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OCEANOGRAPHIC RESEARCH INSTITUTE

Investigational Report No. 56

The Penaeoidea of Southeast Africa

**I. The Study area and key
to the southeast African species**

by
A. J. de Freitas

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THE PENAEOIDEA OF SOUTHEAST AFRICA.
I. The Study Area and Key to the Southeast African Species

by
ANTÓNIO J. DE FREITAS

ABSTRACT

Thirty-seven species of the superfamily Penaeoidea, excluding the family Benthescymidae, have been recorded in the waters of southeast Africa from the Rovuma River in the north to the Kei River in the south. In this, the first of five monographs, the study area is described in general while more details are given for Delagoa Bay where most of the biological work was done between 1971 and 1973. For completeness the typical life-cycle is briefly described. A key to the families (including Benthescymidae), genera and species is presented.

INTRODUCTION

Shrimps and prawns are, economically speaking, the most important marine crustaceans worldwide, being 111% in volume of all the other marine crustacea taken together (FAO, 1981). With the exception of the United States and Japan, most countries consider and utilise these crustaceans as good foreign exchange earners.

The total world catch of shrimps and prawns in 1981 was 1.7 million metric tons of which 41% was fished in the Indo-west Pacific region, where penaeoids are the most valuable of all species caught. According to FAO statistics 701286 tonnes (11% of world total) were caught in the Western Indian Ocean, of which 2% were taken from Mozambique, Madagascar and South Africa.

The terms shrimps and prawns have been indiscriminately used in various parts of the world for members of both the Caridea and Penaeoidea. During the World Scientific Conference on the Biology and Culture of Shrimps and Prawns held in Mexico in 1967, it was decided to draw up a list of economically important species. However, the scientists selected to carry out this task were instructed that no attempt should be made to standardise the common terms, 'shrimps' and 'prawns'. This decision clearly reflects the tremendous difficulty which exists in obtaining general agreement in the use of these terms. Nevertheless, for the purpose of the present paper the term 'prawn' will be used throughout when referring to the Penaeoidea. Further, the word 'penaeoid' will refer specifically to the superfamily Penaeoidea in general, while 'penaeid' will refer specifically to the family Penaeidae.

Until 1965 prawn fishing in Mozambique was only a localised industry and grossly undervalued, while in Natal very little was caught and essentially sold as bait. Not much work has been done on these Crustacea both in Mozambique and Natal and the first studies resulted in a number of preliminary reports, some of which were unpublished, by de Freitas (1963, 1965, 1966), Joubert and Davies (1964, 1965), Davies and Joubert (1964, 1965), Joubert (1964) and Champion (1970).

In Mozambique penaeid prawns proved to be far more plentiful than originally believed and the total catch rose from 390 metric tons in 1963 to 6100 tons in 1974 (Mozambique, Direcção Nacional de Pescas, 1976). In Natal, penaeid prawns were only caught in estuarine areas, such as St Lucia Bay, forming small but important bait fisheries. In 1976, however, Durban based prawn trawlers commenced operations on the Tugela Bank and this resource seems to be of greater importance than first appeared to be the case.

This is the first and introductory paper in the series of five monographs on the Penacoidea of southeast Africa. It briefly describes the study area from the Rovuma River in the north to the Kei River in the south and presents, in more detail, environmental data for Delagoa Bay collected from 1971 to 1973. Very little is known of the coastal ecology of Mozambique as a whole or even of Delagoa Bay, with the exception of work done on Inhaca Island by a few workers (Macnae & Kalk, 1958, 1962a, 1962b; Wells, 1967) and the ecosurvey of the coast by Tinley (1971); a pioneer work, from a whole ecosystem point of view, not only of Mozambique but of any coast in Africa. It is, therefore, felt that the information set out in this paper is of value.

Further, for a clearer understanding of the penaeids, their life history is briefly described. Finally, a key to the Penacoidea of southeast Africa is presented. Although the family Benthicymidae is not included in this study, it has been incorporated into the key for completeness and the information used was taken from Kensley. (1971 & 1977) and Crosnier (1978).

This paper is part of a thesis presented to the University of the Witwatersrand for the degree of Doctor of Philosophy.

The Study Area

Geographical position and coastal classification

The biogeographical region known as the Indo – west Pacific is complex and enormous, its shelf waters extending horizontally more than halfway around the world and vertically through about 60° latitude (Briggs, 1974). The area covered in this project is arbitrarily called the south-east African coast and is about the southern half of the Western Indian Ocean zoogeographical province of the Indo – west Pacific Region. It is limited in the north by the Rovuma River (10°30'S) at the entrance of the Mozambique Channel, a point roughly corresponding to where the South Equatorial Current is deflected southwards to form the Mozambique Current. The southern limit is the boundary between the tropical and warm temperate faunas which Briggs (1974) places at the mouth of the Kei River (32°40'S) (Fig. I-1). The total distance of coastline concerned in this project is about 1600 nautical miles (approx. 3000 km).

Very little work has been done on the geomorphology of the Mozambique coast and the only attempt to classify it has been by Tinley (1971), and is illustrated in Figure I-2.

The northernmost section of the coast, extending about 420 nautical miles (770 km) from the Rovuma River to Silva Island at the extreme south of the Primeira/Segunda Archipelago (17°20'S), is essentially a coral coast. This region is characterised by "... faulted, embayed coast with fringing coral and coral rock cliffs... submarine canyons and north-trending coastline." (Tinley, 1971). In the north and south of this region the characteristics are evident on the Querimba and Primeira/Segunda Archipelago rather than on the mainland where the terrain is typically that of a swamp coast.

The central section of Mozambique, of roughly 430 nautical miles (787 km), between Angoche (16°14'S) and Bartolomeu Dias Island (21°10'S), is classified as a swamp coast with "simple linear beaches, swamp and estuary barrier coast". The sea along this coast is shallow and the waves are high but short which disturb the bottom materials close to the beach, and is one of the causes of the high turbidity found in this region (Macnae, 1968). Twenty four rivers are to be found in this central section of the coast, each with an estuary supporting well established mangrove swamps. The beaches between Pebane and the Zambezi River mouth are of

