indicative of an offshore migration of females for the purpose of spawning during autumn and winter. However, although this is possible, the facts, including the predominance of impregnated females during summer, within Maputo Bay, seems to favour the idea that a considerable degree of spawning occurs during most of the year, within the Bay. The scarcity of impregnated females on the other hand may favour migration.

The fact that the period of spawning activity is so long may indicate that a mature female spawns repeatedly during her lifetime. This could explain the presence, in the population, of large females (Lc = 39-40 mm and larger) with undeveloped ovaries (Stage I) (Fig. III-29). These are very probably females with ovaries in the process of regeneration after spawning.

No work on the planktonic larval forms was carried out in Mozambique. It is therefore impossible to claim with any certainty that *M. monoceros* spawns within Maputo Bay, in spite of the evidence given above. Panikkar and Aiyar (1939) did suggest that *M. monoceros* bred in the backwater areas and Menon (1951) states that "Penaeid prawns with the exception of *M. stebbingi* and *M. monoceros* breed, as far as is known, only in the sea." This implies that *M. monoceros* may breed in backwater areas. However, George and George (1964) claim that "... the presence of mature adults in a sand area at a depth of 50 to 60 metres off Cochin points to this as a possible spawning ground."

In September 1972 off Moma in central Mozambique, in catches predominantly of mating *Penaeus indicus*, a considerable number of large *M. monoceros* females measuring Lc = 46-53 mm with ripe ovaries were caught. This is further indication that spawning is not restricted to backwater areas.

As in most penaeids, the larvae of *M. monoceros* are carried into the nursery areas by the ocean currents, winds and tides. Although it is known that late mysis and postlarval stages are found in the plankton of backwaters and estuaries in India (Pannikar & Aiyar 1939; George 1970) and South Africa (Forbes 1986), the full larval development of this species has never been described (George 1968).

Although it is difficult to generalise from the data presented by de Freitas (1986), it seems that *M. monoceros* favours a nursery area: a) which is well sheltered, offering good protection from predators, b) which has a very muddy substratum, rich in organic content, and c) with a wide range of salinity, being able to tolerate fairly fresh water. In a survey of the rivers of Maputo Bay, *M. monoceros* was the only penaeid species regularly found in completely fresh water, as far as 25.1 km from the river mouths.

In Mozambique and in Maputo Bay itself, there is no lack of optimal conditions for nursery areas for *M. monoceros* particularly within the vast mangrove swamps (de Freitas 1984). Along the coast of Natal favourable nursery areas probably do exist but to a far lesser extent than those found further north. In a detailed survey of 62 Natal estuaries south of the Tugela River (Begg 1983), it was shown that *M. monoceros* was found in 58% of the systems, 2.25 times more systems than the second most frequent species, *Penaeus monodon*. Further, in 66.7% of the occasions on which *M. monoceros* occurred with other penaeids, it was the most abundant.

M. monoceros is frequently infected by an, as yet, unidentified bopyrid parasite, probably *Epipenaeon* sp. This crustacean attaches itself to the gills and is more prevalent in summer. Although Tuma (1967) claimed that bopyrid parasitism resulted in arrested gonadal development, this does not seem to be necessarily so with *M. monoceros* because the majority of the parasitised females of Lc = 35-36 mm were found to have ripening or ripe ovaries. Parasitism does not affect the fusion of petasmal halves of the male, but whether or not the testes are influenced is not known.

De Freitas (1966) showed that in Maputo Bay *M. monoceros* started their migration out of the backwater areas when they were about Lc = 12-13 mm. By the time they have reached Lc = 24-25 mm they were found in the deeper channels of the Bay. This agrees with the data collected during 1968-1973 (Fig. III-34) and the findings of Menon (1955) and Crosnier (1965).

Le Reste and Marcille (1976) working in Madagascar with tagged individuals of *M. monoceros* failed to show definite migration patterns as observed with *Penaeus indicus*. However, they state that the reason for this is due to the fact that the tagging was done "... during the dry season when the salinity is homogeneous".

The migration of young adults of *M. monoceros* from the nursery areas to the deeper waters probably occurs during the ebb tides and, in particular, the ebbs of spring tides. Diniz (unpublished data) during a marking experiment showed that young *M. monoceros* released within the Espirito Santo Estuary were found to be recaptured in the open Bay in waves which corresponded with spring tide ebbs. This agrees with the findings of Copeland (1965) who gave evidence that the brown shrimp *Penaeus aztecus* migrated from inshore waters to the sea during ebb tides, usually during the full moon.

