6)	120-155 (146)

Myiagra ruficollis (Vieillot) **Broad-billed Flycatcher**

Distribution

Coastal northern Australia from Frazier Downs, W.A. To Keppel Bay, Qld. See Storr (1977, 1980) and Boles (1984). Also Timor and northern New Guinea. In Western Australia confined to Kimberley, from far north-east and Cambridge Gulf to Whistle Creek and on continental islands (Sir Graham Moore, Carlia, Boongaree, Augustus and Heywood). See Figure 40.

Figure 40 Map of Kimberley, Western Australia locating records of *Myiagra ruficollis*: 1 25 km E of Shakespeare Hill; 2 Still Bay (A3) and 16 km NNW of Wyndham; 3 Black Cliff Point (A1); 4 Napier Broome Bay (B1) and Sir Graham Moore Islands (B12); 5 Carlia Island (B12); 6 Lawley River delta (B2); 7 Walsh Point Port Warrender (B3); 8 Prince Frederick Harbour; 9 Boongaree Island (B12); 10 Saint George Basin (B7); 11 Kunmunya; 12 Augustus Island (B12); 13 South Heywood Island (B12); 14 near mouth of Sale River; 15 Walcott Inlet; 16 Collier Bay; 17 Wotjulum; 18 Cascade Bay and Port Usborne; 19 Point Torment (B9); 20 Derby (B10); 21 mouth of Fitzroy River; 22 Cygnet Bay (B11); 23 Sunday Island (B12); 24 Packer Island (C1); 25 Cape Borda and Pender Bay; 26 Cape Baskerville; 27 3 km S of Cape Bertholet (C2); 28 Coulomb Point; 29 Willie Creek (C3); 30 Broome (C4); 31 Cape Bossut (C7).

Status and Ecology

Locally moderately common, but generally uncommon. Moderately common at Black Cliff Point in Cambridge Gulf, but scarce elsewhere in the Gulf. In Lawley River estuary and at Walsh Point and Point Torment, moderately common, but in St George Basin and on Dampier Land, uncommon. Usually in ones and twos, often pairs.

Rand and Gilliard (1967) remark that this is one of the few birds in New Guinea that seem restricted to mangrove forests. In the Northern Territory and Queensland found mainly in mangroves but occasionally in other near-coastal vegetation including riverine forest, monsoon thickets and melaleuca swamps. In Western Australia found mainly in

mangroves and occasionally coastal vine forests. In mangroves favour extensive blocks with closed formations. Often found in pure and mixed forests of *Rhizophora, Bruguiera* and *Avicennia,* tall woodlands of *Avicennia* and *Camptostemon,* thickets of *Aegiceras* and *Ceriops* and mixed *Ceriops-Camptostemon.*

Forage at all levels of mangal from canopy to ground. Prey often captured among leaves by rapid sideways snap of bill. Also forage on branches, trunks, prop roots, pneumatophores and ground. At Rumble Bay one seen clinging upside down picking food from hanging aerial root of *Rhizophora.* Occasionally insects taken on wing. Food taken on ground or in air is carried back to a perch. Like Leaden Flycatcher *Myiagra rubecula,* often quivers tail up and down or sideways when perched and sometimes raises short crest.

Field Characters

Male Broad-billed Flycatchers have more rufous on throat and breast and more gloss on head and back than females. Females also have a pale line of feathers on forehead, across top of bill. In the field this flycatcher is difficult to separate from female Leaden Flycatchers. Broad-billed Flycatchers differ from female Leaden Flycatchers in having wider, flatter bill, more white below eye and in lore (Leaden females are blackish in lore) and females have a greyish forehead. Compared to female Leaden, male Broad-billed Flycatchers are darker and glossier on head, back, wings and tail. Immature Broad-billed Flycatchers have whitish throat, buff breast (richer in males), brown wings and dull greyish-blue head and back. They also have white on outer tail feathers.

Voice

Contact calls are mainly churring 'scratch' sounds. Other calls include a 'chee-chew' and 'ka-tree' repeated and a more musical 'joey joey' repeated two or three times and a higher pitched 'chinny chinny' or 'chrinney-chrinney'.

Food

Stomach contents of 12 W.A. specimens were examined. Most important foods were insects: Coleoptera (including Scarabacidae, Melonthinae and Cerambycidae), Lepidoptera, Hemiptera (including Pentatomidae and Reduvioidea), Hymenoptera (wasps, bees and *Polyrachis* ants) and Diptera. Other foods include spiders and once a small mollusc and grit. Most prey was less than 5 mm long, but one beetle measured 9 mm.

Breeding

No breeding records from Western Australia. Males with enlarged gonads collected in October in Cambridge Gulf and Lawley River estuary. In Northern Territory breeds in October (Storr 1977) and in Queensland from November to February (Storr 1984b). Most nests are shallow cups 60 mm wide and deep, made of strips of bark and grass, bound together with spider web. Usually built in a vertical fork of a mangrove 1-3 m above high water. A clutch of three eggs collected by R. Mason on 28 October 1979 in Darwin mangroves, measured 18.9 x 13.7 mm, 18.4 x 13.5 mm and 18.9 x 13.4 mm.

Unfeathered Parts

Adults. Iris dark brown to brown. Bill bluish-black to bluish-grey with a black tip. Mouth pink to greyish-white. Legs grey to greyish-black. Immatures have a brownish bill with a pale base to the lower mandible, and have a yellow mouth.

Geographic Variation

I follow Storr (1977, 1980, 1984b) and Ford (1983) in placing all Australian and New Guinea populations in the same subspecies *M. r. mimikae* Ogilvie-Grant.

Table 13 Measurements (mm) and weight (g) of *Myiagra ruficollis*, means in parentheses.

Population	Sex	N	Wing	Tail	Tarsus	Bill length	Bill width	Weight
Kimberley,	♂	21	66-71(68.8)	63-68(64.9)	16-19(17.6)	16.5-18.0(17.3)	6.4-7.8(7.1)	9.2-11.5(10.2)
W.A.	♀	9	63-71(66.8)	61-67(64.1)	16-20(17.3)	16.5-18.0(17.2)	6.8-7.6(7.2)	9.5-10.5(9.8)
Northern	♂	1	71	64	21	19.0	7.2	
Territory	♀	3	68-70(69.0)	66-69(68.0)	16-19(17.6)	18.0-18.5(18.3)	7.5-8.0(7.7)	
Queensland	♂	2	68,70	66	17,19	16.5,17.0	6.4,7.0	10.0,11.9
	♀	6	65-77(71.0)	65-68(65.8)	15-19(17.5)	16.0-19.0(17.6)	6.6-8.0(7.2)	12.3
New Guinea	♂	3	70-75(72.0)	61-69(66.0)	17(17.0)	17.5-18.0(17.8)	6.8-7.4(7.1)	

Myiagra alecto (Temminck) **Shining Flycatcher**

Distribution

Northern Australia from Point Samson, W.A., to Moreton Bay, Qld. See Storr (1977, 1980, 1984a, 1984b). Outside Australia, the Moluccas, Tenimbar and Aru Islands, New Guinea, the Bismarck Archipelago and Admiralty Islands. In Kimberley, northern and western coasts from Cambridge Gulf to Tilbata Creek and Cygnet Bay on northern Dampier Land and some continental islands. Also recorded in interior of Kimberley along large watercourses, namely middle Carson, middle Drysdale, lower Dunham, lower Ord and Elvire. In the Pilbara all records are from mangal between Cossack and Point Samson. See Storr (1980, 1984a) and Figure 41.

Status and Ecology

In Kimberley mangals, generally uncommon, occurring mainly in ones and twos (often in pairs). Inland records are mostly of single, immature birds. The status of the birds in the Cossack-Point Samson mangal is uncertain. I.C. Carnaby reported a female at Cossack in the 1960s, and T.E. Bush observed a female at Point Samson on 10 September 1976 and three days later a pair at Cossack. On 7 October 1975 one was calling from mangal 2 km SW of Cossack. It appears that these birds are part of a small isolated population in this mangal. There are no other Pilbara records, which one would expect if odd birds were visiting this region from the Kimberley. September-October is also the start of the breeding season in the Kimberley, so most wanderers should be back in their breeding quarters by this time. The mangal between Cossack and Point Samson

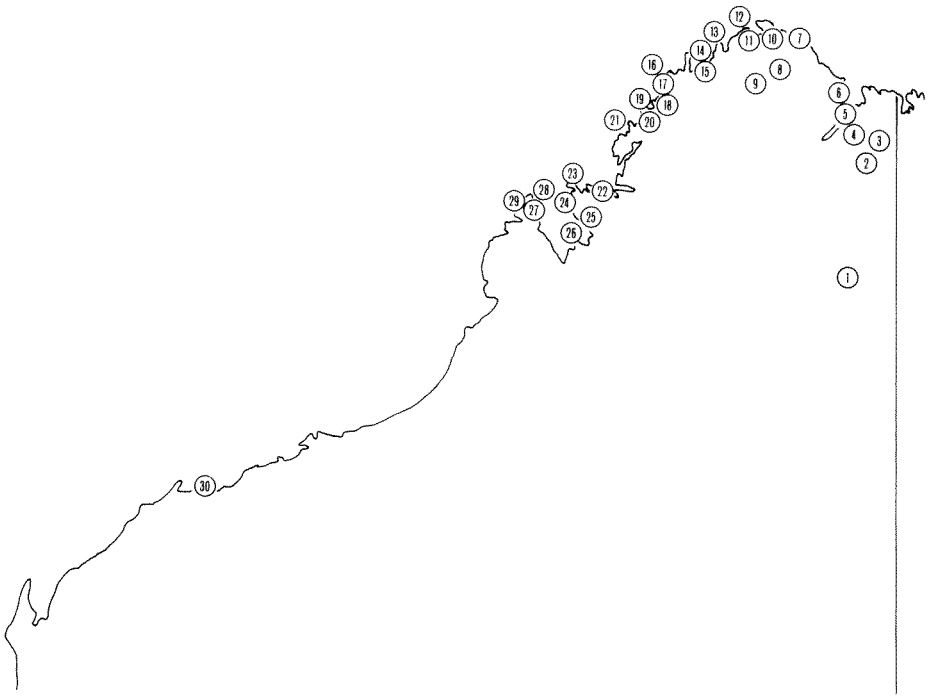

Figure 41 Map of northern Western Australia, locating records of *Myiagra alecto*: 1 Elvire River; 2 lower Dunham River; 3 lower Ord River near Ivanhoe; 4 Parry Creek; 5 near Sphinx Rocks; 6 Black Cliff Point (A1); 7 near Cape Bernier; 8 junction of Johnson Creek and Drysdale River; 9 middle Carson River; 10 near mouth of Drysdale River; 11 Napier Broome Bay (B1); 12 Sir Graham Moore Islands (B12); 13 Cape Bougainville; 14 Osborn Islands (B12); 15 Lawley River delta (B2) and Walsh Point (B3); 16 Bigge Island (B12); 17 York Sound; 18 Prince Frederick Harbour including mouth of Hunter River (B5) and Boongaree Island (B12); 19 near Cape Brewster, Coronation Islands (B12) and Careening Bay (B6); 20 Saint George Basin (B7) including Saint Andrew and Uwins Islands (B12); 21 Augustus Island (B12); 22 Secure Bay; 23 Wotjulum; 24 Port Usborne and 12 km SW of Kimbolton; 25 mouth of Stewart River; 26 Point Torment (B9); 27 Cygnet Bay (B11); 28 Sunday Island; 29 Packer Island (C1); 30 Cossack (D11) and near Point Samson (D12).

is the most luxuriant and one of the largest blocks in the Pilbara. It contains good areas of low-closed forest of *Rhizophora, Rhizophora-Avicennia* and *Bruguiera,* which is suitable habitat for this flycatcher.