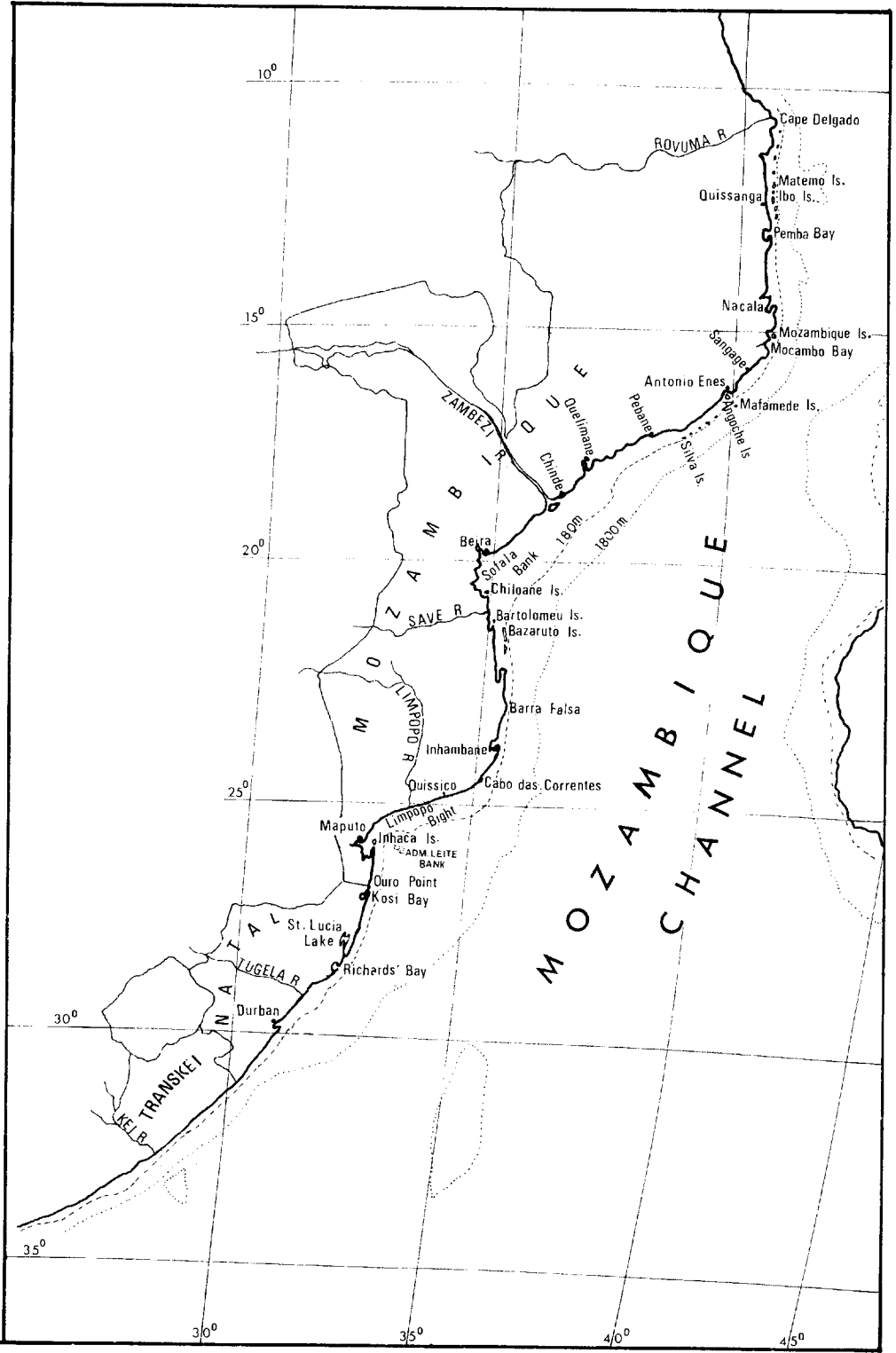


Fig. I-1 Southeast Africa. The study area

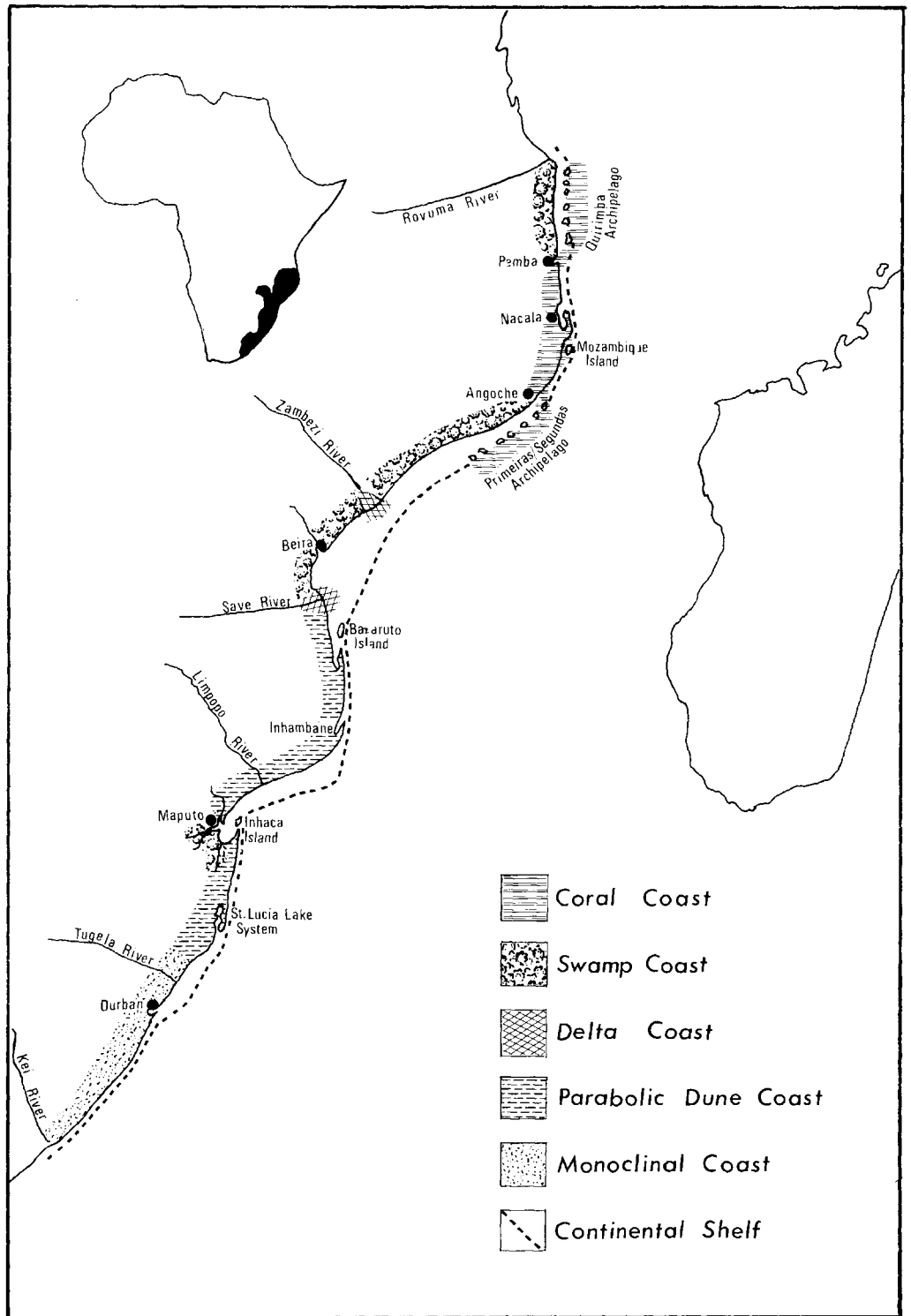


Fig 1-2 The main coastal regions of the study area.
(Modified from Tinley, 1971).

black sand and consequently fairly rich in the minerals ilmenite and rutile (Tinley, 1971). On the south side of the delta the shore is backed by low parallel sets of dunes known as cheniers which run parallel to the coast. The cheniers on the sea front are colonised just above high water mark by a narrow zone of casuarinas (*Casuarina equisetifolia* L.)

In the northernmost 130 nautical miles (140 km) on the mainland opposite the islands of the Querimba Archipelago the coast can clearly be defined as a swamp coast. Numerous sandbanks and coral outcrops, many of which are exposed at low spring tides, occur between the mainland and the islands where the water is less than 20 m in depth. North of the 12°S latitude the sea bottom is of a silica/coral sand substratum. The land behind the small dunes is low, forming large stretches of freshwater swamps. The beaches are white, probably exclusively formed of coral sand and in spite of the coral fringe, short high waves pound the beach. In this stretch of coast mangrove swamps are virtually non-existent.

To the south of this sector, the mainland is more protected from excessive wave action and mangroves are common in the estuaries of small rivers and embayments as well as forming large fringing mangrove forests such as the one which actually links the island of Ibo with the mainland of Quissanga. This southern section of the coast between the mainland and the Querimba Archipelago is rich in penaeid prawns.

The third coastal region stretches from Bartolomeu Dias Island southwards to Ouro Point and beyond to Natal at Mlalazi River (28°57'S) and is classified as a parabolic dune coast. This section of the coast is about 465 nautical miles (850 km) long and is characterised by high, forested parabolic dunes and north-trending capes of dune rock subtending half-heart bays and barrier lakes (Tinley, 1971).

These dunes are Pleistocene formation and reach considerable heights such as 114 metres at Inhaca Island, 120 metres at Mapelane and 188 metres at Cape St Lucia.

There are only two sections of the total study area that can be classified as Delta Coasts and these are the Zambezi and Save deltas.

South of the Mlalazi River the coast has received relatively little attention from the point of view of coastal classification. Discussing this classification with Tinley in August 1977, he was of the opinion that the southeast coast from the Mlalazi River to the Great Fish River mouth can be classified as a "...linear monoclinial coast with high, rounded, youthfully dissected oldland with cretaceous to tertiary outcrops interposed in a few places, and drowned estuaries with bay-mouth bars in the dry season; quartz and/or pebble beaches, linear arcuate, interspersed with rock outcrops and sea-cliffs on the Transkei coast; low parabolic, transverse and hummock littoral dunes in varying width and discontinuous; humic to latosolic old coast sands emplaced over the oldland surface within 8 km of the littoral and covered by a forest-grassland mosaic." (Tinley, pers. comm.)

With regard to the dynamic status of the monoclinial section of the coast, a low level air survey undertaken in March 1982 (Tinley, 1984) showed the following features: (1) stable features in the rocky sector; (2) eroding in the sand beach and foredune areas; (3) temporarily advancing shores being confined to immediate river mouth sites. He continues by stating that "of more importance is the form and content of the alluvial deposits in the estuaries, and types include: (a) delta estuaries enclosed by barrier bars, (b) barrier lagoon or marsh type e.g. Umgeni mouth, (c) simple estuaries and (d) extended linear mouths e.g. Transkei coast."

Summarising then, Tinley (pers. comm.) concluded that "...the southeast coast (south of the Mlalazi River) is a compound shore of both emergence and submergence. The extended drainage next to the coast of many rivers indicates emergence, and subsequent submergence or drowning by the presence of estuarine lagoons and marshes, bayhead bars and cliffed spurs. Some of these drowned mouths retain a deep water condition as exemplified by the Msibaba, but most have been infilled with sediments particularly in the last 100 years."

Mangrove swamps

The abundance of shelf Penaeidae found off the Mozambique coast is almost certainly related to the abundance of suitable nursery areas, very especially those afforded by mangrove swamps or mangals*. In Figure I-3 the distribution of the main mangrove forests of the coast under consideration is shown and for a number of important regions the areas are given.

From the Rovuma River south, the first mangals appear in the estuary formed by the Muacumula-Lingula Rivers opposite Matemo Island of the Querimba Archipelago. South of this point to Pemba Bay, mangals are found around the mouth of all rivers, in small bays and inlets and on the leeward side of most coastal islands. The most remarkable extension of mangroves in this region is found between the historic island of Ibo and Quissanga on the mainland forming an area of approximately 5 000 ha (50 sq. km). The seaward fringes to the north and south are almost exclusively formed by a belt of *Sonneratia alba*, approximately 100 m wide. Between these is a dense forest of *Lumnitzera racemosa*, *Rhizophora mucronata*, *Ceriops tagel*, *Bruguiera gymnorrhiza*, *Avicennia marina*, *Heriteria littoralis* and *Xylocarpus moluccensis* either isolated or in mixed stands. The many drainage channels and creeks are traversed by stake nets or weirs (gamboas) often yielding considerable catches of penaeid prawn to African fishermen.

Just south of Sangage is the first large important estuary around the island of Angoche and, on the mainland, the town of Angoche (Antonio Enes). Here the main rivers contributing to the system are the Meluti River and the much smaller Luazi River. The mangal in this estuary almost covers Angoche Island and extends inland some 10 – 15 km from the town of Angoche in an intricate network of creeks and channels. Hughes (1969, 1971) and Hughes and Oxley-Oxland (1971) believe that this estuary is an important sanctuary for the dugong in northern Mozambique.

From Angoche down passed the Zambezi River delta to the Save River delta and the Bartolomeu Dias estuary, mangals are abundant forming dense forest wherever a river reaches the sea or a seaway (channel) penetrates inland. In most of this area, particularly north of Beira, the coast is characterised by open sandy beaches pounded by short but high waves. Behind the beach, in the Zambezi delta area, one finds a series of cheniers parallel to the coast which sometimes reach a fair distance inland.

Between successive cheniers the depressions are sometimes under freshwater influence, becoming extensive swamps (Macnae, 1968) but when these lows also fall under tidal influence, as estuaries of small rivers, mangals develop and usually form dense forests. In this way most of the mangals along this section of the coast are protected from direct action of the sea. The only mangals exposed to the sea are those of the islands formed by the deltas of the Zambezi and Save Rivers. Coastal fringing mangals are also found along the Sofala coast between Beira and the Save River, but here the water is no more than 3 – 5 m in depth and wave action reduced to a minimum.

From Angoche to the Save River the mangals are generally composed of *L. racemosa*, *B. gymnorrhiza*, *R. mucronata*, *C. tagel*, *H. littoralis*, and *X. moluccensis* with *S. alba* and *A. marina* forming the seaward fringe. Where the rivers, although still tidal, do not have a salt-water influence *Barringtonia racemosa* occurs just below the high water mark (Macnae, 1968).

South of the Save Delta and the Bartolomeu Dias Bay, mangals are once again fairly scarce until Delagoa Bay. There are small patches of mangroves at the south end of St Sebastian Bay, Pomene and at Inhambane. The mangal at this last locality is found on a substratum poor in mud due to the lack of river-borne silt. Further, the rivers of this region are poor in nutrients as they arise in podsolized (leached) acidic sands. In this community large sandbanks are exposed forming halophytic parklands and the normal mangrove trees are stunted in growth. *Sonneratia alba*, although still found, is scarce and Inhambane seems to be the southern limit for the distribution of this species.

*Mangal: The Portuguese word for the community of mangrove trees. The word was coined by Macnae (1968) to avoid confusion with the word mangrove, meaning the tree of any of the usual species of the community. A mangal is here defined as a littoral plant community of mangroves and associated species growing below the high water mark in saline waterlogged soils.