If one accepts that there is a certain degree of spawning in offshore areas, particularly in central Mozambique, a north-south 'migration' is made possible by the Mozambique and Agulhas Currents. Inshore counter currents and eddies may result in some of the larvae produced by adults from a particular nursery area being returned to the parental nursery areas for development.

Laboratory observations that *M. monoceros* do not bury themselves completely contrasts with the findings of Hughes (1966). However, it is quite possible that Hughes was confusing *M. monoceros* with *P. japonicus*. To the naked eye these two species are very similar in appearance and in colouring. Also, the description of the nursery area atributed by Hughes (1966) to *M. monoceros*, namely "intertidal pools on sandflats" is typically that found for *P. japonicus* (de Freitas 1986).

George (1959) studied the backwater juvenile population of Cochin during 1952 to 1955 and found a slightly higher percentage of females than males, namely 51.38% of females. Shaikhmahmud and Tembe (1960) for inshore waters in Bombay and Crosnier (1965) off Madagascar also recorded a slight predominance of females in the *M. monoceros* populations (George 1970). This concurs with the data from the backwater areas of Maputo Bay where the female to male ratio is 3:2, slightly favouring the females.

On the other hand, the adult population in the open bay and offshore on the Tugela Bank have a 1:1 ratio.

During the period of the study (1968-1973) *M. monoceros* constituted, on average, 32% of the total commercially caught penaeids in Maputo Bay, 42% of the catch of the Tugela Bank fishery. Miquel (1982) states that, in 1977, this species formed 31% of the commercial catches in Mozambique.

Metapenaeus stebbingi Nobili, 1904

(Fig. III-48)

Metapenaeus stebbingi Nobili, 1904: 229; Nobili, 1906: 15; Burkenroad, 1934a: 33; Barnard, 1950: 599; Dall, 1957: 184; Tirmizi, 1962: 103; Lewinsohn & Holthuis, 1964: 46; Ramamurthy, 1964: 170; Racek & Dall, 1965: 57 (in key); de Freitas, 1972: 5 (in key); Kensley, 1972: 22 (in key); Holthuis, 1980: 29; Miquel, 1982: 120-122; Miquel, 1984: (PEN Metap 22)
Metapeneus stebbingi Alcock, 1906: 50.
Penaeopsis stebbingi De Man, 1911: 9; Tattersall, 1921: 365; Balss, 1927: 221; Gurney, 1927: 228, 233.

Material examined

Mozambique: Maputo Bay, 12♂♂, 10.4-14.8 mm, 10♀♀, 11.4-23.1 mm; Mafamede Island (10 m), 5♀♀, 16.5-23.0 mm; Moma (20 m), 8♀♀, 19.4-27.1 mm, 1♂, 15.8 mm; Ligonha River, 7♀♀, 23.9-29.4 mm; Chinde (22 m), 8♀♀, 21.5-29.2 mm; Macuse (20 m), 3♀♀, 23.8-26.6 mm.

Description

Rostrum: Straight but very slightly curved upwards at tip; reaching a little beyond last article of antennular peduncle; rostral formula 9-10/0; two teeth behind orbital margin of carapace; adrostral sulcus fairly well developed, reaching eipgastric tooth; postrostral carina short, terminating just posterior to epigastric tooth; median sulcus absent.

Carapace: Glabrous except along edges of sulci and a small patch below posterior portion of adrostral sulcus; no gastrofrontal sulcus; postocular sulcus small but clearly defined, arising below adrostral sulcus under second rostral tooth; cervical sulcus well defined, starting below end of adrostral sulcus and runs anteroventrally; cervical carina terminating in fairly prominent hepatic spine; a short and somewhat ill-defined gastro-orbital sulcus; branchiocardiac carina absent; orbital spine small but well developed; antennal carina short but well developed, terminating in very prominent antennal spine; orbito-antennal sulcus restricted to slight depression above antennal carina; no postorbital spine; hepatic carina distinct; hepatic sulcus adjacent to it deep and more or less 'L-shaped' descending vertically from hepatic spine and curving anteriorly to slightly before pterygostomian angle; pterygostomian angle more or less rounded and bears no spine; branchiostegal spine absent; a clear submarginal carina parallel to posterolateral margin of carapace.