In Kimberley found mainly in mangroves. Occasionally seen in coastal semi-deciduous vine forests and riverine vegetation with *Melaleuca* and *Pandanus.* Within mangal favour closed formations, especially forests of *Rhizophora* and *Bruguiera,* mixed stands of *Rhizophora-Avicennia* with *Aegiceras* understory, and pure and mixed thickets of *Rhizophora, Aegiceras, Bruguiera* and *Ceriops.*

Feed mainly in lower levels of mangal: on tree trunks, among tangled prop roots and pneumatophores, on fallen logs and on ground. In muddy areas feet and legs often covered in mud. Fairly active, with short flights and hops, often flick tail from side to side or up and down and occasionally fan tail. Quick to snap up insects disturbed by their movements. Often forage just above water line on incoming tides, searching tree trunks and prop roots for insects displaced by rising water. At Mt Trafalgar in August 1974 a female was flying out over a freshwater pool, hovering for second and snatching water beetles from surface. Often bathe at freshwater springs in mangal, alight in water and flick it over head and back with wings.

Voice

Contact calls include low grating 'screek' or 'ngaar' like creaking door, a drawn-out 'scratch' and 'squeeel'. Song includes loud melodious whistles and trills, 'zwick' repeated four or five times, loud ringing 'joey joey' and long or short 'fil-fil'. When calling often raise crown feathers in low crest. Often loud whistling calls of males answered by grating or creaking calls from other birds, probably females.

Food

Stomach contents of 9 W.A. specimens were examined. Most important foods were Crustacea (crabs), Hymenoptera (wasps) and Coleoptera (beetles). Minor foods were spiders, Hemiptera, ants of the genus *Polyrachis* and Lepidoptera. Most prey was between 2-5 mm long. G.F. Hill (1911) listed small shells, crabs and ants as food taken by birds in Napier Broome Bay.

Breeding

In Kimberley from about mid-October to March. Pairs share in nest building. Most nests built from 1-3 m above water in vertical forks. They are cup-shaped, made of fine pieces of dry bark, leaves and twigs, bound together with spider web and lined with coarse twigs, bark and rootlets. A nest collected near Black Cliff Point, Cambridge Gulf, on 12 October 1982 was 75 mm wide and 35 mm deep externally, and 55 mm wide and 30 mm deep internally. It was placed 2.5 m up in a vertical fork of a *Rhizophora* sapling. A clutch of two eggs was collected by G.F. Hill at Napier Broome Bay on 31 January 1910.

Unfeathered Parts

Adult. Iris dark brown to brown. Bill bluish-black to bluish-grey with a black tip. Mouth orange to reddish-orange. Legs blue-grey to greyish-black. Immatures have an all-dark greyish-black bill.

Geographic Variation

Mayr (1941) grouped all Australian populations under one subspecies (*nitida*). Keast (1958) divided the Australian populations into three subspecies: *tormenti* in west Kimberley, *nitida* in north-east Kimberley and the Northern Territory, and *wardelli* in Queensland.

The range of the Shining Flycatcher is continuous in Kimberley and the Northern Territory, but there is a break between the latter and Queensland populations in the Gulf of Carpentaria. Keast believed that *tormenti* differed from *nitida* in having a long, narrow bill, and that the males had a sooty black not glossy black abdomen, and females lacked the sheen on the head. Mees (1982) also recognized *tormenti*. However neither Keast nor Mees had adequate adult material from the Kimberley. Kimberley birds certainly have long narrow bills, but so do birds from the Victoria River drainage, N.T. Indeed a female from the Bullo River has not only a long bill but a narrower bill than all Kimberley females. Adult Kimberley males have a shiny abdomen and adult females a glossy blue-black crown, as in other races. It is worth noting that juvenile males are coloured like immature females except for a few black feathers on their chin. They change gradually to black with immature birds still lacking the sheen on the belly. Until knowledge is gained on the manner of the changes between the Victoria River drainage and Melville Island, I follow Ford (1983) in treating the Kimberley-Northern Territory population as a separate subspecies *melvillensis* from the north Queensland population *wardelli*. In passing however I note that an immature female from Tully, Queensland, is very similar to a female from the Roper River, Northern Territory. If only one Australian subspecies is recognized, as before Keast, *wardelli* is its name.

Table 14 Measurements (mm) and weight (g) of *Myiagra alecto* from Western Australia and Northern Territory, means in parentheses.

Population	Sex	N	Wing	Tail	Tarsus	Bill length	Bill width	Weight	Total length
Kimberley, W.A.	♂	11	80-89(84.0)	68-78(73.4)	20-23(21.2)	22.0-24.0(23.0)	4.7-5.6(5.1)	18-20(19)	160-189(173)
	♀	14	76-84(81.0)	69-74(71.8)	20-22(21.0)	21.0-23.5(22.5)	4.5-5.8(5.2)	15-21(18)	163-184(175)
Northern Territory	♂	7	83-90(86.0)	72-78(74.4)	19-22(20.5)	21.0-22.5(21.7)	4.9-5.6(5.3)	18,22	
	♀	5	79-83(81.0)	68-76(72.6)	20-22(21.4)	21.5-22.0(21.9)	4.8-5.6(5.1)	18-22(20)	179-188(183)

Gerygone levigaster Gould — **Mangrove Flyeater**

Distribution

Coastal northern and eastern Australia from southern Kimberley, W.A., to Lake Macquarie, N.S.W. See Storr (1977, 1980, 1984b) and Morris *et al.* (1981). In Western Australia from Cambridge Gulf around northern and western coasts to Nita Downs. See Figure 42.

Status and Ecology

Usually in ones and twos, often pairs. Much more common in some blocks of mangal than others. Common in Cambridge Gulf but scarce in north-west Kimberley at Pago, Port Warrender and St George Basin. Common to moderately common at Point Torment and common in south-west Kimberley from Cygnet Bay to Nita Downs.

In Cambridge Gulf mainly in mangroves. Favours open areas within the mangal and landward zones with *Avicennia, Aegiceras* and *Excoecaria*. Also in *Melaleuca* woodland

Figure 42 Map of Kimberley, Western Australia, locating records of *Gerygone levigaster*: 1 25 km E of Shakespeare Hill; 2 near mouth of King River (A6); 3 Wyndham (A5) and 16 km NNW of Wyndham; 4 Parry Creek; 5 mouth of Ord River and 7 km NNE of Mount Connection (A2); 6 Black Cliff Point (A1); 7 Napier Broome Bay (B1); 8 near mouth of Roe River; 9 Saint George Basin (B7); 10 mouth of Trent River (B8); 11 Point Torment (B9); 12 Derby (B10); 13 mouth of Fitzroy River; 14 Cygnet Bay (B11); 15 One Arm Point and near Cape Leveque; 16 Lombadina, Packer Island (C1) and Martins Well; 17 Pender Bay; 18 Beagle Bay; 19 Cape Baskerville; 20 3 km S of Cape Bertholet (C2); 21 Willie Creek (C3); 22 16 km NE of Broome and Broome (C4); 23 Roebuck Plains; 24 Thangoo; 25 Lagrange; 26 Frazier Downs; 27 Nita Downs.

and thickets backing mangal and fringing creeks and rivers. In Port Warrender and St George Basin, only in tall mixed forest of *Rhizophora-Bruguiera*. At Point Torment, favours mixed mangal of *Bruguiera*, *Ceriops* and *Camptostemon* with scattered *Avicennia*, also mixed and pure stands of *Camptostemon-Avicennia;* and often in thickets of *Melaleuca acacioides* backing mangal. On Dampier Land the most common flyeater. Here favours thickets of *Melaleuca acacioides* (often mixed with *Acacia*) growing around coastal samphire flats, behind coastal dunes and along watercourses. Less frequently in mangal, mainly pure and mixed stands of *Camptostemon*, *Rhizophora* and *Bruguiera*. Further south at Thangoo, Lagrange, Frazier Downs and Nita Downs mainly in near-coastal belts of

Melaleuca acacioides and swamps with *M. cajuputi*. Overall has preference for *Melaleuca*. Within mangal favours edges and more open landward zones.

Feed mainly in canopy, moving rapidly through foliage with short hops and flights, taking insects from leaves and flowers. Occasionally hovering at flowers to peck at insects, and making short flights to catch flying prey.

Voice

Soft chattering contact calls, and rich melodious rising and falling song, similar to that of Western Flyeater *Gerygone fusca*.

Food

Stomach contents of 11 W.A. specimens were examined. Most important foods were Hemiptera (mostly bugs), Coleoptera (beetles), Hymenoptera (wasps), Lepidoptera and spiders. Forty-nine Hemiptera were found in 9 stomachs, 30 Coleoptera (in 8 stomachs), 24 Hymenoptera (in 6 stomachs), Lepidoptera (in 5 stomachs) and 6 spiders (in 5 stomachs). Minor foods were ants, Diptera and insect eggs and larvae. Most items were 2-5 mm long.

Breeding

In Kimberley from February to July. At Willie Creek on 23 September 1975 an adult was displaying to another adult and juvenile on same perch. Its wings were held vertical (almost touching), head to one side and tail fanned and held low. As it sang it began to flick and lower wings slowly. A similar display by one bird observed at Roebuck Plains in July 1975. It appeared to be in response to others calling nearby.