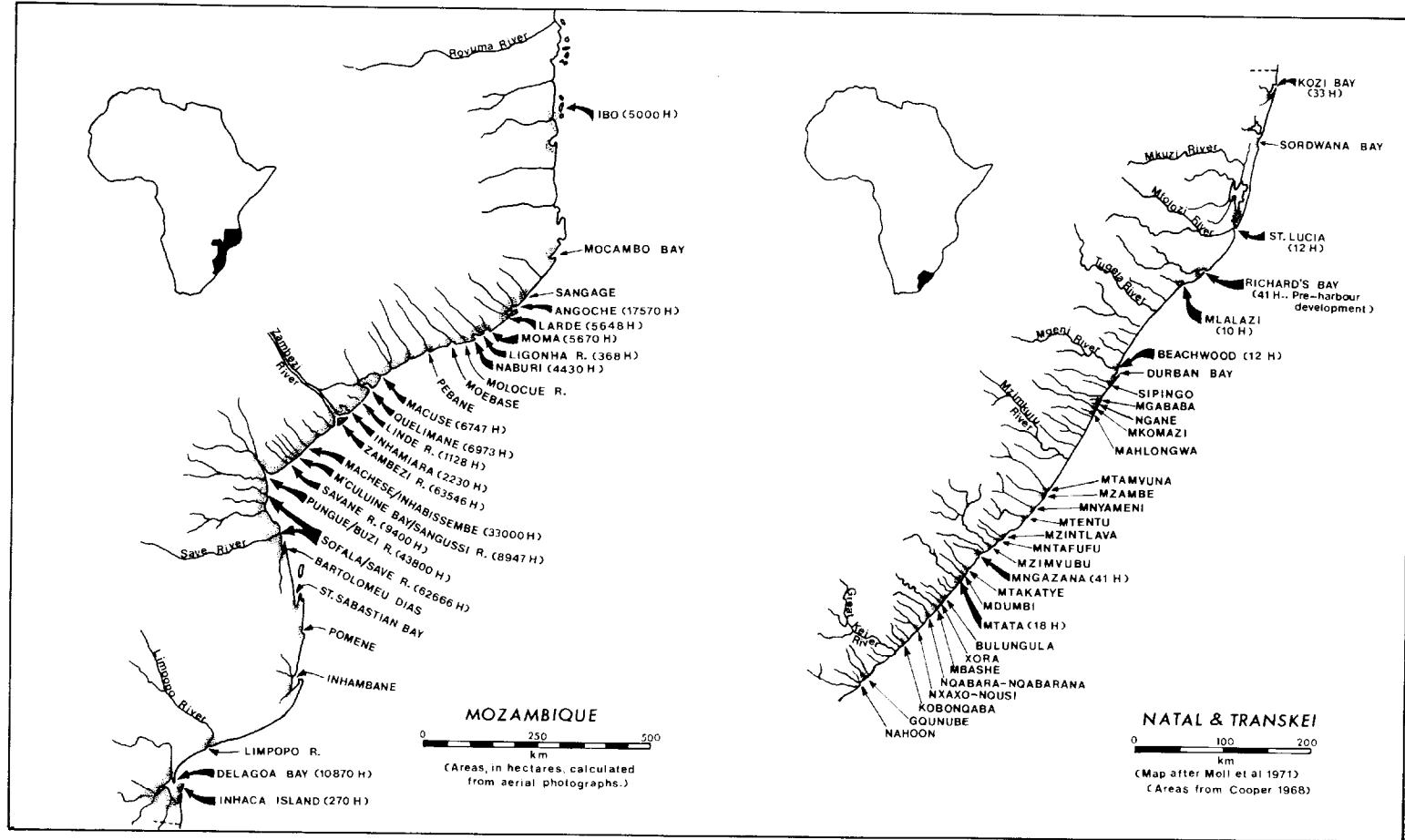


Fig. 1-3 Distribution of mangroves along the southeast African coast.

The Delagoa Bay mangals are well developed and distinctly zoned, occupying a total area of about 11 100 ha (111 sq. km) and will be dealt with in more detail in the section on Delagoa Bay.

South of Delagoa Bay the extent of mangrove swamps decreases drastically as can be verified by comparing the areas given with those along the Mozambique coast (Fig. I-3). Small mangrove communities are found to as far south as the Gqunube River mouth (32°57'S) (Moll *et al.* 1971) and south of this in a "...straggle of occasional trees in a few estuaries" and elements of mangrove fauna reach beyond Knysna (Macnae, 1963). The southernmost trees are found in the Nahoon Estuary at East London (Tinley, pers., comm.).

Kosi Bay, just south of Delagoa Bay, has a mangal with an area of about 33 ha and is the only mangal in the Republic of South Africa where all five of the common east African mangroves are found. This community is important because it is the southernmost point of distribution of two mangroves, namely *C. tagal* and *L. racemosa* (Tinley, 1958; Cooper, 1969; Moll *et al.*, 1971).

The largest mangal south of Mozambique is found in the Transkei at the mouth of the Mngazana River. It has an area of about 41 ha (Cooper, 1969) with a healthy community of the mangroves *R. mucronata*, *A. marina* and *B. gymnorhiza*. The mangal at Richards Bay was originally as large, in area, as that of the Mngazana River but has recently been greatly reduced with the development of the harbour. However, on the mud-bank "delta" where the Umhlatuze River enters the sanctuary an extensive stand of seedlings (mainly *A. marina*) is rapidly being established.

Joubert and Davies (1966), Champion (1976), Berjak *et al.* (1977) and others have all indicated that the estuaries of Natal, especially those where mangroves are established, serve as nursery areas for the shelf species of penaeid prawns. Small as these mangrove areas are in comparison with those in Mozambique, they do, together, play an important part in supporting the small but economically significant penaeid resource found on the Tugela Bank.

The Ocean Currents

By virtue of the fact that penaeid larvae are planktonic and therefore at the mercy of the movements of water masses, ocean currents become the most important agents for the distribution of the members of this family. The study area is essentially under the constant influence of the South Equatorial Current and dominated by two large anticyclonic eddies: the Mozambique Channel Gyre and the Agulhas Gyre, whose principal components are the Mozambique Current and Agulhas Current respectively.

The South Equatorial Current has its origin in the West Australian Current at about the Tropic of Capricorn due to the prevalence of the Southeast Trade Winds. Although the dimensions of the South Equatorial Current change from summer to winter, the axis of flow at all seasons is roughly at 15°S (Duncan, 1970) and it is at this latitude that the core of the current strikes Madagascar. Here it splits to form the East Madagascar Current and a north division which passes over Cape d'Ambaro and continues westward to, once again, be split into two flows by the African continent at roughly Cape Delgado in Mozambique.

The Mozambique Current has two components: the south flowing branch of the South Equatorial Current and west flowing arms of the recycling Mozambique Channel Gyre (Orren, 1963; Fairbridge *et al.*, 1966; Darbyshire, 1966). It flows along the Mozambique coast following the edge of the continental shelf. Between 25°S and 30°S a branch of this current is deflected eastwards and then northwards as it meets the west coast of Madagascar (Menache, 1961, 1963; Harris, 1970). This north flowing current may, at times, be reinforced by a recurving branch of the East Madagascar Current as it passes south of the island (Duncan, 1970).

The velocity of the Mozambique Current fluctuates with the seasons from almost zero during the SW Monsoon to 1.5 – 2.0 m/second during the Northeast Monsoon (Fairbridge *et al.*, 1966). According to the information supplied by the Hydrographic Institute of Portugal, the strongest currents are known from October to February especially where the continental shelf narrows between Cape Delgado and Mozambique Island in the north and Bazaruto Island and Cabo das Correntes in the south. During the southern winter the flow is greatly reduced and much of the water is deflected eastwards into the Mozambique Channel Gyre although a small portion of the current continues southward (Harris, 1970). The actual reversal (Menache, 1963) as a regular feature of the current has not, as yet, been fully substantiated.

On the Sofala Bank a regular counter current, reaching velocities of 0.75 m/sec., occurs flowing in a northeasterly direction from just north of Bazaruto to the Primeiras Archipelago. At times a branch of this counter current is felt moving northeast between the mainland and the Primeiras/Segundas Archipelago and there is a fairly strong longshore drift moving southwestwards close inshore. Between Beira and the Zambezi Delta and again in the region of the Limpopo Mouth, the coast is being eroded away and the estuaries of both the Limpopo and Zambezi Rivers are continuously being truncated, resulting in dead mangrove trees standing in the advancing intertidal zone. This is particularly evident on the island of Timbue on the Zambezi Delta. The sediments from the coastal erosion in the Limpopo Bight are being deposited along the Macaneta Peninsula, which is south tending and accreting. (Hydrographic Institute of Portugal, Moz. Chart N°401, 1963; Tinley, 1971).

The Agulhas Current assumes its identity between 25°S and 30°S depending on the influence of the Mozambique Current (Duncan, 1970). It has essentially three components: the Mozambique Current, the westward flowing branch of the East Madagascar Current and the recycling arm of the Agulhas Gyre. This important Current has been well studied in the past by a host of researchers among them Anderson (1961), Darbyshire (1964), Shannon (1967), Duncan (1970), Harris (1972) and Grundlingh (1976). A very good summary of the existing knowledge of the Agulhas Current is given by Bang and Pearce (1976) and the same paper edited by Heydorn (1978) brings together very aptly the part played by this current system on the ecology of the southeast coast of the Republic of South Africa and the Transkei.

The width of the Agulhas current is about 100 km (Bang & Pearce, 1976) and its core may be situated between 40 and 65 km offshore (Pearce, 1976). The mean velocity is calculated at 1.1 m/sec. although speeds of 2.25 – 2.45 m/sec. have been recorded (Fairbridge *et al.*, 1966; Pearce, 1976).

On the continental shelf of the Natal coast between Green Point and Port Durnford there occur periodic northward movements of cool water which, particularly in winter, have been interpreted as an unstable, colder counter current which, although more frequently flows north-eastwards, may rapidly turn to flow southwest (Harris, 1964; Bang & Pearce, 1976). According to Duncan (1970) this is a weak current with a rate of flow of about 0.25 m/sec although the speed may exceed 0.5 m/sec. at times (Bang & Pearce, 1976).

Figure I-4 shows the main current systems influencing the study area, compiled from the work of most of the authors mentioned above.

Delagoa Bay

Methods

Most of the work done on the biology of the commercially important species of Penaeidae was carried out in Delagoa Bay, where a fairly substantial tonnage of prawn was caught by small trawlers and beach seiners every year.

A series of 22 sampling stations (Fig. I-5) was established after a preliminary survey of the whole embayment had been carried out. All stations were sampled once a month during spring tides and, whenever possible, a second monthly visit was made during neap tide conditions.