Antennule: Flagella about half length of antennular peduncle; prosartema narrow, wider at its base, reaching distal end of first antennular article; stylocerite about half length of basal article of antennular peduncle, terminating in a point; small but sharp spine at distolateral angle of basal article; parapenaeid spine absent.

Scaphocerite: Distolateral spine stops just short of distal end of antennular peduncle; basicerite free of spines.

Mandibular palp: Reaching to base of carpocerite; proximal article 1:1 times as long as wide; ventral surface slightly concave and lightly setose; margins bear long setae; distal article twice as long as proximal article and 1.7 times as long as wide; surface slightly convex and lightly setose; distally tapering to rounded apex.

Maxilliped III: Endopodite reaching about half way along basal article of antennular peduncle; exhibits no sexual dimorphism; exopodite almost reaching distal end of carpus of endopodite; no epipodites present.

Pereiopods: Exopodites present on pereiopods I to IV; epipodites found on first three only; first three basipodites bearing strong spines; none present on ischipodites; ischipodites of fifth pereiopod of females rather flattened; meropodites of males have well developed notch on lower proximal edge; at distal edge of notch there is rounded crest-like projection; coxopodites of fourth pereiopod of females have plate-like dilations which extend over sternite almost reaching ventral midline; third coxopodites have small and less developed dilations; none present in male. Pereiopod III reaching to beyond basal antennular article by half of chela; pereiopod V reaching half way in basal antennular article. Extended laterally lengths of pereiopods in ascending order are: first, fourth, second/third and fifth.

Abdomen: Uniformly glabrous; dorsally carinated from posterior third of fourth segment to tip of sixth where carina terminates in spine; a wavy broken lateral cicatrix on posterior part of fifth and sixth segments.

Telson: Telson is just longer than sixth abdominal segment; about as long as mesial ramus of uropods; dorsal median sulcus wide and deep; telson terminating in long acute point; 6-15 small movable lateral spines present but are often missing leaving distinct notch.

Thelycum: Posterior portion composed of two subquadrate and convex plates rising up from sternite; between these two plates is median process formed from anteromedian projection of sternite between and behind fifth pereiopods. Anterior portion located between fourth pereiopods and between anterolateral extensions of lateral plates of posterior portion; consisting of three small plates normally hidden by dilations of fourth coxopodites; plates