Nests are small compact domes, with short tail, and spout-like entrance near the top. Usually built in hanging leaves of *Melaleuca* trees or mangroves and often near nesting colonies of wasps. A nest collected by N. Kolichis on 18 March 1980 was placed 5 m up on a thin twig of drooping *Melaleuca acacioides* branch. It measured 150 mm long (tail 20 mm long), and 50 mm wide, with circular spout-like entrance 25 mm wide near top. It was made of pieces of *Melaleuca* bark, bound together with spider web and lined with feathers. Two or three eggs form the clutch. They are pinkish-white, finely spotted and flecked with light reddish-brown, mainly on larger end. A clutch of two eggs collected by N. Kolichis at Roebuck Plains on 26 February 1986 measured 16.5 x 11.9 mm and 16.6 x 11.3 mm, and one egg collected there on 18 March 1980, 15.0 x 10.8 mm.

Birds just fledged have face and brow yellow and wings, back and rump tinged with buff.

Unfeathered Parts

Adults. Iris brick red (N14), red (11), red-brown (8), brown (2), dark red (1) and pale red (1). Bill black. Legs black (19), grey-black (2), grey-brown (1), grey (1), dark grey

(1) and light grey (1). Mouth black or greyish. Three immatures. Iris reddish, pale grey-brown or grey. Bill dark brown or pale grey. Legs grey, blue-grey or light grey. Mouth yellow.

Table 15 Measurements (mm) and weight (g) of *Gerygone levigaster* from Western Australia, means in parentheses.

Population	Sex	N	Wing	Tail	Tarsus	Bill length	Bill width	Total length	Weight
Kimberley, W.A.	♂	21	50-55(52.5)	36-41(38.4)	16-18(16.8)	12.0-13.5(12.4)	2.8-3.7(3.3)	97-110(104)	5.0-6.5(5.6)
	♀	8	49-51(50.2)	32-38(35.6)	16-17(16.3)	11.5-13.5(12.1)	2.4-3.6(3.1)	99-105(101)	5.0-6.6(5.5)

Gerygone tenebrosa (Hall) **Dusky Flyeater**

Distribution

Endemic to Western Australia. In Kimberley restricted to south-west, from mouth of Trent River to Whistle Creek. In the Pilbara from Cape Keraudren south-west to Giralia Bay and Mangrove Bay and islands in Dampier Archipelago. In Carnarvon region at Lake MacLeod, and on mainland coasts from Miaboolia Beach south to 8 km NNW of Long Point. See Figure 43. Two large breaks in its range: one along Eighty Mile Beach from Whistle Creek to Cape Keraudren, the other along rocky coast devoid of mangal between Mangrove Bay and Miaboolia Beach. Its distribution in Kimberley appears to be limited in north by presence of Large-billed Flyeater *Gerygone magnirostris*.

Status and Ecology

Throughout its range one of the most common birds in mangal. Usually in ones or twos (often pairs) and occasionally in family parties.

Confined to mangal. In Kimberley, occurs in wide range of habitats including tall forest of *Rhizophora*, whipstick thickets of *Bruguiera* and *Ceriops*, woodlands of *Avicennia* and *Camptostemon*, and low open *Avicennia*. Attracted to flowering trees and shrubs especially *Bruguiera* and *Aegiceras*. In the Pilbara favours forests and woodlands of *Rhizophora* and *Avicennia* in pure or mixed stands and thickets of *Avicennia* and *Ceriops*. In Carnarvon region mainly in woodlands and thickets of *Avicennia*.

Very active, being almost continuously on the move. Feed mainly in outer canopy, gleaning insects from leaves and flowers. Frequently hover about foliage and at flowers snapping at insects, and often hang from leaves and small branches to peck at prey. Often make short quick jumps to snatch insects from air or from leaves. Occasionally forage below canopy on tree trunks and branches and sometimes even on prop roots.

Pairs often feed close together and keep in touch with short chattering contact calls. Has a melodious but hesitating song 'chee-chee chew-wee witwee', less vigorous and more repetitive than Western Flyeater's.

Food

Stomach contents of 32 W.A. specimens were examined. Most important foods were Lepidoptera (moths and butterflies) recorded in 20 stomachs, 110 Coleoptera (beetles)

Figure 43 Map of northern Western Australia, locating records of *Gerygone tenebrosa*: 1 mouth of Trent River (B8); 2 12 km SW of Kimbolton; 3 Point Torment (B9); 4 Derby (B10) and mouth of Fitzroy River; 5 Cygnet Bay (B11) and One Arm Point; 6 Packer Island (C1) and Pender Bay; 7 Cape Baskerville and 3 km S of Cape Bertholet (C2); 8 Willie Creek (C3), Barred Creek and Broome (C4); 9 Thangoo (C5); 10 Lagrange Bay (C6); 11 Cape Bossut (C7), Rocky Creek (C8) and Whistle Creek (C9); 12 Cape Keraudren (D2), Mt Blaze (D3) and Pardoo Creek (D4); 13 mouth of De Grey River (D5); 14 Leslie Salt (D6) and Port Hedland (D7); 15 Cowrie Creek (D9); 16 Balla Balla Harbour (D10); 17 Cossack (D11), 2 km SW of Point Samson (D12) and Popes Nose Creek (D13); 18 Nickol Bay (D14), King Bay (D16) and Dolphin and Legendre Islands (D29); 19 Dampier Salt (D17) and West Lewis and Enderby Islands (D29); 20 mouth of Maitland River and mouth of Devil Creek (D18); 21 mouth of Fortescue River (D19); 22 mouth of Cane River (D20); 23 mouth of Ashburton River (D21); 24 Giralia Bay (D22) and Gales Bay (D23); 25 Bay of Rest (D24) and near Learmonth (D25); 26 Mangrove Bay (D26); 27 Lake MacLeod (E1); 28 Miaboolia Beach (E2), Carnarvon, Oyster Creek (E3) and Mangrove Point (E4); 29 Bush Bay (E5) and New Bay (E6); 30 Greenough Point near Denham Hummock (E7), 5 km SSE of Denham Hummock (E8) and 8 km NNW of Long Point (E9).

found in 14 stomachs, 70 Hemiptera (mainly bugs Cicadellidae) in 12 stomachs, 42 Hymenoptera (wasps) in 13 stomachs, 35 Araneida (spiders) in 10 stomachs and 26 Diptera in 9 stomachs. Minor foods were snails (11 in 5 stomachs), crabs, ants and insect eggs. Prey 3-15 mm long.

Breeding

In Kimberley in June, in the Pilbara from September to October and in Carnarvon region from October to January. Adults share in nest construction and feeding of young. Most nests built in canopy, often in *Avicennia*. They are compact domes with short tail and spout-like entrance near top. Nests suspended only from top usually have longer tails than those suspended from top and sides. Eight nests ranged in size from 170-330 mm long (including tail), tail 60-175 mm long, and entrance hole which is roughly circular 20-25 mm in diameter. Nests made of strips of bark, dry seaweed, leaves and feathers, bound together with spider web and plant fibre, and lined with feathers and soft plant material.

Two eggs form the clutch. They are white to whitish-pink with reddish-brown spots and small blotches mainly confined to larger end and sometimes forming a cap. Eight eggs ranged in size from 17.8-20.5 mm long and 10.6-12.7 mm wide.

Birds just fledged have throat and abdomen whitish. Slightly older birds develop a yellowish wash on face, throat and abdomen.

Unfeathered Parts

Iris white (N72), greyish-white (7), straw-coloured (1) and light brown (1). Bill black (N68) or greyish-black (2) (more brownish in immatures, with the base of the lower mandible yellowish-white). Legs black (N59) and often glossy, or leaden black or dark grey (18). Mouth black in adults, yellow in immatures.

Geographic Variation

In my earlier paper on this species (Johnstone 1975) I tentatively recognized three subspecies: nominate *tenebrosa* in southern Kimberley, *whitlocki* in the Pilbara and *christophori* in the Carnarvon region. I noted that although isolated geographically *christophori* and *whitlocki* only differ from nominate *tenebrosa* slightly in size and coloration. I have since collected a much larger series, which allows a better understanding of variation. The differences between all three populations are indeed slight. Northern specimens of *christophori* from Miaboolia Beach and Lake MacLeod are very similar to Pilbara specimens in size and coloration. There is also little difference between Pilbara birds and those from southern Kimberley from One Arm Point to Whistle Creek. The most significant change occurs at Point Torment; here and northwards birds are a little darker on the head and back, being greyish-brown rather than olive grey. In this respect Point Torment and Trent River specimens approach the closely related Large-billed Flyeater *G. magnirostris*. Previously I believed that *tenebrosa* extended north to Kunmunya on the basis of a male collected there by K.G. Buller on 20 June 1954 with supposedly cream irides. Ford (1983) identified this bird as a *magnirostris*, and after re-checking

the specimen I would agree, as it matches *magnirostris* in all but iris colour. This reduces the overlap of *magnirostris* and *tenebrosa* to the small area on Yampi Peninsula between the mouth of the Trent River and Port Usborne. At the mouth of the Trent River I observed several *tenebrosa* including two near a nest 4 m up in a *Bruguiera*. In the same block of mangal I observed and collected *G. magnirostris*, that showed no tendency towards *tenebrosa*.

In summary, I would no longer recognize any subspecies in *G. tenebrosa*.

Table 16 Measurements (mm) and weight (g) of *Gerygone tenebrosa*, means in parentheses.

Population	Sex	N	Wing	Tail	Tarsus	Bill length	Bill width	Total length	Weight
Carnarvon	♂	10	53-59(57.0)	41-47(43.6)	19-22(20.5)	14.0-15.0(14.5)	3.0-3.8(3.4)	115-124(117)	8.0-9.0(8.6)
Region	♀	11	50-56(53.0)	38-42(40.0)	16-22(18.9)	13.5-14.5(14.0)	3.0-4.1(3.3)	111-116(114)	6.9-8.2(7.4)
Pilbara	♂	20	53-63(57.6)	42-49(44.9)	19-22(20.4)	12.5-15.5(14.4)	2.9-4.1(3.4)	111-125(119)	7.2-10.0(8.1)
	♀	11	53-57(54.8)	40-45(42.3)	19-21(20.0)	13.5-15.0(14.2)	3.0-3.9(3.5)	110-120(115)	7.0-8.2(7.4)
Kimberley	♂	13	50-57(54.4)	38-44(41.4)	18-21(19.3)	13.5-15.0(14.4)	2.9-3.8(3.3)	107-125(114)	6.6-8.5(7.2)
	♀	12	50-54(52.0)	37-42(39.8)	17-20(18.7)	13.0-14.5(14.0)	3.2-3.7(3.4)	100-118(110)	5.8-7.5(6.5)

Gerygone magnirostris Gould — **Large-billed Flyeater**

Distribution

New Guinea, islands in Torres Strait and coastal northern Australia from MacKay, Qld, to King Sound, W.A. See Storr (1980, 1984b). In Western Australia, northern and western Kimberley coasts from Cambridge Gulf to Port Usborne and to continental islands (Sir Graham Moore, South-west Osborn, Carlia, Boongaree, Uwins and St Andrew). See Figure 44. Storr (1980) gives Napier Broome Bay as the easternmost Kimberley locality. In October 1982 I found this flyeater common in the outer parts of Cambridge Gulf, which extends their known range east by about 200 km.