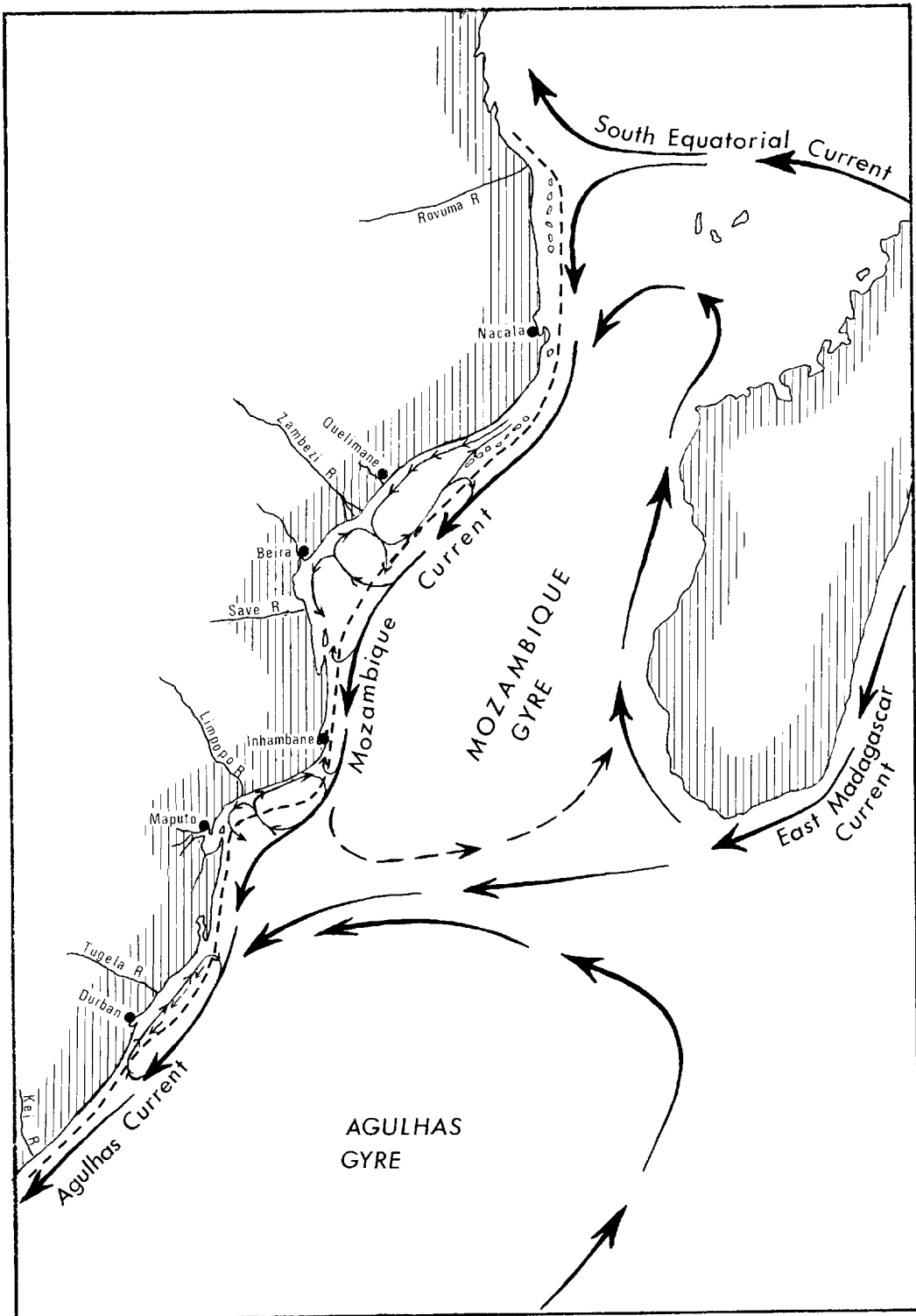


Fig. 1-4 The general ocean current systems of the study area.
(Data from various sources).

From 1971 – 1973, every two months, stations 4, 15 and 22 were sampled over a period of 24 hours.

Air temperatures were recorded with a standard mercury thermometer and surface and bottom water temperatures were measured by means of a protected reversing thermometer mounted on a water sampling bottle. Where depths were less than two metres, only one measurement was taken and the surface and bottom temperatures were considered to be the same.

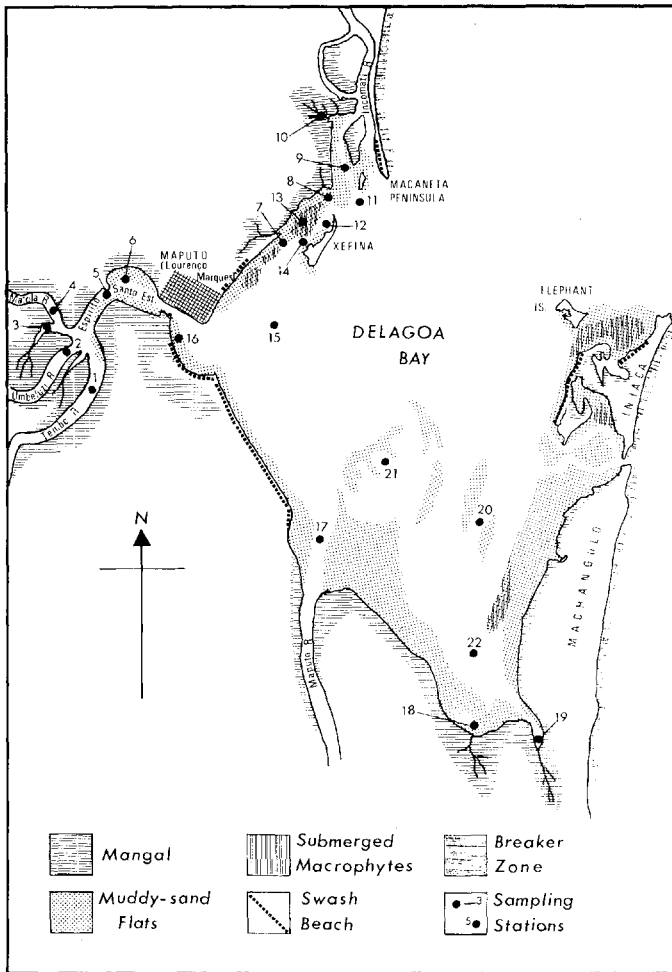


Fig. 1-5 Delagoa Bay showing location of sampling stations.

Surface and bottom water samples, for the purpose of salinity measurements, were collected by means of a Nansen reversing bottle and salinities were measured by means of a Goldberg T/C Refractometer (Model 10423). For the purpose of water temperatures and salinities, surface is taken to be about one metre below the surface, and bottom to be one metre above the sea floor.

Water transparency was measured by means of a 30 cm Secchi Disc and was not determined, due to a decrease in light, from one hour before sunset to one hour after sunrise.

Biological samples were taken from a drag of 15 minutes using a 3 m beam trawl with a 12 mm stretched mesh net (Fig. I-6). Once a week the catch of one commercial shrimp trawler

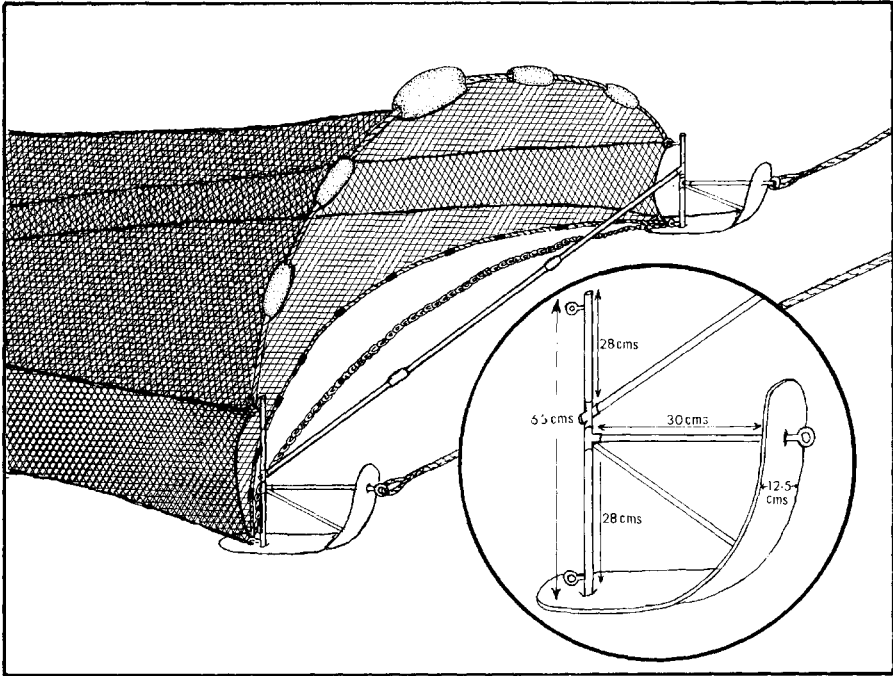


Fig. I-6 Juvenile prawn sampling net.

was analysed for catch rates and a sample of each prawn species caught was taken to the laboratory for morphometric analysis.

The hydrological and biological data were subsequently transcribed from the field forms to computer cards for computer analysis.

Geomorphology

The Delagoa Bay complex, situated between latitudes 25°52'S and 26°16'S and longitudes 32°25'E and 35°59'E is geologically composed of Quaternary dune formations and Quaternary to Recent alluvial deposits.

Delagoa Bay itself is a drowned estuary originally formed by the confluence of four rivers and with a fairly narrow, north orientated opening to the sea. With the submergence of the Mozambique plain, the opening to the sea, as well as the area of the Bay increased considerably. Presently, Delagoa Bay has an area of about 960 km² and the entrance, stretching from the Macaneta Peninsula to Elephant Point on Portuguese Island is 18.5 km wide. The Bay is generally very shallow; roughly 246 km² are exposed during low spring tides and only 175 km² are deeper than 10 metres. Fernandes (1960) claims that the bathymetry of Delagoa Bay has not suffered any great change since 1825.

Within the boundaries of the Bay there are four islands, Xefina Grande, Xefina do Meio, Portuguese Island and Inhaca Island. The last of these is the largest and, together with the Machangulo Peninsula, forms the eastern boundary of the Bay. A fifth island, Xefina Pequena is found within the Incomati River Estuary.

*Rivers**

The Incomati River enters Delagoa Bay in the north. Its drainage basin has an area of 37 600 km² with a mean monthly flow 75.5 m³/sec and a mean annual discharge of $2\,425 \times 10^6$ m³. For the last 10 km of its course it is separated from the open sea by the Macaneta Peninsula which, at places, is a mere 20 – 30 m in width. It is to be expected that at some stage in the future the river will breach at one of these points and flow straight out to sea, thus severing any influence it may have on the ecology of Delagoa Bay.

The Incomati Estuary stretches for about 13 km from the mouth and has an area of 20.4 km². It consists of two arms of the river separated by the island of Xefina Pequena. Presently the main river course flows to the east of the island while the western arm is very shallow. On the whole about 10.4 km² of its area is formed of mudflats exposed during low spring tides.

The Maputo River flows into Delagoa Bay in the south, almost directly opposite the Incomati River. The Maputo River has a drainage basin with an area of 29 000 km², a mean monthly flow of 82.7 m³/sec and a mean annual discharge of $2\,555 \times 10^6$ m³. It rises as the Pongola River in the mountainous regions of southern Swaziland, drains the Makatini flats and enters Mozambique as the Maputo River.

The Espírito Santo Estuary is formed by the confluence of the Tembe, Umbeluzi and Matola Rivers. It is roughly 14 km long and has a 400 m wide channel of 5 – 10 m depth. The estuary has an area of roughly 37.7 km² of which 12 km² consist of mudflats usually exposed during low spring tides. The connection with the embayment is through a 5 km wide mouth.

The Tembe River has a drainage basin with an area of 2 300 km² arising along the Little Lebombo mountain range. No figures on flow or discharge are available.

The Umbeluzi River is the most important from the point of view of freshwater contribution. Its main tributaries are the Impamputo and the Movane Rivers all arising from the Little Lebombo mountain range. The Umbeluzi has a drainage basin of 5 400 km² with a mean monthly flow of 11.4 m³/sec and a mean annual discharge of 371×10^6 m³.

The Matola River is the smallest of the Delagoa Bay complex. It has a drainage basin of 1 330 km² and no information on the annual discharge or monthly flow is available.

Rainfall

According to the pluviometric chart published in 1960, in the Incomati River Estuary and the Maputo River, Machangulo and Inhaca areas the mean rainfall lies between 800 and 1 000 mm per year while the rest of Delagoa Bay lies within the 600–800 mm isohyets.

The monthly rainfall from January 1967 to December 1973 is given in Figure I-7A while the mean monthly rainfall and total annual rainfall are shown in Figures I-7B and C respectively. Delagoa Bay has rainfall the year round with the highest figures being recorded in the first quarter of the year (131.4 mm) and the lowest during the third quarter (19.6 mm).

Temperature

For the Delagoa Bay complex as a whole, during the period of the study, the lowest air temperature recorded was 11.5°C in July 1971 and the highest was 39.5°C in December 1969, with an overall mean temperature of 24.5°C. The warmest months were January, February and March

* All data on drainage basin areas and river discharge were supplied by the Mozambique Department of Hydrology.

with a mean temperature of 27.6°C while the coolest months were June, July and August with a mean of 20.8°C.