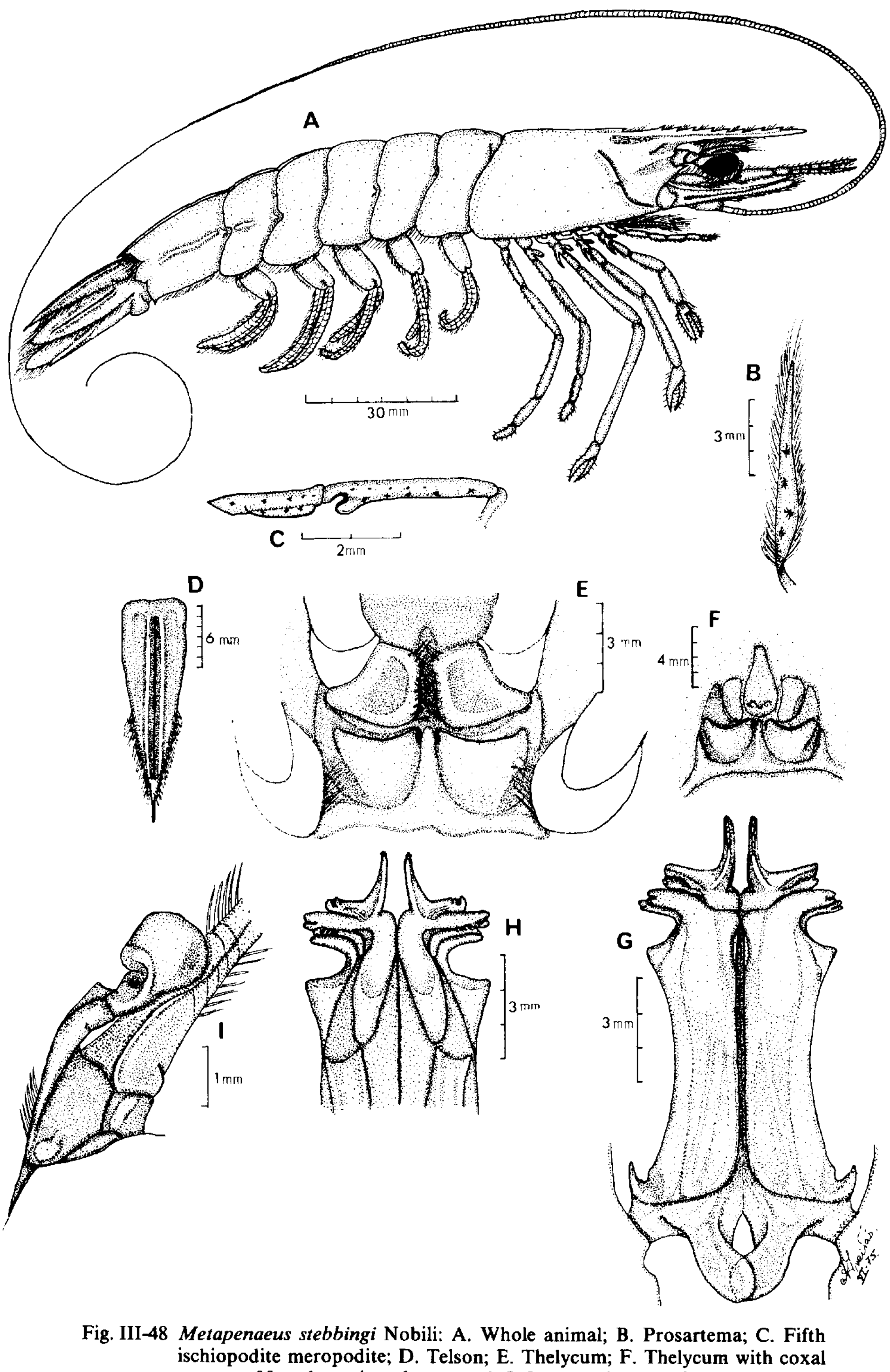

Fig. III-48 *Metapenaeus stebbingi* Nobili: A. Whole animal; B. Prosartema; C. Fifth ischiopodite meropodite; D. Telson; E. Thelycum; F. Thelycum with coxal process of fourth pereiopods removed; G. Petasma (ventral view); H. Petasma (dorsal view of distal end); I. Appendix masculina.

consist of two flattened elongated lateral plates and wider, swollen median plate possessing two slight but distinct tubercles.

Petasma: Involuted pod-like structure with complicated series of distal processes. Dorsomedian lobules very narrow, thin and united along midline. Ventromedian lobules narrower and as long as dorsomedian lobules; together forming furrow deep within petasmal structure; these lobules are best seen from dorsal view. Dorsolateral lobules also best seen from dorsal view; a thickly sclerotinized lobule and apparently divided into anterior and posterior section; posterior section about twice length of anterior section; is narrow distally, broadening out, forming pointed lateral process; it runs proximally, mesial edge broadening out into half rectangular bulge which touches its pair in midline about level of proximal end of median lobes; beyond this point dorsolateral lobule twists forming club-like process; anterior section formed by dorsal subrectangular plate; distally divides into three finger-like processes; first is directed anteriorly while other two project laterally and are difficult to distinguish apart; tips of anteriorly projected process and lower lateral processes bear several tiny tubercles. Ventrolateral lobules very thickly sclerotinized subrectangular plates; distally forming deep lateral notch above which lobules divide into two lateral horn-like processes; proximally lobules have lateral tooth-like process just above point of attachment to exopodite.

Appendix masculina: Club-shaped; shaft of 'club' slender and twisted inwardly; apical surface convex with small tuft of short setae on mesial edge. Basal article of endopodite wide at base with mesial margin projected distally into twisted arm, bearing appendix masculina; article glabrous except for few setae on mesial edge.

Colour in life: Generally a white to cream with numerous brown and blue chromatophores. The antennules are banded while the antennae are a deep reddish-brown. The extremity of the telson and the mesial ramus of the uropods as well as the extremity and outer margin of the lateral uropodal ramus are bright green. All fringing setae are white except those fringing the uropods which are light brown in colour.

Taxonomic status and comments

This species belongs to the *M. monoceros* group because of the structure of the fifth pereiopods of the male. However, it differs from it by being essentially glabrous, by the shortness of the postrostral carina, by the structures of the petasma and thelycum and by the presence of movable marginal spines on the telson (Nobili 1906).