Status and Ecology

Common in Cambridge Gulf and along most northern and western Kimberley coasts. Moderately common on islands, but scarce in extreme south of range at mouth of Trent River and in Port Usborne where it overlaps with *G. tenebrosa*. Usually seen in ones and twos and generally quiet and unobtrusive.

In Queensland and the Northern Territory occurs in a wide range of habitats, including dense riverine vegetation, mangroves, melaleuca forests, monsoon forests and rainforests (Storr 1977, 1984b). In Western Australia, confined to mangroves. In Cambridge Gulf favours tall seaward forests of *Rhizophora* in pure stands or with *Aegiceras* understory, mixed forest of *Rhizophora-Bruguiera*, and mixed vegetation along tidal creeks with *Avicennia, Rhizophora, Bruguiera, Xylocarpus, Aegiceras* and *Excoecaria*. In mouth of Lawley River and at Port Warrender mainly in *Rhizophora* forests, *Rhizophora-Ceriops* and *Avicennia-Aegiceras;* in St George Basin in *Bruguiera exaristata* and *Rhizophora* forests; in mouth of Trent River mainly in mixed forest and woodland of *Rhizophora*,

Figure 44 Map of Kimberley, Western Australia, locating records of *Gerygone magnirostris*: 1 Parry Creek (A4); 2 7 km NNE of Mount Connection (A2); 3 Black Cliff Point (A1); 4 near Evelyn Island; 5 Napier Broome Bay (B1); 6 Sir Graham Moore Islands (B12); 7 South East and South West Osborn Islands (B12); 8 Lawley River delta (B2); 9 Walsh Point Port Warrender (B3); 10 Crystal Creek (B4); 11 Boongaree Island (B12); 12 Careening Bay (B6); 13 Uwins Island (B12); 14 Saint George Basin (B7); 15 Kunmunya; 16 mouth of Glenelg River; 17 mouth of Trent River (B8) and Port Usborne.

Avicennia and *Aegiceras* with scattered *Camptostemon* and *Bruguiera;* and on islands mostly in *Rhizophora*. Overall has a preference for forest habitats.

Feed mainly in canopy, gleaning insects from outer branches and leaves. Occasionally venture below canopy to forage on tree trunks and prop roots. Attracted to flowering trees, especially *Aegiceras*. Feed very like Mangrove and Dusky Flyeaters, moving almost constantly through canopy with short hops and flights, occasionally flicking the wings and hovering. The coexistance of Mangrove, Dusky and Large-billed Flyeaters in Western Australian mangroves is dealt with in discussion.

Voice

Contact calls are short chatters or trills. Song is a rising and falling 'wee will' or 'we-will-wee'.

Food

Stomach contents of 12 W.A. specimens were examined. Most important foods were Coleoptera (beetles, including many weevils), Hemiptera and Hymenoptera (wasps). Eighty-five Coleoptera were found in 11 stomachs, 16 Hemiptera (in 5 stomachs) and 10 Hymenoptera (in 4 stomachs). Other foods were Lepidoptera and spiders, found in small numbers in 4 stomachs, and one grasshopper. The largest prey was 15 mm long.

Breeding

In Kimberley from August to October. Adults share in nest construction and feeding young. Most nests built 1-10 m up in *Rhizophora* and *Bruguiera* trees, usually where tidal debris is draped over branches. Nests are dome-shaped and suspended from top and have very long ragged tail and small spout-like entrance near top. Nests have coarse, ragged appearance that resembles flood debris, and often built close to colonies of paper wasps. A nest from Cambridge Gulf measured 90 mm wide and 130 mm deep and had a tail 260 mm long. Tail of a nearby nest was 600 mm long. Most nests built of leaves, bark, grass and lichen, loosely bound together with spider web and lined with feathers, soft seeds and fine pieces of bark.

The two or three eggs are dull white, lightly flecked and spotted with reddish-brown. One from Cambridge Gulf measured 17.1 x 12.5 mm and three collected by R. Mason in the Northern Territory 16.2 x 12.0 mm, 16.1 x 12.2 mm and 16.3 x 12.1 mm.

Unfeathered Parts

Iris red or red-brown. Bill black (brown in immatures). Mouth black (yellowish-white in immatures). Legs greyish-black, grey, blue-grey or slate grey.

Geographic Variation

Specimens from Western Australia and the Northern Territory show little geographic variation. In Western Australia odd southern birds are a little whiter less buff on breast and belly but there is individual variation in this character. Age is also important, for immature birds are less buff on the underparts than adults. Queensland specimens are more strongly buff on the underparts than Northern Territory and Kimberley birds, and are slightly smaller in wing and tail. Differentiation between these populations is weak, so I follow Ford (1983) in treating all Australian populations as one subspecies *Gerygone magnirostris magnirostris.*

Table 17 Measurements (mm) and weight (g) of *Gerygone magnirostris*, means in parentheses.

Population	Sex	N	Wing	Tail	Tarsus	Bill length	Bill width	Total length	Weight
Kimberley	♂	16	50-59(55.0)	40-46(42.1)	16-20(17.2)	13.0-15.0(13.8)	3.7-4.8(4.2)	95-115(109)	5.8-8.0(6.7)
W.A.	♀	7	49-55(52.4)	37-44(39.5)	15-17(16.5)	13.0-14.0(13.5)	4.0-4.5(4.2)	100-113(106)	5.0-6.3(5.7)
Northern Territory	♂	7	52-58(55.7)	35-45(41.8)	16-19(17.3)	12.0-15.0(14.0)	3.8-4.5(4.0)	100-116(105)	7.5-8.0(7.7)
Queensland	♂	8	53-57(54.6)	38-42(39.7)	16-18(17.0)	12.5-14.0(13.5)	3.5-4.3(3.8)	105,113	6.0-7.8(7.0)
	♀	7	49-55(52.4)	36-40(38.4)	16	12.0-14.0(13.0)	3.6-4.1(3.8)		6.3, 7.0

Distribution

Coastal northern Australia from the Edward River, Qld, to Shark Bay, W.A. See Storr (1977, 1980, 1984a, 1984b, 1985). In Kimberley around northern and western coasts from Cambridge Gulf to Whistle Creek and Nita Downs and many islands in the Bonaparte and Buccaneer Archipelagoes. Occasionally ascends larger rivers, e.g. the Ord to House Roof Hill and Fitzroy to Langey Crossing. In the Pilbara from Mandora Creek south-west to Point Cloates also many islands. Here too occasionally ascends larger rivers well inland for example the Maitland to Karratha HS and Fortescue to Millstream. In Carnarvon-Shark Bay region occurs on Lake MacLeod, along mainland coast from Miaboolia Beach south to Long Point, and northern Peron Peninsula south to Little Lagoon. See Figure 45.

Status and Ecology

In Western Australia common to moderately common. Usually in ones, twos, small parties of six to ten, and flocks of up to fifty.

In Kimberley, found in wide range of mangrove habitats including forests, woodlands and thickets. Often in pure stands of *Avicennia*, thickets of *Ceriops* and mixed *Ceriops-Camptostemon*, and *Avicennia, Rhizophora, Camptostemon* and *Bruguiera*. Also in near-coastal vine scrubs, *Melaleuca* thickets, riverine forests and coastal town gardens, e.g. at Broome. In the Pilbara favouring pure and mixed stands of *Avicennia-Rhizophora*. Occasionally wandering into other near-coastal habitats including thickets and woodlands of *Acacia coriacea, Ficus platypoda* and riverine woodland of *Melaleuca leucadendra* and *Sesbania formosa*. In Carnarvon-Shark Bay region where *Avicennia* is only mangrove, occurring in all formations from woodlands to stunted shrubland. Also visiting coastal *Nitraria* and *Acacia* thickets.

One of the most successful mangrove birds. Has colonized nearly every block of mangal in Western Australia, including very isolated blocks on Eighty-Mile Beach, Lake MacLeod and Peron Peninsula. Very active feeders, searching with short hops through canopy, occasionally perching sideways or even upside down to peck at prey and sometimes hover-gleaning at leaves and flowers. Frequently make short flights from branch to branch or from tree to tree. Attracted to flowering mangroves especially *Rhizophora, Aegiceras* and *Sonneratia*. Feed mostly among foliage and small branches, sometimes below the canopy on tree trunks and thick branches, and less frequently near the ground on prop roots and pneumatophores.

Voice

Contact call a continuously uttered plaintive 'mew', 'zee' or 'pleewee'. Song a series of piping melodious notes. Single birds in full song often mimic other birds.

Food

Stomach contents of 11 W.A. specimens were examined. Most important foods were Diptera (mainly mosquitoes and midges), Coleoptera (including Chrysomelidae,