The mean surface and bottom water temperatures recorded during 1969 – 1973 for the Delagoa Bay complex were 23.6°C and 23.4°C respectively. There was very little difference between the surface and bottom water temperatures. The warmest mean water temperatures (surface 27.4°C; bottom 27.1°C) were recorded in January, February and March, while the coolest temperatures (surface 19.5°C; bottom 19.6°C) were found in June, July and August.

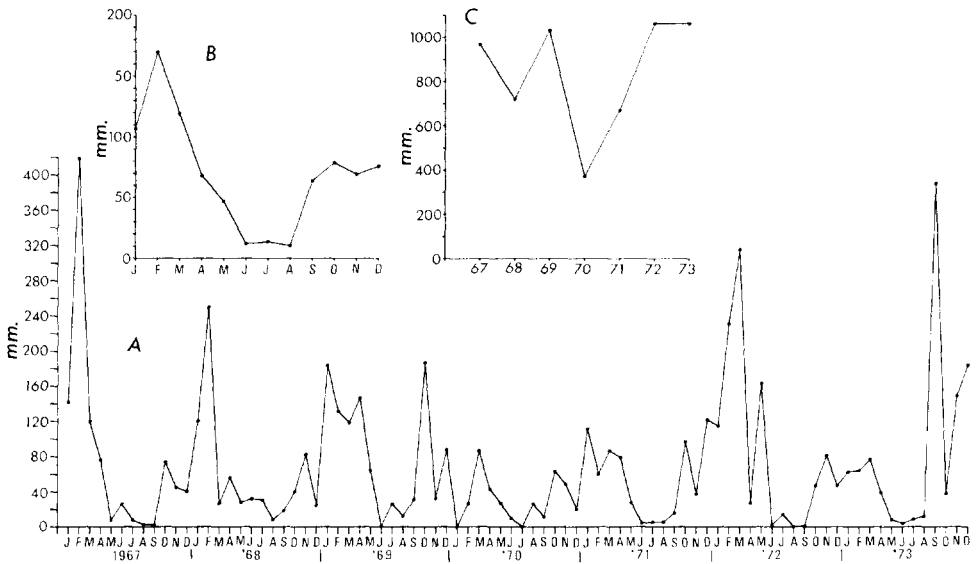


Fig. 1-7 Rainfall recorded in Maputo (Lourenço Marques) from 1967-1973. A -- monthly rainfall. B -- Mean monthly rainfall. C -- Annual rainfall.

Salinity

The Delagoa Bay complex as a whole can be classified as mixohaline according to the Venice system (Perkins, 1974), with salinities ranging from freshwater at some river stations to 39.7‰ in the shallow tidal pools on the mudflats. In the open bay, however, the minimum and maximum surface salinities recorded were 15.8‰ and 34.1‰ and the minimum and maximum bottom salinities were 20.5‰ and 33.9‰ respectively.

As was to be expected the lowest mean surface and bottom salinities were recorded during the height of the rainy season in January, February and March, while the highest mean surface and bottom salinities were recorded in August, September and October, at the end of the dry season.

There was very little difference between the bottom and surface salinities. Only in stations 2, 5, 9 and 17, all influenced by the river discharges, was the bottom salinity more than 1‰ higher than the surface.

There seems to be little doubt, therefore, that in general the Delagoa Bay complex, including the estuaries, can be considered as virtually homogeneous due to the mixing efficiency of the tidal regime (Pritchard, 1967; Martins & da Costa, 1972). With the exception of those stations in river mouths, very little, if any, difference in surface and bottom salinity was found between high and low tides.

Water transparency

Without exception the lowest Secchi disc readings were between 5 and 10 cm. The clearest water was recorded in May and June 1971 at station 7 over a field of submerged macrophytes. The lowest mean transparency (30 cm) was found in station 10, Montanhana River, which is in fact only a fairly small but deep (4 m) mangrove channel. The Costa do Sol stations (7, 8, 12, 13, 14) and the Bay stations (15, 20, 21) had the highest mean transparencies of 110 cm and 100 cm respectively.

The variation in transparency of the complex as a whole is irregular. De Freitas and Diniz (1972) show that for the Matola River station the transparency is directly but not proportionately related to the tidal amplitude. This seems to be the case for the whole Delagoa Bay complex. That is to say that the turbidity of the water is related to the movement of the water masses rather than to wet or dry season.

The mean water transparency for all stations taken together and for the period of the study was 60 cm.

Biota

Vegetation

The peripheral vegetation of the Delagoa Bay complex is either mangroves, mangrove associates or dune scrub. Just about 51% of the bay shoreline is bordered with mangals while the remaining 49% is occupied by dune scrub, the most common species being *Scaevola thunbergi*, *Ipomoea braziliensis*, *Casuarina equisetifolia* and *Rhus macowani*.

Inhaca Island has 271 hectares of mangals and these have been well studied by Macnae and Kalk (1958, 1962b) and Mogg (1963). The most common species found are the halophytes *Arthrocnemum perenne*, *Suaeda maritima*, *Sesuvium portulacastrum* and *Salicornia perrieri*, the mangrove associates *Hibiscus tiliaceus* and *Thespesia populnea* and finally the mangroves, *Avicennia marina*, *Ceriops tagal*, *Bruguiera gymnorrhiza*, *Rhizophora mucronata* and *Lumnitzera racemosa*.

South of Inhaca there is a narrow band of *A. marina* stretching along the Machangulo Peninsula for about 14 km. In the Machangulo Sack there is a large mangal of roughly 3 000 hectares, extending to the mouth of the Maputo River. In this river the more common mangroves form a narrow belt to about 10 km upstream after which the margins are lined by *Barringtonia racemosa*, often overgrown by the lianas *Entada pursaetha* (Macnae 1968).

In the Incomati River and Estuary mangals occupy about 3 200 hectares. All the already mentioned mangrove and mangrove associated species are to be found. It is interesting to note that in the small mangal behind Costa do Sol (125 hectares) one tree of *Sonneratia alba* was found in May 1970. Whether any more are present is not known.

Mangroves border the Espírito Santo Estuary and most of the Matola River while along the Umbeluzi and Tembe Rivers well zoned mangals are found only for 5 km upstream in each case, after which pockets of *A. marina* alternate with areas occupied by halophytes such as *S. portulacastrum*, *S. perrieri* and the grass *Sporobolus virginicus*.

The submerged macrophytes of Delagoa Bay are less well known than the mangroves. Large areas are to be found on the muddy-sand flats between Inhaca and Portuguese Islands and again on the protected side of Ponto Torres to the south of the island. There are small patches along the intertidal flats west of the Machangulo Peninsula and again on the intertidal zone between Xefina Grande Island and the mainland.

Seven species of seagrasses have been recorded from Delagoa Bay namely, *Thalassodendron ciliatum*, *T. serrulatum*, *T. rotundum*, *Diplanthera unicervis*, *Syringodium isoetifolium*, *Halophila ovalis* and *Thalasia hemprichii* (Cohen 1939; Macnae & Kalk 1958, 1962a). According to Cohen (1939) and Macnae and Kalk (1958) these marine angiosperms occur in three well defined zones. The narrow-leaved *D. unicervis* is dominant in the upper zone usually exposed

or covered only with 2 or 3 cm of water during low spring tides. In this zone *H. ovalis* may also be found. The next belt, in the region covered with 5 to 8 cm of water during low springs, *Thalassodendron rotundatum* and *T. serrulatum* replace the "narrow leaved" community along the intertidal fringe *T. ciliatum* intermingled with *S. isoetifolium* are found, the former species being dominant. *T. hemprichii* is widespread on the intertidal mudflats.

Fauna

The marine fauna to be found within the Delagoa Bay complex is too numerous to be detailed here and one can refer to a fair number of publications which deal with specific groups, although by far the majority relate to the fauna of Inhaca Island (Macnae & Kalk 1958; Wells 1967; etc.). Mention will be made here only of those species that were found related to the study of the prawns of the system.

A total of 75 species of fish were recorded from the samples taken during the study. The 44 most common species are listed in Table I – 1. where the catch rate per 15 minutes trawl is

Table I-1. Mean number of fish caught per 15 min. trawl from selected areas of Delagoa Bay.

LOCALITIES	River Tembe	River Umbeluzi	River Matola	Polana	Xefina	River Incomati	Machangulo	Machangulo Sack
STATIONS	1	2	3 & 4	15	7 & 8	9	22	18 & 19
<i>Hilsa kelee</i> (109)	x	19.4	0.1	3.4	0.3	0.6	0.3	0.5
<i>Sauvagella madagascariensis</i> (110)	-	0.5	0.8	-	-	-	-	-
<i>Harengula vitata</i> (112)	-	-	-	0.4	-	-	x	x
<i>Pellona ditchella</i> (116)	-	0.1	0.3	6.4	0.1	0.4	4.3	3.0
<i>Stolephorus commersonii</i> (119)	0.3	8.3	26.1	95.0	37.0	42.7	119.6	351.6
<i>Thryssa malabaricus</i> (121)	2.6	44.4	4.0	46.2	x	2.9	12.3	6.2
<i>Tachysurus feliceps</i> (165)	x	-	-	-	0.2	-	-	-
<i>Pseudorhombus arsius</i> (304)	-	-	0.1	x	0.7	0.6	0.1	0.3
<i>Solea bleekeri</i> (328)	2.3	2.6	0.7	4.5	3.6	1.1	0.6	2.7
<i>Cynoglossus lingua</i> (339)	-	-	-	-	0.1	0.1	0.3	-
<i>Cynoglossus lida</i> (340)	32.8	8.9	9.7	36.1	1.0	48.9	1.5	1.2
<i>Terapon jarbua</i> (401)	-	-	-	x	0.3	x	-	x
<i>Pelates quadrilineatus</i> (402)	x	x	x	0.2	3.0	x	0.4	4.3
<i>Epinephelus tauvina</i> (447)	0.2	0.4	0.4	-	0.1	-	0.1	0.2
<i>Sillago sihama</i> (467)	0.5	1.8	-	1.9	4.9	5.3	5.1	3.7
<i>Achamia</i> sp. (490)	-	-	-	-	6.1	x	-	-
<i>Caranx</i> spp. (508)	0.4	0.5	-	2.0	1.6	0.1	0.5	0.4
<i>Johnius belengerii</i> (549)	99.7	19.4	24.5	8.6	-	63.1	2.9	0.8
<i>Otolithes ruber</i> (553)	0.2	0.1	x	1.8	-	0.7	0.4	0.3
<i>Dendrophysa dussumieri</i> (555)	0.3	0.1	0.1	0.1	-	0.1	0.2	x
<i>Upeneus vitatus</i> (561)	-	-	0.1	0.2	x	0.2	0.1	0.5
<i>Drepane punctata</i> (576)	0.3	0.2	0.2	x	x	0.2	0.1	0.2
<i>Pygoplites tetracanthus</i> (585)	0.1	x	0.3	-	-	-	-	x
<i>Secutor insidiator</i> (625)	-	0.1	-	0.2	0.1	0.7	6.0	0.1
<i>Leiognathus equula</i> (626)	0.5	39.5	26.9	2.1	4.1	27.0	17.8	1.1
<i>Gazza minuta</i> (627)	-	2.6	0.5	0.1	0.1	x	2.3	1.0
<i>Gerres punctatus</i> (628)	-	0.1	0.9	-	0.7	-	1.2	0.5
<i>Ambassis commersonii</i> (635)	0.1	20.6	5.3	4.7	27.0	137.0	x	x
<i>Pomadasys hasta</i> (676)	7.5	11.5	7.9	20.2	1.1	9.5	6.2	6.1
<i>Pomadasys maculatus</i> (677)	2.4	2.2	2.4	7.0	0.3	3.4	1.5	2.4
<i>Pomadasys commersonni</i> (679)	x	-	-	x	-	-	0.1	x
<i>Lethrinus harak</i> (701)	-	-	-	-	0.2	-	-	-
<i>Acanthopagrus berda</i> (707)	0.1	0.1	0.4	x	3.6	0.1	0.1	0.1
<i>Cridens cridens</i> (732)	-	-	x	-	1.3	-	-	-
<i>Liza macrolepis</i> (886)	0.1	7.8	x	-	0.1	1.0	0.4	-
<i>Polydactylus sextarius</i> (900)	0.4	-	0.3	20.1	0.1	1.3	1.2	2.7
<i>Siganus canaliculatus</i> (901)	-	-	-	-	-	0.1	-	0.1
<i>Gobius nebulosus</i> (917)	1.1	1.6	3.2	0.3	x	1.1	6.9	4.9
<i>Parachaeturichthys polynema</i> (920)	-	-	x	0.5	0.4	-	-	-
<i>Trypanchm microcephalus</i> (937)	3.8	1.3	3.9	0.8	-	1.1	0.1	0.5
<i>Bufo</i> sp. (940)	0.8	0.4	0.4	0.2	0.7	0.8	-	x
<i>Petrosciartes breviceps</i> (960)	-	-	-	-	0.2	-	-	-
<i>Platycephalus indicus</i> (1063)	-	-	-	0.2	0.1	-	x	x
<i>Platycephalus crocodilus</i> (1064)	-	-	0.1	2.1	1.3	1.4	0.5	4.4

X : Present but less than 0.1 per 15 mins.

- : Not recorded.

given for eight areas. These catch rates cannot be considered as truly reflecting abundance because the sampling gear used, being a trawl net, was only coincidentally capturing such pelagic species as *Stolephorus commersonii*, *Hilsa kelee* and *Liza macrolepis*. However, what the table does show in relation to these species, is that, for example, *H. kelee* is probably more abundant in the vicinity of the Umbeluzi River while *S. commersonii* is about seven times more abundant in the Machangulo area than anywhere else in Delogo Bay.

Among the invertebrates caught in the sampling net used, the penaeids were by far the most abundant group. However, at times the sergestid shrimp *Acetes erythraeus* was so abundant that literally sackfulls were caught in relatively short drags. This small crustacean is much sought after by the local African populations who fish on the intertidal mudflats of the Espírito Santo Estuary during the ebbing tide (de Freitas 1966).

Other Crustacea commonly found were the mangrove crab *Scylla serrata* and the portunids *Portunus pelagicus* and *P. sanguinolentus*. These three species have some commercial value, *S. serrata* being specifically exploited by local fishermen using hoopnets and supplying the local market. *Charybdis cruciata* is also fairly common but seldom reaching a size larger than 90-99 mm in carapace width (Morais 1972).

Life Cycle

When describing the life cycle of the Penaeidae it is essential to separate the shallow-water or shelf Penaeidae from the deep-water or oceanic Penaeidae. The shelf Penaeidae constitute the bulk of the economically important species in the main prawn fishery areas of the world. For this reason most of the research effort on penaeids is directed on the shallow-water species and has resulted in fairly detailed knowledge of the life history of many species (Dakin 1938; Hudinaga 1942, Joyce & Eldred 1966; Moffet 1967).

The life cycle of many of the known shelf penaeids seems to follow the same pattern and in general consists of an oceanic and an estuarine or comparable brackish environment phase (Fig. 1-8). Mating occurs at sea, usually at night and in most species between a freshly moulted

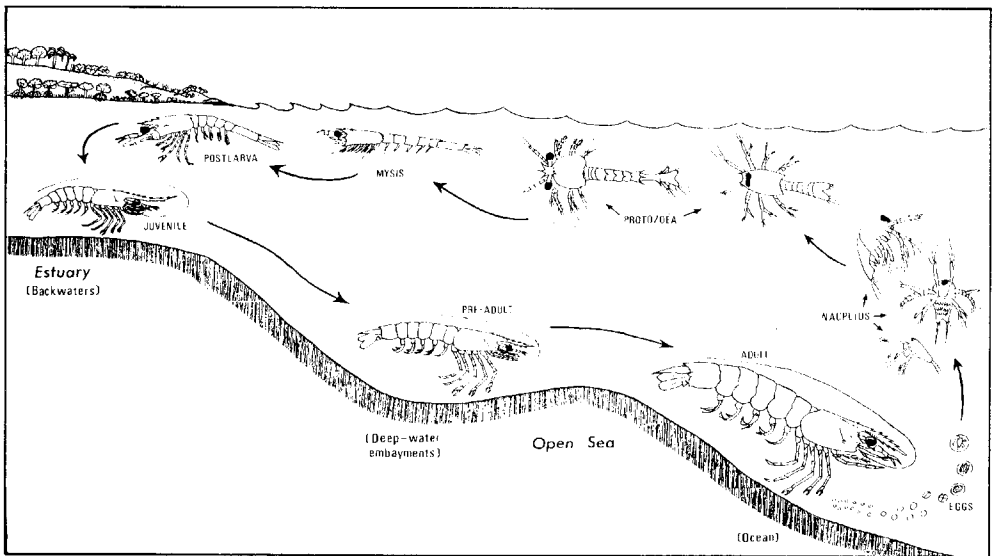


Fig. 1-8 The life-cycle of a typical shelf penaeid prawn.

female and a hard-shelled male (Hudinaga 1942). During mating, the male transfers the spermatophore (a sac-like structure containing the spermatozoa) to the thelycum or female genitalia. Mating occurs at random and immature females may frequently be impregnated. Should the females not be ready to spawn, the spermatophore is shed when next she moults (Eldred 1958).

In most shelf penaeids, spawning occurs at sea at distances and depths which vary according to the species. The eggs and spermatozoa are simultaneously discharged into the water where fertilization occurs (Hudinaga 1942) because, among the Penaeidae, the females do not carry their eggs as is generally the case with most crustaceans. The fertile eggs are demersal and hatch, within 14 to 24 hours, into the first larval stage or *nauplius*. There are several moults within the nauplius stage before they metamorphose to the next larval stage known as the *protozoa*. Again there are several moults before the emergence of the *mysis* and after a few moults the mysis finally metamorphose into the last larval stage known as the *postlarval* stage.

The first three larval stages are planktonic in habit and are therefore at the mercy of water movements whether they be influenced by the winds, tides or ocean currents. In the late mysis or early postlarval stage some individuals will have found themselves taken by the current, winds and tides into the shelter of bays, estuaries or river mouths. During the larval stages there is a high rate of mortality due to predation and other causes and it has been said that larval forms that do not reach the backwater environments perish (Johnson & Fielding 1956).

In these brackish backwater environments or penaeid nursery areas, the postlarvae become omnivorous bottom feeders, feeding voraciously on epiphytic algae, small worms, crustacea and molluscs as well as decomposing matter. The post larvae soon change into juveniles and during the next three to four months grow rapidly until they are finally large enough to once again migrate out to deep water where they become adults, gradually maturing sexually, and finally reach the spawning grounds.

According to Kutkuhn (1966) there is "... appreciable variation... among the commercial Penaeidae of the world, both in the degree to which each species utilizes an estuarine-type environment during its life history and in the distribution of its parent population along the brackish-marine gradient of the littoral zone at the sea's edge." The eastern Australian species *Metapenaeus mastersii* apparently completes its life cycle totally within an estuary (Morris & Bennett 1951).

On the other hand, deep-water species of Penacoidea (e.g. *Plesiopenaeus edwardsianus*) are believed to undergo their entire development in the depths of the open sea (Kutkuhn 1966), but very little is known about the life history of these species. Some work has been done on the larval forms of *Aristeus antennatus* and *Aristaeomorpha foliacea* by Heldt (1955) and *Pleoticus robustus* is receiving some attention although the larval forms are unknown (Anderson & Lindner 1971). Off the southeast coast of Africa several deep-water penaeoids are known but only one, *Haliporoides triathrus vnirio*, has some economic value. For this reason a preliminary study of its biology was undertaken by Berry *et al* (1975).

Taxonomic Criteria and Key

Taxonomic criteria

In the process of identifying many of the specimens collected in southeast African waters, the task was made more difficult because certain important features were not mentioned in the descriptions consulted. This left one uncertain as to whether the omission meant that the particular features was actually not present or whether it was simply not considered by the worker. To overcome this problem I have adopted the system of mentioning, in every species described, all

the same features and stating whether they are present or absent. This makes for easier comparison.

The morphological features most widely used in taxonomic differentiation of the Penaeoidea are the rostrum, carapace, antennular flagella, scaphocerite, third maxilliped, pereopods, abdomen, telson and the male and female genitalia as well as the appendix masculina in the male (Fig. I-9). The terminology followed is basically that elaborated by Kubo (1949) and modified by Pérez Farfante (1969, 1971, 1977).

All measurements are given in millimetres and the length of the specimens examined refer to the carapace length which is measured from the orbital margin to the posterior dorsal margin of the carapace. The spelling of the generic names of the species follow Opinion 864 of the International Commission for Zoological Nomenclature (1969), which was based on the proposals of Holthuis (1962). Pérez Farfante (1977) proposed elevating the former four subfamilies of the family Penaeidae (Superfamily Penaeoidea) and consequently, the former subfamilies to the rank of families. This system has been adopted in this work. Finally, due to the extensive material of the Genus *Penaeus*, available to her, Pérez Farfante (1969) was able to evaluate the inter-relationships between the various species. Consequently she expressed the supra-specific relationships by proposing four subgenera, namely *Melicertus*, *Fenneropenaeus*, *Litopenaeus* and *Penaeus s.s.* In the following key, subgenera are not taken into account but mention will be made of these taxa when the genus *Penaeus* is dealt with, in Part IV of this series.

Fig. I-9. Features used in penaeoid taxonomy.

A. *Carapace*: 1 = epigastric tooth; 2 = dorsal rostral teeth; 3 = ventral rostral teeth; 4 = postocular sulcus; 5 = gastrofrontal sulcus and carina; 6 = orbital spine; 7 = gastro-orbital carina; 8 = postorbital spine; 9 = antennal spine; 10 = orbito-antennal sulcus; 11 = branchiostegial spine; 12 = antennal carina; 13 = pterygostomial angle; 14 = hepatic sulcus and carina; 15 = hepatic spine; 16 = suprahepatic spine; 17 = cervical sulcus and carina; 18 = posthepatic carina; 19 = submarginal carina; 20 = transverse suture; 21 = branchiocardiac carina; 22 = longitudinal suture; 23 = median sulcus; 24 = postrostral carina; 25 = adrostral sulcus and carina; 26 = suprahepatic carina.

B. *Pterygostomial angle*: a) rounded; b) straight; c) acute; d) spinose.

C. *Antennule*: st = statocyst; styl = stylocerite; es = eye socket; ps = parapenaeid spine; dl = distolateral spine; pts = prosartema; mf = mesial flagellum; lf = lateral flagellum.

D. *Scaphocerite*: bc = basicerite; bs = basicerite spine; cs = carpocerite; af = antennal flagellum; sl = lamella; ds = distolateral spine.