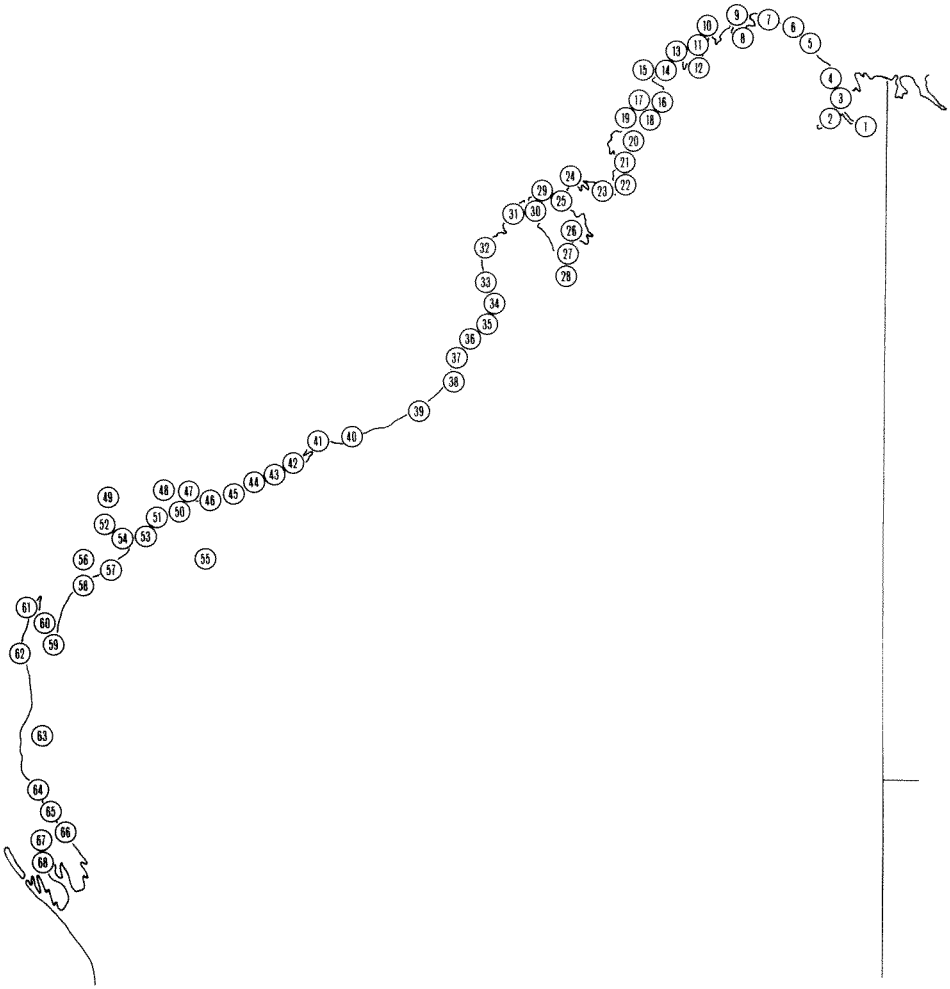

Figure 45 Map of northern Western Australia, locating records of *Zosterops lutea*: 1 House Roof Hill Ord River; 2 mouth of King River (A6) and Wyndham (A5); 3 Still Bay (A3) and 7 km NNE of Mount Connection (A2); 4 Black Cliff Point (A1); 5 4 km W of Cape St Lambert; 6 near Cape Bernier; 7 19 km W of Cape Rulhieres; 8 Napier Broome Bay (B1); 9 Sir Graham Moore Islands (B12); 10 Hecla Island and Parry Harbour; 11 Borda Island, Osborn Islands and Carlia Island (B12); 12 Lawley River delta (B2), Walsh Point Port Warrender (B3), Crystal Creek (B4) and mouth of Mitchell River; 13 Fenelon Island and Voltaire Passage; 14 Katers and Wollaston Islands (B12); 15 East Montalivet, Bigge (B12) and South Maret Islands; 16 Prince Frederick Harbour including mouth of Hunter River (B5), mouth of Roe River and Boongaree Island (B12); 17 Careening Bay (B6) and Coronation Islands (B12); 18 Saint George Basin (B7); 19 Uwins, Augustus and Heywood Islands (B12) and near Kunmunya; 20 George Water; 21 mouth of Sale River; 22 Walcott Inlet; 23 Collier Bay; 24 Wotjulum; 25 mouth of Trent River (B8); 26 Point Torment (B9); 27 Derby (B10); 28 mouth of Fitzroy River and Langey Crossing; 29 Sunday Island; 30 Cygnet Bay (B11), One Arm Point

and Cape Leveque; 31 Packer Island (C1) and near Cape Borda; 32 3 km S of Cape Bertholet (C2); 33 Barred Creek and Willie Creek (C3); 34 Broome (C4); 35 Thangoo (C5); 36 Lagrange Bay (C6) and Injudinah Swamp; 37 Cape Bossut (C7), Rocky Creek (C8) and Whistle Creek (C9); 38 7 km W of Nita Downs; 39 Mandora (D1); 40 Cape Keraudren (D2) and Pardoo Creek (D4); 41 mouth of De Grey River (D5); 42 Leslie Salt (D6) and Port Hedland (D7); 43 mouth of Turner River (D8); 44 Cowrie Creek (D9) and mouth of Little Yule River; 45 Depuch Island and Balla Balla Harbour (D10); 46 Harding River, Cossack (D11), 2 km SW of Point Samson (D12) and Popes Nose Creek (D13); 47 Nickol Bay (D14), Withnell Bay (D15) and Legendre and Dolphin Islands (D29); 48 West Lewis and Enderby Islands (D29); 49 Hermite Island (D29); 50 Dampier Salt (D17) and Maitland River at Karratha HS; 51 mouth of Devil Creek (D18); 52 Barrow Island (D29) and Lowendal Islands (D29); 53 mouth of Fortescue River (D19); 54 Great Sandy Island; 55 Millstream; 56 Thevenard Island; 57 Weld Island and mouth of Cane River (D20); 58 Onslow and mouth of Ashburton River (D21); 59 Giralia Bay (D22) and Gales Bay (D23); 60 Bay of Rest (D24) and near Learmonth (D25); 61 Mangrove Bay (D26) and Yardie Creek (D28); 62 Point Cloates; 63 Lake MacLeod (E1); 64 Miaboolia Beach (E2), Carnarvon, Pelican Island, Oyster Creek (E3) and Mangrove Point (E4); 65 Bush Bay (E5) and New Bay (E6); 66 Greenough Point near Denham Hummock (E7), 8 km NNW of Long Point (E9) and Long Point (E10); 67 Guichenault Point (E11); 68 Little Lagoon (E12).

Curculionidae, Buprestidae and Cleridae), Hemiptera, Lepidoptera and insect larvae. Diptera were found in 14 stomachs often in large numbers, 29 Coleoptera (in 13 stomachs), 12 Hemiptera (in 9 stomachs) and Lepidoptera and insect larvae (in 5 stomachs). Minor foods were wasps, molluscs (including *Littoraria* spp.), Orthoptera, spiders, leaves, fruits, seeds and a single pseudoscorpion. Most prey items were 2-12 mm long.

Breeding

In Kimberley from November to March, in the Pilbara from May to November, and in the Carnarvon-Shark Bay region from July to February (Storr 1980, 1984a, 1985). Sexes share in nest building and care of young. Most nests built 2-3 m up in outer foliage of *Avicennia* trees. A nest collected at Carnarvon in February 1982 was 2 m from ground in almost vertical fork of *Avicennia* branch; it was 75 mm wide and 60 mm deep externally, and 35 mm deep internally, made of fine pieces of bark, plant fibre and insect cocoons, and lined with soft rootlets and small pieces of grass. Two or three bluish-white eggs form the clutch. Three eggs from Miaboolia Beach measured 16.4 x 11.7 mm, 16.2 x 11.9 mm and 16.6 x 11.8 mm.

Unfeathered Parts

Iris brown (N24), dark brown (18), light brown (10), light red-brown (6). Upper mandible black or dark brown. Lower mandible tip black, base blue-grey. Legs grey or dark grey.

Geographic Variation

Mees (1969) in his revision of the Indo-Australian Zosteropidae recognized two subspecies in Australia: *Zosterops l. lutea* from the lower Edward River, Qld, to Napier Broome Bay, W.A., and *Z. l. balstoni* from Wotjulum, W.A., south to Peron Peninsula. The southern

race '*balstoni*' supposedly differed from the nominate form by its slightly paler underparts and less greenish (more greyish, upperparts) and slightly shorter bill.

The range of the Yellow White-eye is continuous in Western Australia, and the birds show very little geographic variation. Many specimens from the Pilbara and south-west Kimberley are as yellow on the underparts and as green on the upperparts as Wyndham birds. North-east Kimberley specimens have on average slightly longer and thicker bills but there is much overlap in this character.

There is however considerable variation within certain populations in Western Australia. The most variable of these is at Dampier, where birds range in coloration from typical (yellow-bellied and green-backed) to pale cream-bellied with grey flanks and grey backs. These pale birds have the forehead pale yellow, the head, back, tail coverts and tail light mouse-grey, the rump light grey tinged with olive, the wings light grey, the primaries dark grey with dull white outer fringes, the throat and mid belly dull yellow, the sides of the breast and flanks buff-grey and the undertail coverts cream. The more typically patterned birds from this area are very slightly darker on the upperparts than birds to the immediate north and south. At Dampier Salt the pale-bellied, grey-backed birds made up about one third of the population. Most flocks studied here contained the full range of colour variation. In October 1982 I collected eleven specimens at Dampier Salt, three of them are pale-bellied, grey-backed birds, three are intermediate with a little more yellow on the underparts and an olive tinge to the greyish upperparts, and five are typical yellow-bellied, green-backed birds. All of these specimens are adults in breeding condition, in new plumage with little wear.

There is one other of these pale grey birds in the WAM collection, a specimen from Hermite Island, also collected along with several typically patterned birds. Mathews type specimen of *Zosterops lutea headlandi* from Port Hedland, Western Australia, is possibly another one, for he noted that this bird was more greenish-yellow on the undersurface and greyish-green above. Mees (1969) examined this specimen and noted that it was in fact very grey. He was no doubt puzzled by this, as other specimens from the same locality agreed perfectly with '*balstoni*', and he believed that the bird was perhaps preserved in spirits for a short time. I examined two specimens in the Australian National Wildlife

Table 18 Measurements (mm) and weight (g) of *Zosterops lutea*, means in parentheses.

Population	Sex	N	Wing	Tail	Tarsus	Bill length	Bill width	Weight
Carnarvon-Shark Bay	♂	6	53-54(53.5)	38-40(38.8)	15-18(16.1)	12.5-14.0(13.1)	3.1-3.5(3.2)	7.0-8.0(7.5)
	♀	3	50-55(52.6)	36-39(37.6)	16(16.0)	12.5-14.0(13.3)	3.1-3.2(3.1)	6.2-8.0(7.4)
Pilbara	♂	28	51-57(54.3)	34-42(38.5)	15-18(16.3)	11.5-14.0(12.9)	3.0-3.8(3.2)	6.8-8.4(7.6)
	♀	9	52-56(54.3)	36-40(38.1)	14-18(16.3)	12.5-14.0(13.3)	3.1-3.7(3.4)	7.0-9.2(8.1)
Kimberley	♂	23	53-59(55.5)	36-44(39.0)	15-20(16.5)	13.0-16.0(14.1)	3.1-4.2(3.6)	7.2-11.0(8.5)
	♀	9	52-57(54.6)	37-41(38.8)	15-17(16.2)	13.5-14.0(13.7)	3.2-4.0(3.6)	7.5-9.0(7.9)
Northern Territory	♂	13	54-58(56.1)	37-43(40.4)	16-18(16.7)	14.0-16.0(14.5)		8.5-10.5(9.5)
	♀	11	54-57(55.7)	37-42(40.2)	15-19(16.4)	14.0-15.0(14.4)		7.9-10.0(9.1)
Queensland	♂	3	55-58(56.3)	38-42(40.6)	17-19(17.6)	14.5-15.0(14.8)		8.2-9.0(8.7)
	♀	1	58	39		13		

Collection, from 40 km north of Borroloola, N.T., which were preserved in spirit for six months. These birds are patterned very like the pale grey Pilbara birds. The two Borroloola specimens may have been discoloured in alcohol; however a spirit specimen in the WAM, collected in June 1974, at Cape Keraudren has lost little or no yellow. It may well be that the Borroloola birds were greyish to begin with.

The occurrence of these pale-bellied, grey-backed birds is of interest because it was previously believed that no other *Zosterops* apart from *Z. lateralis* had a grey back. In summary, I would not recognize any subspecies within *Zosterops lutea*.

Myzomela erythrocephala Gould **Red-headed Honeyeater**

Distribution

Eastern Lesser Sunda Islands, New Guinea and northern Australia from Cape York Peninsula to southern Kimberley. In Western Australia from Cambridge Gulf around northern and western coasts to Whistle Creek and continental islands (Sir Graham Moore, Middle Osborn, Carlia, Bigge, Boongaree, Uwins, St Andrew, Augustus and Sunday). See Storr (1980) and Figure 46.

Status and Ecology

Common to moderately common throughout its range, except in extreme south at Whistle Creek where it is scarce. Usually in ones or twos, occasionally in threes or fours at flowering trees.

Favours mangroves, but also visiting near-coastal waterside forest, semi-deciduous vine forest and scrubs and melaleuca thickets. Within mangal preferring areas with extensive stands of *Rhizophora, Bruguiera, Avicennia, Ceriops, Camptostemon and Aegiceras.* One of the few species in western mangals that takes advantage of mangrove flowers. Especially attracted to flowering *Rhizophora, Bruguiera, Aegiceras* and mangrove mistletoe *Amyema thalassium*. Also wandering as far as 3 km inland visiting flowering trees and shrubs, particularly of *Eucalyptus* and *Melaleuca*.

Alert active birds, feeding mainly in canopy. Dart from flower to flower and from tree to tree. Frequently flick wings and often dash out from cover to catch flying insects. Most food obtained from leaves and flowers. Very aggressive; frequent conflicts occur among themselves and with Brown Honeyeaters *Lichmera indistincta*. Male Red-headed Honeyeaters often fight, birds grappling in mid-air and falling nearly to ground before breaking. Conflicts with Brown Honeyeaters are usually chases through canopy.

Often bathe and drink at freshwater springs and pools.

Voice

Most calls are buzzing and harsh 'caseep' sounds.

Figure 46 Map of Kimberley, Western Australia, locating records of *Myzomela erythrocephala*: 1 mouth of King River (A6); 2 Wyndham (A5); 3 7 km NNE of Mount Connection (A2); 4 Black Cliff Point (A1); 5 near Evelyn Island; 6 Napier Broome Bay (B1); 7 Sir Graham Moore Islands (B12); 8 Osborn Islands (B12); 9 Lawley River delta (B2); 10 Walsh Point Port Warrender (B3); 11 Crystal Creek (B4); 12 Bigge Island (B12); 13 Prince Frederick Harbour and mouth of Hunter River (B5); 14 Boongaree Island (B12); 15 Uwins Island (B12); 16 Saint George Basin (B7); 17 Augustus Island (B12); 18 Kunmunya: 19 Maitland Bay; 20 George Water; 21 Secure Bay; 22 Collier Bay; 23 Wotjulum; 24 mouth of Trent River (B8); 25 Kimbolton; 26 near Oobagooma; 27 Point Torment (B9); 28 Derby (B10); 29 Cygnet Bay (B11); 30 One Arm Point; 31 Sunday Island; 32 Packer Island (C1); 33 Pender Bay; 34 Cape Baskerville; 35 3 km S of Cape Bertholet (C2); 36 Coulomb Point; 37 Barred Creek and Willie Creek (C3); 38 Broome (C4); 39 Thangoo (C5); 40 Cape Bossut (C7); 41 Whistle Creek (C9).

Food

Stomachs of 6 W.A. specimens contained nectar, some pollen, Hymenoptera (wasps), Coleoptera (beetles) and once a spider.

Breeding

In Kimberley reported in March and September. Most nests are built 6-10 m up in the foliage of mangrove trees. They are small oval-shaped cups, made of small pieces

of bark, leaves and fine rootlets, bound together with spider web and lined with fine pieces of bark and rootlets. A nest found by G.F. Hill at Napier Broome Bay on 26 March 1910 measured 58 mm long, 51 mm wide and 38 mm deep externally and 38 mm long, 33 mm wide and 30 mm deep internally. Two eggs form the clutch. They are white with reddish spots and blotches on larger end.

Unfeathered Parts

Iris brown (N13) or dark brown (5). Bill black, lower mandible brown on some specimens. Legs brown (N6) or dark grey (5). Mouth yellow.

Table 19 Measurements (mm) and weight (g) of *Myzomela erythrocephala*, means in parentheses.

Population	Sex	N	Wing	Tarsus	Bill length	Weight
Kimberley,	♂	11	57-60(58.3)	14-16(15.2)	16.5-18.0(17.2)	6.9-9.0(7.5)
W.A.	♀	3	53-56(54.6)	14-15(14.3)	16.5, 17.0	6.0, 6.6
Northern	♂	16	55-60(58.6)	14-17(15.5)	14.5-17.5(16.5)	7.8, 9.5
Territory	♀	7	52-59(55.2)	15-16(15.2)	15.0-17.5(16.0)	8.0, 8.2
Queensland	♂	5	57-63(59.6)	14-17(15.7)	14.5-17.5(16.2)	
	♀	1	57	16	16.5	

Artamus leucorhynchus (Linnaeus) — White-breasted Woodswallow

Distribution

South-east Asia to the western Pacific and northern and eastern Australia. In Western Australia in Kimberley, Pilbara and Carnarvon regions. See Storr (1980, 1984a, 1985) and Figure 47. In Kimberley, occurs throughout most of the Division, south to Anna Plains, the Fitzroy drainage and Sturt Creek, and on islands in the Bonaparte and Buccaneer Archipelagoes. In the Pilbara around north-west coast from Mandora Creek south-west to Giralia Bay and Mangrove Bay, on many islands and on middle Fortescue at Millstream. In Carnarvon region confined to northern Lake Macleod and vicinity of Carnarvon. Occasionally wandering to Peron Peninsula, one collected there by F.M. Rayner in May 1858, and two observed by A.G. and B.A. Wells in mangal at Herald Bight in July 1978.

Status and Ecology

In Kimberley moderately common on coasts and islands, but scarce to uncommon inland. Usually in pairs or small flocks (up to 50). In the Pilbara common, in ones, twos or small parties and occasionally flocks (up to 20). In Carnarvon region common, usually in small parties (up to 12).

In Kimberley, found mainly around mangroves and riverine vegetation especially tall *Melaleuca*. In the Pilbara mainly in and near mangal, but also in town and homestead gardens and about tall river gums and *Melaleuca* at permanent pools. At Lake MacLeod and near Carnarvon in and around stands of *Avicennia*, plantations and gardens.

Figure 47 Map of northern Western Australia, locating records of *Artamus leucorhynchus*: 1 Lissadell; 2 Rosewood; 3 Lake Argyle; 4 Ivanhoe, Kununurra, Diversion Dam and Packsaddle Plain; 5 House Roof Hill and Parry Lagoons; 6 Parry Creek (A4) and Wyndham (A5); 7 Black Cliff Point (A1); 8 Drysdale River National Park; 9 lower Drysdale River; 10 near mouth of Drysdale River; 11 Sir Graham Moore Islands (B12); 12 Napier Broome Bay (B1); 13 King Edward River; 14 Crystal Creek (B4); 15 Mitchell Plateau; 16 Uwins Island; 17 Champagny Island, Heywood Islands and Augustus Island (B12); 18 Wotjulum and Cockatoo and Koolan Islands; 19 mouth of Stewart River; 20 Napier Downs and Mount Bell; 21 Lake Gladstone and Mount House; 22 Mount Caroline; 23 Mount Barnett and Manning Creek; 24 Lake Gilbert; 25 Mount Elizabeth; 26 Durack River; 27 Sturt Creek; 28 Mary River; 29 Fitzroy Crossing; 30 Noonkanbah; 31 Mowla Downs and Geegully Creek; 32 Camballin and Liveringa; 33 Mount Anderson; 34 Yeeda; 35 Derby (B10); 36 Meda; 37 Cygnet Bay (B11) and One Arm Point; 38 Lombadina and Packer Island (C1); 39 near Cape Bertholet (C2); 40 Coulomb Point; 41 Barred Creek and Broome (C4); 42 Roebuck Plains; 43 Thangoo (C5); 44 Lagrange Bay (C6); 45 Cape Bossut (C7) and Whistle Creek (C9); 46 Anna Plains; 47 Mandora (D1); 48 Cape Keraudren (D2) and Pardoo Creek (D4); 49 mouth of De Grey River

(D5); 50 lower De Grey River; 51 Leslie Salt (D6); and Port Hedland (D7); 52 Cowrie Creek (D9); 53 Balla Balla Harbour (D10) and Depuch Island; 54 Roebourne and near Point Samson (D12); 55 Nickol Bay (D14), Karratha, Legendre Island and Withnell Bay (D15); 56 Rosemary and West Lewis Islands (D29); 57 Maitland River; 58 mouth of Devil Creek (D18); 59 mouth of Fortescue River (D19); 60 Hermite Island (D29); 61 Barrow Island and Lowendal Islands (D29); 62 Millstream; 63 mouth of Cane River (D20); 64 Onslow; 65 mouth of Ashburton River (D21); 66 Giralia Bay (D22); 67 near Learmonth (D25); 68 Mangrove Bay (D26); 69 Lake MacLeod (E1); 70 Miaboolia Beach (E2) and Carnarvon; 71 Callagiddy.

Favour edges and breaks in mangroves. Like to perch and roost in emergent trees especially *Avicennia*, often close together in pairs or small groups on bare branch. Pairs perched side by side often preen each other. Nearly all food captured in flight, either by darting from a perch or by sweeping through air high up. Occasionally make fast hawking pursuits chasing insects low over vegetation or water. Sometimes food pecked from vegetation including tree trunks and branches. Pairs and groups often feed close together and keep in touch with chattering contact calls 'dirt dirt' or 'pert pert'. Bold and aggressive. In May 1977 at Crab Creek one attacked an Australian Hobby *Falco longipennis* as it flew over mangal and only gave up when outdistanced.

Food

Stomachs of 4 W.A. specimens contained Coleoptera, Hemiptera, Diptera, Hymenoptera (wasps), Lepidoptera and insect larvae. At Whistle Creek in April 1974 one caught a dragon fly and passed it to its mate in mid-air. Largest prey was a beetle 9 mm long.