E. *Thelycum*: ap = anterior portion of sternite XIII between fourth pereopods; pp = posterior portion of sternite XIV between fifth pereopods; ptr = posterior thoracic ridge.

F. *Petasma*: dml = dorsomedian lobule; vml = ventromedian lobule; dll = dorsolateral lobule; vll = ventrolateral lobules; vc = ventrocostal; dmp = distomedian projection; prp = proximal process.

G. *Transverse section of petasma*: dml = dorsomedian lobule; vml = ventromedian lobule; mir = median ridge; dll = dorsolateral lobule; lr = lateral ridge; vll = ventrolateral lobule.

H. *Appendix masculina*: am = appendix masculina; bp = basal article of endopodite of pleopod II.

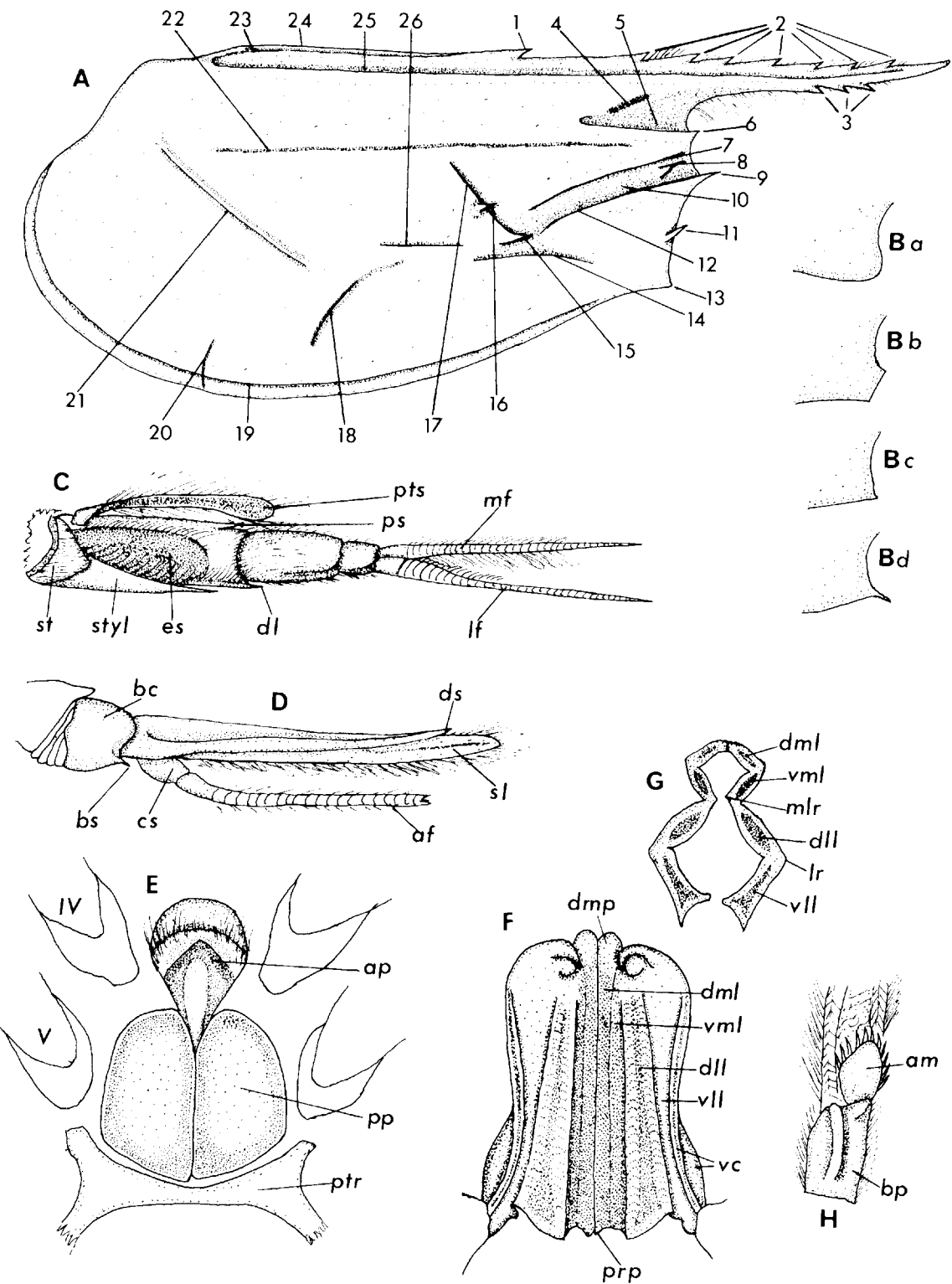


Fig. 1-9 Features used in penaeid taxonomy.

Key to the Southeast African families of the superfamily Penaeoidea

- A. 1) – Postorbital spine absent B
- 2) – Postorbital spine present Solenoceridae
- B. 1) – Exopodites present on second and
 third maxillipeds; endopodites
 present on third to fifth pleopods C
- 2) – Exopodites absent from second and
 third maxillipeds; endopodites
 absent from third to fifth pleopods Sicyoniidae
- C. 1) – Prosartema absent or reduced to tuft of
 setae; cervical sulcus reaching or almost
 reaching dorsal midline of carapace D
- 2) – Prosartema well developed; cervical
 sulcus seldom reaching beyond half the
 distance between hepatic spine and
 dorsal midline of carapace Penaeidae
- D. 1) – Mesial antennular flagella very short
 and flattened; three or more dorsal rostral
 and postrostral teeth Aristeidae
- 2) – Both antennular flagella very long
 and filamentous; 1 or 2 dorsal rostral
 and postrostral teeth Benthescymidae

Key to the Genera and Species of the Family BENTHESICYMIDAE (Modified from Crosnier, 1978)

- A. 1) – Abdomen dorsally carinated on segment
 6 only; telson truncate B
- 2) – Several abdominal segments dorsally
 carinated; telson pointed D
- B. 1) – Podobranchs present from maxilliped II
 to third pereopod inclusive: antennal
 spine absent Genus *Bentheogennema* Burkenroad, 1936 ... C
- 2) – Podobranchs present on maxilliped II
 only; antennal spine present
 (refer to Kensley 1971) Genus *Gennadas* Bate, 1881
- C. 1) – Telson with 4 pairs of marginal
 spines *Bentheogennema intermedia* (Bate, 1888)
- 2) – Telson with only 1 pair of marginal
 spines (not in S.E. African
 waters) *Bentheogennema pasithea* (de Man, 1907)

- D. 1) – Hepatic spine present; dactyl of fourth and fifth pereopods long, pitted and multiarticulate Genus *Benthonectes* Smith, 1885
 Only one known species *Benthonectes filipes* Smith, 1885
- 2) – Hepatic spine present or absent; dactyl of fourth and fifth pereopods not elongate, pitted or multiarticulate Genus *Benthesicymus* Bate, 1881 ... E
- E. 1) – Dorsal carina of fifth abdominal segment prolonged posteriorly into long spines ... *Benthesicymus tirmizae* Crosnier, 1978
- 2) – Dorsal carina of fifth abdominal segment not prolonged posteriorly into long spine F
- F. 1) – Dorsal carina of fifth abdominal segment terminating in small tooth; width of Maxilliped II merus 0.28 of length *Benthesicymus investigatoris* Alcock & Anderson, 1899
- 2) – Dorsal carina of fifth abdominal segment not terminating in small tooth; width of maxilliped II merus 0.60 of length *Benthesicymus expansus* Kensley, 1977

Key to the Genera and Species of the Family ARISTEIDAE

- A. 1) – Hepatic spine present B
 2) – Hepatic spine absent C
- B. 1) – Rostrum with more than 3 dorsal teeth; well developed epipodite on fourth pereopod; no movable spine on merus of first and second pereopods; exopodites absent from all pereopods Genus *Aristaeomorpha* Wood Mason, 1891
 Only one species in southeast African waters *Aristaeomorpha foliacea* (Risso, 1827)
- 2) – Rostrum with 3 or less dorsal teeth; epipodite on fourth pereopod absent or, if present, very reduced; movable spine present on merus of first and second pereopods; small rudimentary exopodites present on all pereopods Genus *Hepomadus* Bate, 1881
 Only one species known, but as yet not found in the study area *Hepomadus tener* Bate, 1881
- C. 1) – Epipodite of fourth pereopod well developed; well developed podobranch on third pereopod; cervical sulcus well developed Genus *Plesiopenaeus* Bate, 1881 ... D
- 2) – Epipodite of fourth pereopod minute or lacking; podobranch on third pereopod small or lacking E
- D. 1) – Third abdominal segment dorsally carinated; cervical sulcus distinct, almost reaching dorsum of carapace *Plesiopenaeus edwardsianus* (Johnson, 1867)
- 2) – Third abdominal segment not dorsally carinated; cervical sulcus indistinct, and very short ... *Plesiopenaeus nitidus* Barnard, 1947
- E. 1) – Podobranch lacking on third pereopod; exopodites absent from all pereopods F
- 2) – Podobranch on third pereopod present but small; exopodites present on all pereopods Genus *Hemipenaeus* Bate, 1881
 (as yet not found in study area)

- F. 1) – Cervical sulcus short and indistinct except for basal part Genus *Aristeus* Duvernoy, 1840... G
- 2) – Cervical sulcus well defined and reaching or almost reaching dorsum of carpace Genus *Pseudaristeus* Crosnier 1978
Only one species as yet found
in S.E. Africa *Pseudaristeus sibogae* (de Man 1911)
- G. 1) – Movable spine at distal end of merus of first 3 pereiopods; integument irregularly pubescent *Aristeus virilis* (Bate, 1881)
- 2) – Movable spine at distal end of merus of first 2 pereiopods only; integument glabrous H
- H. 1) – Carpus of fifth pereiopod with less than 10 photophores *Aristeus mabahissae* Ramadan, 1938
(not known from S.E. Africa)
- 2) – Carpus of fifth pereiopod with more than 10 photophores I
- I. 1) – Chela of first pereiopod much longer than carpus; carpus of fifth pereiopod with more than 50 photophores *Aristeus antennatus* (Risso, 1816)
- 2) – Chela of first pereiopod equal to or just longer than carpus; carpus of fifth pereiopod with 10 to 30 photophores *Aristeus semidentatus* Bate, 1881

Key to Genera and Species of the Family SOLENOCERIDAE

- A. 1) – Telson with a pair of fixed lateral spines only B
- 2) – Telson with one or more pairs of movable lateral spines anterior to fixed pair Genus *Haliporus* Bate, 1881... H
- B. 1) – Antennular flagella with concave inner surface Genus *Solenocera* Lucas, 1849... I
- 2) – Antennular flagella subcylindrical or dorsal subcylindrical and ventral flattened C
- C. 1) – Branchiocardiac carine present D
- 2) – Branchiocardiac carina absent F
- D. 1) – Branchiostegal spine present; epigastric and first rostral teeth separated from remaining teeth by long interval Genus *Hymenopenaeus* Smith, 1882
Only one species so far recorded in S.E. African waters *Hymenopenaeus halli* Bruce, 1966
- 2) – Branchiostegal spine absent; epigastric tooth and first rostral tooth separated by interval equal to or slightly greater than that between first and second rostral teeth E

- E. 1) – Suprahepatic spine present; second abdominal segment not carinated; ventral margin or rostrum concave; rostrum very broad with ventral teeth Genus *Haliporoides* Stebbing, 1914
Only one species so far recorded in S.E. Africa *Haliporoides triarthrus vniroi* Crosnier, 1978
- 2) – Suprahepatic spine absent; second abdominal segment not carinated; ventral margin of rostrum strongly convex Genus *Cryptopenaeus* de Freitas, 1979
Only one known species so far *Cryptopenaeus catherinae* de Freitas, 1979
- F. 1) – Orbital spine absent Genus *Hadropenaeus* Pérez Farfante, 1977
(Not known from S.E. Africa)
- 2) – Orbital spine present G
- G. 1) – Submarginal carina present; antennular flagella subcylindrical, similar and longer than carapace Genus *Pleoticus* Bate, 1888
(Not known from S.E. Africa)
- 2) – Submarginal carina absent; antennular flagella dissimilar, dorsal flagella subcylindrical, ventral flagella depressed Genus *Mesopenaeus* Pérez Farfante, 1977
Only one species so far recorded in S.E. Africa *Mesopenaeus mariae* Pérez Farfante & Ivanov, 1982
- H. 1) – Antennal spine prominent with short carina; no podobranch on third maxilliped; only branchiocardiac carina present behind cervical sulcus *Haliporus taprobanensis* Alcock & Anderson, 1899
- 2) – Antennal spine absent, rudimentary podobranch on third maxilliped; 3-4 lateral carinae present behind cervical sulcus *Haliporus villosus* Alcock & Anderson, 1894
(Not known from S.E. Africa)
- I. 1) – Pterygostomian angle spinose J
- 2) – Pterygostomian angle rounded, lacking spine L
- J. 1) – Postrostral carina continuous behind cervical sulcus; more than 2 teeth behind orbital margin of carapace K
- 2) – Postrostral carina absent behind cervical sulcus; only 2 teeth behind orbital margin of carapace *Solenocera comata* Stebbing, 1915
- K. 1) – Cervical carina with shallow notch slightly behind hepatic spine *Solenocera africana* Stebbing, 1917
- 2) – Cervical carina without notch *Solenocera algoensis* Barnard, 1947
- L. 1) – Postrostral carina high, forming laminose crest which continues behind cervical sulcus *Solenocera choprai* Nataraj, 1945
- 2) – Postrostral carina not forming laminose crest M
- M. 1) – Anterior end of hepatic carina curves backwards in 'U'-shape N
- 2) – Anterior end of hepatic carina not 'U'-shaped O
- N. 1) – Six or seven dorsal rostral and postrostral teeth; ventral antennular flagella with less than 60 articles *Solenocera pectinulata* Kubo, 1949
(Not known from S.E. Africa)

- 2) – Eight or nine dorsal rostral and postrostral teeth; ventral antennular flagella with more than 50 articles *Solenocera pectinata* (Bate, 1888)
(Not known from S.E. Africa)
- O. 1) – Antennular flagella less than 1.5 times carapace and with less than 60 articles *Solenocera rathbuni* Ramadan, 1938
(Not known from S.E. Africa)
- 2) – Antennular flagella more than 1.5 times carapace and with more than 80 articles *Solenocera waltirensis* George & Muthu, 1970
(Not known from S.E. Africa)

Key to the Genera and Species of the Family PENAEEIDAE

- A. 1) – Rostrum with dorsal and ventral teeth Genus *Penaeus* Fabricius, 1798 ... I
- 2) – Rostrum with dorsal teeth but no ventral teeth B
- B. 1) – Third maxilliped with epipodite; incisor of mandibular palp prolonged into scythe-like process Genus *Funchalia* Johnson, 1867
Only one species in S.E. Africa *Funchalia villosa* Bouvier, 1905
- 2) – Third maxilliped without epipodite; incisor of mandibular palp not prolonged in long scythe-like process C
- C. 1) – Carapace with transverse or longitudinal suture; latter may or may not reach posterior margin of carapace D
- 2) – Carapace without horizontal or longitudinal sutures E
- D. 1) – Longitudinal sutures reaching posterior margin of carapace; branchiostegal spine present; short transverse suture present just above second pereopod; telson with 1 pair of fixed subapical spines Genus *Parapenaeus* Smith, 1885 ... O
- 2) – Longitudinal sutures usually falling conspicuously short of posterior margin of carapace (in *P. hardwicki* length 1/10); branchiostegal spine absent; telson with no fixed subapical spines Genus *Parapenaepsis* Alcock, 1901 ... P
- E. 1) – Parapenaeid spine present, either well developed or small; pterygostomial angle with distinct spine; telson with fixed pair of subapical spines as well as movable marginal spinnules F
- 2) – Parapenaeid spine absent; pterygostomial angle may be subacute but distinct spine absent; telson with no fixed subapical spines but 3 or more pairs of movable marginal spines present G

- F. 1) – Basipodite of third maxilliped with strong spine; orbital spine present; abdomen dorsally carinated on segments 2 to 6; carina on segment 2 short and almost indistinct; petasma asymmetrical Genus *Metapenaeopsis* Bouvier, 1905 ... Q
- 2) – Basipodite of third maxilliped without spine; orbital spine absent; abdomen dorsally carinated on segments 4 to 6; petasma symmetrical Genus *Penaeopsis* Bate, 1881 ... T
- G. 1) – Exopodites present on first to fourth or fifth pereopods; orbital spine present but small; telson with well developed median sulcus; abdomen dorsally carinated on segments 4 to 6 at least; antennal carina well developed; distal apex of petasma not extended to form long stiletto-like processes H
- 2) – Exopodite present on first pereopod only; orbital spine absent; telson with no median sulcus; abdomen dorsally carinated from posterior half of fifth to sixth only; antennal carina absent; distal apex of petasma extended to form long stiletto-like processes reaching buccal region Genus *Macropetasma* Stebbing, 1914
Only one known species *Macropetasma africanus* (Bals, 1913)
- H. 1) – Fifth pereopods with exopodites; basipodites of only first and second pereopods with strong spine; abdomen dorsally carinated on segments 2 to 6, carina on segment 2 small and tubercle-like; short transverse suture present, just dorsal to third pereopods Genus *Trachypenaeus* Alcock, 1901 ... U
- 2) – Fifth pereopods without exopodites; basipodites of first to third pereopods with strong spines; abdomen dorsally carinated on segments 4 to 6; transverse suture lacking Genus *Matapenaeus* Wood Mason 1891 ... V
- I. 1) – Adrostral sulcus well developed but usually not completely reaching posterior margin of carapace; rostrum with 3 or more ventral teeth; gastrofrontal carina absent M
- 2) – Adrostral sulcus well developed, usually reaching or almost reaching posterior margin of carapace; rostrum with 1 or 2 ventral teeth; gastrofrontal carina present J
- J. 1) – Postrostral carina lacking median sulcus *Penaeus marginatus* Randall, 1840
- 2) – Postrostral carina with distinct median sulcus K
- K. 1) – Telson with no lateral spines *Penaeus canaliculatus* Olivier, 1811
- 2) – Telson with 3 pairs of lateral spines L
- L. 1) – In female, seminal receptacle of thelycum with single ventral plate and anterior opening. In male, dorsomedian lobules of petasma thickened distally forming fleshy protruberance bent into petasma as hoodlike structure *Penaeus japonicus* Bate, 1888
- 2) – In female, seminal receptacle of thelycum with 2 ventral plates and ventral opening. In male, dorsomedian lobules of petasma not forming fleshy

- protruberance distally nor bent into petasma
as hook-like structure *Penaeus latisulcatus* Kishinouye, 1900
- M. 1) – Hepatic carina absent *Penaeus indicus* Milne-Edwards, 1837
2) – Hepatic carina present N
- N. 1) – Hepatic carina horizontal; postrostral
carina with no median sulcus; exopodite
absent from fifth pereopod *Penaeus monodon* Fabricius, 1798
2) – Hepatic carina anteroventrally inclined;
postrostral carina with distinct but shallow
median sulcus; exopod of fifth pereopod present
but very reduced in size *Penaeus semisulcatus* de Haan, 1849
- O. 1) – Rostrum reaching well beyond first antennular article;
telson longer than sixth abdominal segment;
branchiostegal spine marginal and just above
pterygostomial angle *Parapenaeus fissurus* (Bate, 1881)
2) – Rostrum just reaching end of first antennular
article; telson shorter than sixth abdominal
segment; branchiostegal
spine submarginal *Parapenaeus investigatoris* Alcock & Anderson, 1899
- P. 1) – Epigastric tooth lacking; epipodites absent
from all pereopods; telson lacking subapical
or marginal spines *Parapenaeopsis acclivirostris* Alcock, 1905
2) – Epigastric tooth present; epipodites present
on first and second pereopods; telson with 4 pairs
of movable marginal spines *Parapenaeopsis atlantica* Balss, 1914
- Q. 1) – Dorsal carina of third abdominal segment
with distinct median sulcus *Metapenaeopsis mogiensis* (Rathbun, 1902)
2) – Dorsal carina of third abdominal segment
with no median groove R
- R. 1) – Parapenaeid spine minute, difficult
to find *Metapenaeopsis hilarula* (de Man, 1911)
2) – Parapenaeid spine long S
- S. 1) – Telson considerably shorter than sixth
abdominal segment *Metapenaeopsis quinquedenta* (de Man, 1907)
2) – Telson longer than sixth abdominal
segment *Metapenaeopsis philippii* (Bate, 1881)
- T. 1) – Rostrum straight or sinuous and long,
reaching or over-reaching distal end of third
antennular article; branchiocardiac carina with anterior
end very close to hepatic sulcus; apex of anterior
portion of thelycum rounded *Penaeopsis jerryi* Pérez Farfante, 1979
(Not known from S.E. Africa)
2) – Rostrum arched and short, not surpassing midlength
of second antennular article; branchiocardiac
carina with anterior end not approaching hepatic
sulcus; apex of anterior portion
of thelycum pointed *Penaeopsis balssi* Invanov & Hassan, 1976
- U. 1) – Antennular flagella as long as basal article of
antennular peduncle. In males, distolateral horns of
petasma broad with apices not curved forward. In

- female, posterior portion of thelycum consisting of single transverse plate *Trachypenaeus curvirostris* (Stimpson, 1860)
- 2) – Antennular flagella longer than basal article of antennular peduncle in males, distrolateral horns of petasma narrow with apices forwardly curved. In female, posterior portion of thelycum 'U'-shaped not consisting of single transverse plate *Trachypenaeus sedili* Hall, 1961
- V. 1) – Branchiocardiac carina present; postrostral carina almost reaching posterior margin of carapace; ischial spine on first pereopods; integuments irregularly pubescent *Metapenaeus monoceros* (Fabricius, 1798)
- 2) – Branchiocardiac carina absent; postrostral carina terminating just behind epigastric tooth; no ischial spine on first pereopods; integuments essentially glabrous *Metapenaeus stebbingi* Nobili, 1904

Key to the Species of Genus *Sicyonia* Milne-Edward, 1837 Family SICYONIIDAE

- A. 1) – No spines on abdominal sterna; 2 teeth behind orbital margin of carapace B
- 2) – Well developed spines on sterna of abdominal segments 1 to 5; 5 to 7 teeth behind orbital margin of carapace *Sicyonia lancifera* (Olivier, 1811)
- B. 1) – Rostrum apically acute *Sicyonia longicauda* Rathbun, 1906
- 2) – Rostrum apically truncate *Sicyonia truncata* Kubo, 1949
(Not known from S.E. Africa)

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