Breeding

In Western Australia, from August to February. In mangal most nests built in *Avicennia* trees. Outside mangroves often build in old Magpie-lark *Grallina cyanoleuca* nests, and in river gums and *Melaleuca*. A pair at Onslow nested for several years in fire bucket on a jetty. In mangroves most nests built 3-6 m up in vertical forks. Sexes share nest building, incubation and feeding young. A nest collected 7 km north of Mandora on 26 September 1980 was built 5.5 m up in clump of mangrove mistletoe in *Avicennia* growing on seaward edge of mangal. This nest is a tidy cup or small bowl, made of dried pieces of *Spinifex longifolius* and lined with fine *Spinifex* rootlets. It measured 130 mm wide and 70 mm deep externally and 65 mm wide and 35 mm internally. A nest collected 10 km SSW of Cape Thouin on 3 October 1980, 4 m up in vertical fork of *Avicennia* was a large untidy bowl, made of samphire twigs and pieces of *Triodia, Spinifex longifolius* and small pieces of seaweed. It measured 220 mm wide and 70 mm deep externally and 65 mm wide and 35 -mm deep internally.

Two or three eggs form the clutch. Eggs are pinkish white, spotted and blotched with reddish-brown and light grey mainly in zone around larger end. Two eggs from Mandora measured 20.2 x 18.0 mm and 20.8 x 18.1 mm, and three from near Cape Thouin 22.5 x 17.2 mm, 22.9 x 16.9 mm and 23.6 x 17.2 mm.

Unfeathered Parts

Iris brown (N10), dark brown (5), black (3) or deep brown (2). Bill blue or blue-grey with a black tip. Legs black, dark grey or grey. Mouth black or dark grey.

Table 20 Measurements (mm) and weight (g) of *Artamus leucorhynchus* from Western Australia, means in parentheses.

Population	Sex	N	Wing	Tail	Tarsus	Bill length	Bill width	Weight
Kimberley	♂	4	123-130(128.0)	54-58(55.7)	14-18(16.2)	21.0-23.0(22.0)	8.0-9.2(8.5)	41-43(42)
	♀	2	125,131	53,54	16,18	21.0,22.0	7.4,8.0	
Pilbara	♂	8	127-135(130.7)	54-59(56.2)	15-17(16.0)	20.0-22.0(21.5)	8.1-9.4(8.7)	44
	♀	11	128-137(131.2)	56-59(58.1)	15-17(16.3)	20.0-23.5(21.8)	7.5-9.7(8.9)	45-54(48.5)
Carnarvon	♂	1	130	57	17	24.0	9.2	42
	♀	1	126	57	16	23.0	8.6	44

Cracticus quoyi (Lesson & Garnot) **Black Butcherbird**

Distribution

New Guinea, the Aru Islands and northern and north- eastern Australia. In Western Australia only in outer parts of Cambridge Gulf. See Figure 48.

Status and Ecology

In October 1982 I observed or heard about twenty Black Butcherbirds in three well-separated stands of mangal 40-50 km north of Wyndham. Previously the westernmost record of this species in northern Australia was at Port Keats, N.T.

In Cambridge Gulf, mostly in ones and twos (pairs), and only seen in most extensive blocks of mangal. Favoured tall forests of *Rhizophora* and *Bruguiera parviflora*. Extremely shy, taking flight at slightest sound or movement. Forage below canopy on branches, tree trunks, prop roots and ground. Most birds had mud on feet and bill. Breeding had commenced and they were very noisy at dawn, with only odd calls during day. Main call was a loud harsh 'caw clock — coo coo cow cow caulk' ending sharply. Other shorter calls included a loud 'calock alock' similar to call of Grey Currawong *Strepera versicolor*.

Food

Stomachs of 3 W.A. specimens contained: 1) small white crabs, small fish bones and scales, and beetle fragments; 2) beetles; 3) one grasshopper (63 mm long), one mudskipper (45 mm long) and one small bug.

Breeding

One nest found near Mt Connection on 10 October 1982 was built 6 m up in a *Bruguiera parviflora* overhanging tidal creek; I was unable to check its contents, but a bird was seen close by. Another found at Black Cliff Point on 12 October was built 5 m up in fork of a *Rhizophora*, in *Rhizophora* forest; it was bowl-shaped, made of mangrove

Figure 48 Map of Cambridge Gulf, Western Australia, locating records of *Cracticus quoyi*: 1 Black Cliff Point (A1); 2 Hardman Point; 3 7 km NNE of Mount Connection (A2).

twigs, lined with thin pieces of couch grass and was 250 mm wide and 80 mm deep externally and 125 mm wide and 30 mm deep internally. Both adults attended this nest. It contained two eggs, one chipping, the other undeveloped; they measured 35.7 x 25.8 mm and 36.8 x 25.5 mm and are light greyish-green spotted and blotched with brown, mainly on larger end.

Unfeathered Parts

One male and two females from Cambridge Gulf. Iris dark brown. Bill black or greyish-black with base of both mandibles blue-grey to front of nostrils. Mouth black. Legs black.

Geographic Variation

Ford (1983) discusses geographic variation in the Australian region. Northern Territory birds average longer in wing, bill and tail, but are narrow-billed compared to other

populations. The three Kimberley specimens are similar in size and coloration to Northern Territory specimens, but have slightly wider bills (Table 21).

Table 21 Measurements (mm) and weight (g) of *Cracticus quoyi*, means in parentheses.

Population	Sex	N	Wing	Tail	Tarsus	Bill length	Bill width	Total length	Weight
Cambridge Gulf, WA	♂	1	196	146	45	61.0	14.9	189	395
	♀	2	181,194	139,145	39,43	56.0	14.4,15.0	180,185	360,375
Northern Territory (from Ford 1983)	♂	11	196-205(201)	145-163(155)		58.0-65.5(60.7)	12.5-14.4(13.4)		
	♀	8	181-195(187)	139-151(145)		52.0-56.0(53.9)	12.4-13.9(13.1)	12.4-13.9(13.1)	

DISCUSSION

Different mangrove areas seldom have the same zonation of mud flats and plant species, for they differ widely in soil type, silt deposits, rainfall, tidal range and erosion. These areas likewise vary in the composition and density of birds. In Western Australia density and species richness of birds decreases with decreasing number of mangrove species and structural complexity of the mangal (greatest in the Kimberley and decreasing southwards). Of the 16 mangrove species and 22 bird species studied here, region A (Cambridge Gulf) and region B (NW Kimberley) have 15 mangrove species and 21 bird species, region C (SW Kimberley) has 12 mangroves and 16 birds, region D (Pilbara) 8 mangroves and 11 birds, and region E (Carnarvon-Shark Bay) one mangrove and 6 birds. See Table 22.

In Western Australia 16 species of bird are virtually confined to mangal, and another 6 species are confined to it in at least part of their range. Many of these birds also occur in a wide range of other habitats in other parts of Australia, including rainforest, monsoon forest, riverine forest and paperbark swamps, e.g. the Great-billed Heron, Shining Flycatcher, Large-billed Flyeater and Black Butcherbird. In Western Australia rainforest or semi-deciduous vine forest, riverine forest and paperbark swamps are poorly represented. North-west and south-west Kimberley are the only regions in Western Australia that have (in some areas) other structurally similar habitats close to the mangal, namely semi-deciduous vine forests and melaleuca thickets. The semi-deciduous vine forests are visited or inhabited by the Little Bronze Cuckoo, Mangrove Golden Whistler, Wood Fantail, Shining Flycatcher, Broad-billed Flycatcher, Yellow White-eye and Red-headed Honeyeater. In Kimberley the total area of vine forests is small, about 50 sq km compared to about 2,000 sq km of mangal. It is probably fair to say that without the mangal, most or all of these birds would not survive in vine forests. In south-west Kimberley the coastal *Melaleuca-Acacia* belts are important for the Mangrove Grey Fantail and the Mangrove Flyeater.

South of the Kimberley, mangal forms the only closed forest community, and here the Mangrove Golden Whistler, Mangrove Grey Fantail and Shining Flycatcher are confined to mangroves. The Bar-shouldered Dove is also of interest. In the Kimberley it is widespread in mangroves, vine forests and riverine forests, but in the Pilbara it is largely confined to mangal, leaving it for only short distances to feed and drink.

Mangrove Breaks

Many mangrove birds in Western Australia have disjunct distributions, due to large breaks in the mangrove vegetation. There are three major breaks in Western Australian mangals: one along the western side of the Joseph Bonaparte Gulf between Cape Dussejour and Cape Londonderry (where mangal occurs in fairly small isolated pockets); another along the Eighty Mile Beach; and a third along the coast between Yardie Creek and Miaboolia Beach. Today mangrove forests typically occur as fringes along tidal estuaries and sheltered coasts. Between 6,500 and 7,000 years ago mangal was far more extensive in northern Australia than now (Woodroffe *et al.* 1985). The changing nature of the coastline no doubt meant that the historic breaks in the mangal would have been different to present ones. In the past Joseph Bonaparte Gulf probably contained vast tracts of mangal, making this break far less effective in isolating mangrove birds. The gaps provided by the Eighty Mile Beach and the coast between Yardie Creek and Miaboolia Beach probably have a longer history. There are however small blocks of mangal at Mandora on the Eighty Mile Beach and a small inland stand near Sandfire, so perhaps mangal was also more extensive here in the past. It is also probable that mangroves once lined Lake MacLeod which would have made the Yardie Creek-Miaboolia Beach gap less effective.

These present mangrove breaks terminate the ranges of some bird species and serve to isolate some subspecies. The Black Butcherbird cannot extend west from Cambridge Gulf because of the lack of suitable habitat on the western shores of the Joseph Bonaparte Gulf. The Cambridge Gulf population of the Mangrove Kingfisher is possibly also isolated from the west Kimberley population by the same break. The birds west of the break are larger than those further east.

The Eighty Mile Beach has prevented four mangrove birds from colonizing the Pilbara, namely the Little Bronze Cuckoo, Broad-billed Flycatcher, Mangrove Flyeater and Red-headed Honeyeater. It also separates subspecies of the Mangrove Kingfisher (*H. c. sordida* and *H. c. pilbara*).

The break between Yardie Creek and Miaboolia Beach is an effective barrier to the Bar-shouldered Dove.

Physical Structure of Mangal

Not only breaks in mangal but changes in vegetation structure can terminate the range of a mangrove bird. Cambridge Gulf and north-west Kimberley (regions A and B) have the same number of mangrove species and bird species. Both regions have large rivers, a highly dissected coast and high tidal ranges, resulting in a proliferation of mangrove habitats. These habitats range from broad to narrow river deltas and embayments, river and tidal channels, silt islands and rocky, sandy and muddy coasts, all of which have

distinct mangrove assemblages. These rich mangrove habitats end in King Sound along with the ranges of five mangrove birds, viz. Chestnut Rail, Grey Goshawk, Mangrove Robin (Kimberley population), Wood Fantail and Large-billed Flyeater.

South-west Kimberley (region C), lacks large rivers, and most mangal is located behind barrier dunes and in small bays. The mangal is floristically and structurally poorer, and the habitats less extensive and less diverse than in north-west Kimberley and even in parts of the Pilbara (Region E). There is, for example, little habitat for the Chestnut Rail in south-west Kimberley, and the lack of extensive *Rhizophora* forest precludes the Mangrove Robin.

The Pilbara (region D) has in many places a greater diversity of mangal habitats than most of south-west Kimberley. This is due to the large number of rivers and a more dissected coast. On the other hand it is more arid than regions to the north, lacks some mangrove species, and to landward has no structurally similar habitats except for small *Acacia* thickets. Extensive *Rhizophora* forest occurs throughout the region south to Exmouth Gulf, which is the southern limit for the Mangrove Golden Whistler and Mangrove Robin, both of which depend on *Rhizophora*. Exmouth Gulf also supports the southernmost woodland of thick-trunked *Avicennia*, a habitat important for the Mangrove Kingfisher whose range also ends at the Gulf. The main food of the Mangrove Kingfisher, fiddler crabs (*Uca* spp.), are scarce south of Exmouth Gulf (nine species are recorded from the Gulf but only two species from further south).

Mangrove Bay (D 26) on the upper west coast of the North West Cape Peninsula is the only mangrove block from which we have some historical bird data. Carter visited it in 1902 and collected two Mangrove Robins and a Mangrove Golden Whistler from 'dense mangroves'. Both species are restricted to mangal with *Rhizophora* forest, and both are now absent at Mangrove Bay. Carter did not record the Bar-shouldered Dove, White-breasted Whistler and White-breasted Woodswallow, three very conspicuous birds that have since colonised this mangal. Clearly both the mangroves and the birds have changed dramatically at Mangrove Bay since 1902. A number of factors may have caused these changes, including devastation or flooding by tropical cyclones, resulting in local extinction of some birds and plants.

Only one mangrove, *Avicennia*, occurs in the Carnarvon-Shark Bay region (E), and even this species is not represented by woodlands of thick-trunked trees. Judging from my own observations there is also a great reduction in insects and other terrestrial animals, molluscs, crabs, and mudskippers in this region. To landward samphire becomes more extensive than further north and often spreads into the mangal. Some mangrove birds, including the Yellow White-eye and Mangrove Grey Fantail, feed in and over samphires. South of Carnarvon structure of the mangal changes fairly rapidly. The White-breasted Whistler occurs south to Bush Bay (E5) which supports the last closed-canopy *Avicennia* on the mainland side of Shark Bay. A little further south at Greenough Point (E7) the mangal becomes more open and stunted. The Dusky Flyeater and Mangrove Grey Fantail occur south to 8 km north of Long Point (E9) in low *Avicennia* shrubland. Only the Yellow White-eye ranges further south to Long Point (E10) where there are a few *Avicennia* trees growing with *Nitraria* and samphire. This is the last block of mangal on the mainland side of Shark Bay.

Guichenault Point (E11) on northern Peron Peninsula contains one of the largest blocks of mangal south of Carnarvon. It has good *Avicennia* woodland but only three mangrove birds, viz. the Mangrove Heron, Mangrove Grey Fantail and Yellow White-eye. All three also occur at Little Lagoon (E12).

Foraging Methods

Mangrove birds can be grouped into those that forage in the same manner and in similar habitats. Of the 22 bird species studied here 6 are ground feeders, viz. Great-billed Heron, Mangrove Heron, Chestnut Rail, Bar-shouldered Dove, Mangrove Kingfisher and Black Butcherbird; 4 feed mainly in the lower levels (on ground, tree trunks, prop roots and low vegetation), viz. Mangrove Robin, White-breasted Whistler, Wood Fantail and Shining Flycatcher; 6 species forage mainly in the canopy, viz. Little Bronze Cuckoo, Mangrove Golden Whistler, Mangrove Flyeater, Dusky Flyeater, Large-billed Flyeater and Red-headed Honeyeater; 4 species forage at all levels (ground to canopy), viz. Lemon-breasted Flycatcher, Mangrove Grey Fantail, Broad-billed Flycatcher and Yellow White-eye; the White-breasted Woodswallow is mainly an aerial feeder and the Grey Goshawk is a pursuit and ambush hawk.

The foraging method of some of these birds, including seasonal visitors to mangal, are discussed briefly. The Great-billed Heron and Mangrove Heron are mainly fish eaters and obtain most of their food from the waters edge and on mudflats. They stand quietly waiting for prey to come within striking distance. Its huge size enables the Great-billed Heron to take much larger prey than the Mangrove Heron. The Chestnut Rail feeds mainly on crabs. It moves slowly through the mangal along banks and mudflats, mostly in the central and seaward zones. The Mangrove Kingfisher and Black Butcherbird feed mainly by pouncing from a perch onto the ground to pick up mudskippers, crabs etc. In Western Australia these two species only coexist in Cambridge Gulf; here the kingfisher favours the outer seaward edge of the mangal, the butcherbird the interior of the mangal. The Sacred Kingfisher (*Halcyon sancta*) is a common winter visitor to northern mangals from southern Australia. It probably competes with the Mangrove Kingfisher for some foods but is considerably smaller.

The Lemon-breasted Flycatcher and Mangrove Robin feed by gleaning and pouncing on prey from perches. The flycatcher feeds almost exclusively on ants and forages at all levels of the mangal. The robin takes a large number of ants, but its food also includes a wide range of other prey, and it forages mainly in the lower levels, especially in *Rhizophora.*

The Mangrove Golden Whistler and White-breasted Whistler feed mainly by snatching and gleaning. Both take fairly slow or stationary prey, the Mangrove Golden mainly insects, the White-breasted insects and crabs. The Mangrove Golden Whistler is smaller than the White-breasted and forages mainly in the canopy, whereas the White-breasted feeds mainly at lower levels and on the ground.

The Mangrove Grey Fantail and Wood Fantail take both stationary and flying insects. The Mangrove Fantail forages in all levels of the mangal and often in other nearby vegetation. It is the most active and aerobatic of mangrove birds, which is reflected in such mobile prey as Hymenoptera and Diptera. The Wood Fantail forages mainly in

the lower levels of the mangal. It is less active than the Mangrove Fantail and does more gleaning.

The Broad-billed Flycatcher and Shining Flycatcher feed mainly by snatching insects from vegetation. The Broad-billed forages at all levels of the mangal, the Shining mainly in the lower levels.

The Mangrove, Dusky and Large-billed Flyeaters are similar in size and foraging behaviour. The Dusky and Large-billed replace each other in north-west Kimberley, probably because of competition, although the Large-billed takes more beetles (especially weevils) than the Dusky. The Mangrove Flyeater is more often in melaleuca than mangal and when in mangroves prefers the edge and landward zone.

In the Kimberley the Red-headed Honeyeater competes at flowering trees with the similar-sized Brown Honeyeater (*Lichmera indistincta*) which is a common visitor to flowering mangroves. There are frequent aggressive encounters between these two; neither species is a consistent winner. In the Pilbara the Brown is the only honeyeater that regularly exploits flowering mangroves.

Tree Martins (*Hirundo nigricans*) are common winter visitors from the south-west of this State to northern mangals. They probably compete for some aerial insects with the White-breasted Woodswallow, but the woodswallow is considerably larger.

Other Birds Visiting Mangal

Apart from the 22 bird species dealt with in this paper, many other birds frequently visit mangal to feed, nest or shelter. In the Kimberley these include the Darter, Black-necked Stork, Sacred Ibis, Brahminy Kite, Torres Strait Pigeon, Horsfield's Bronze Cuckoo, Pheasant Coucal, Tawny Frogmouth, Sacred Kingfisher, Tree Martin, Little Shrike-thrush, Northern Fantail, Red-backed Fairy-wren, Mistletoebird, Brown Honeyeater, Singing Honeyeater, White-gaped Honeyeater, Banded Honeyeater, Little Friarbird, Silver-crowned Friarbird, Chestnut-breasted Mannikin, Spangled Drongo and Great Bowerbird.

In the Pilbara frequent mangrove visitors include the Darter, Little Egret, Black-necked Stork, Sacred Ibis, Brahminy Kite, Banded Land Rail, Horsfield's Bronze Cuckoo, Pheasant Coucal, Sacred Kingfisher, Tree Martin, Variegated Fairy-wren, Mistletoebird, Brown Honeyeater and Singing Honeyeater.

In the Carnarvon-Shark Bay region mangrove visitors include the Pied Cormorant, Darter, Little Egret, Brahminy Kite, Sacred Kingfisher, Tree Martin, Broad-tailed Thornbill, White-browed Scrubwren, Variegated Fairy-wren, Little Grassbird, Singing Honeyeater and Zebra Finch.

Tidal flats and creeks with varying water depth provide food for many wintering and resident wading birds including Red-capped Plover, Large Sand Plover, Whimbrel, Eastern Curlew, Common Sandpiper, Grey-tailed Tattler and Red-necked Stint. On the Houtman Abrolhos mangroves are vital for the Lesser Noddy and important for the Pied Cormorant and Spotless Crake.

Table 22 Regional Distribution of Mangrove Birds in Western Australia.

	Region A Cambridge Gulf	Region B NW Kimberley	Region C SW Kimberley	Region D Pilbara	Region E Carnarvon- Shark Bay
Mangrove species (N)	15	15	12	8	1
Great-billed Heron	*	*	*		
Mangrove Heron	*	*	*	*	*
Grey Goshawk	*	*			
Chestnut Rail	*	*			
Bar-shouldered Dove	*	*	*	*	
Little Bronze Cuckoo	*	*	*		
Mangrove Kingfisher	*	*	*	*	
Lemon-breasted Flycatcher	*	*	*		
Mangrove Robin	*	*		*	
Mangrove Golden Whistler	*	*	*	*	
White-breasted Whistler	*	*	*	*	*
Wood Fantail	*	*			
Mangrove Grey Fantail	*	*	*	*	*
Broad-billed Flycatcher	*	*	*		
Shining Flycatcher	*	*	*	*	
Mangrove Flyeater	*	*	*		
Dusky Flyeater		*	*	*	*
Large-billed Flyeater	*	*			
Yellow White-eye	*	*	*	*	*
Red-headed Honeyeater	*	*	*		
White-breasted Woodswallow	*	*	*	*	*
Black Butcherbird	*				
Bird species (N)	21	21	16	11	6

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