The specimens described here clearly belong to this species although there are some slight differences from the descriptions given by other authors. Both Nobili (1904, 1906) and Tattersall (1921) refer to the presence of six to eight pairs of movable marginal spines on the telson whereas Alcock (1906) mentions only three to four pairs. The specimens examined here have eight to fifteen pairs of marginal spines in agreement with Barnard (1950).

Nobili (1906) describes the notch on the merus of the male as preceded by a tooth and Barnard (1950) also mentioned a "triangular tooth". Tattersall (1921) does not describe the notch and tooth but in his illustration (Plate 26, Fig. 8) the notch is preceded by a keeled dilation rather than a tooth as is seen in *M. monoceros*. All the male specimens examined by myself agree with Tattersall's figure.

Burkenroad (1934a) seems to be correct in pointing out that Tattersall's figures 9 and 12 of Plate 27 have been transposed, as the thelycum of the specimen examined from Mozambique agrees with figure 12 rather than with Tattersall's figure 9.

Distribution (Fig. III-49)

Metapenaeus stebbingi has a limited distribution. It was first recorded from Suez and the Red Sea (Nobili, Tattersall). Subsequently it has been recorded from Egypt — Port Said (Balss); Pakistan — off Karachi (Tirmizi); India — Gulf of Cutch (Ramamurthy);

Mozambique — Mafamede Island, Moma, Ligonha River, Chinde, Macuse, Maputo Bay (Barnard, de Freitas); South Africa — Tugela Bank (de Freitas).

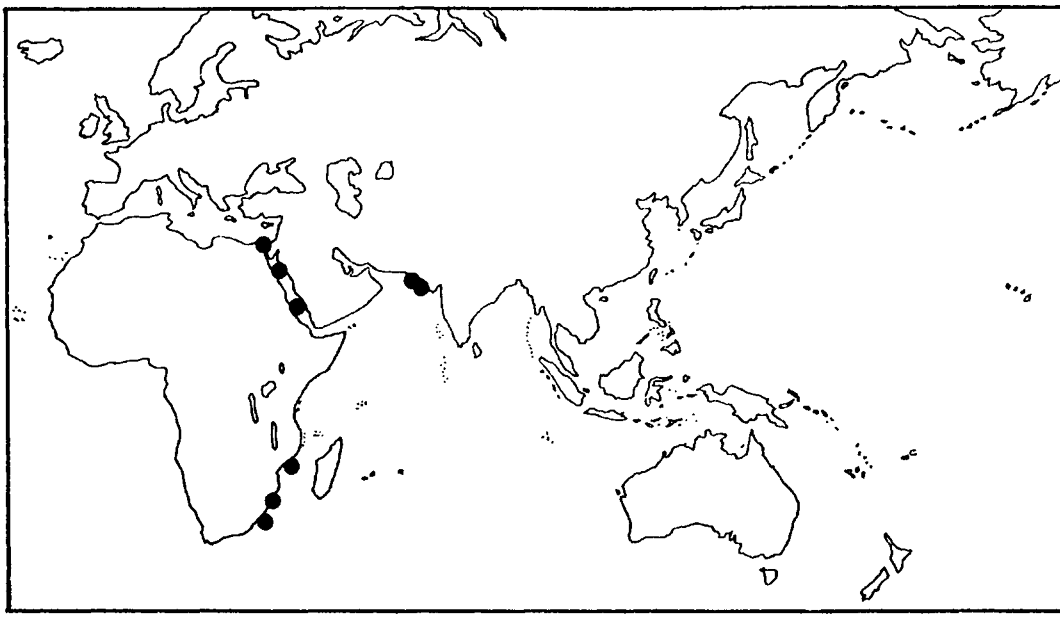

Fig. III-49 Distribution of *Metapenaeus stebbingi.*

Gurney (1927) found penaeid eggs and all larval stages of a penaeid species within the Bitter Lakes of the Suez Canal. By a process of elimination he arrived at the conclusion that they probably belonged to *M. stebbingi.* The presence of eggs indicated that this species actually bred in the Lakes where the adults were also found.

In Maputo Bay juveniles were also found in backwater areas and adults were found in deeper areas although in almost landlocked large bodies of water. Adults have also been found offshore in 3-20 metres of water in central Mozambique and India.

Biology

Metapenaeus stebbingi is a species with limited economic importance as it is seldom found in large quantities. Very little is known on the biology of this species as it has attracted negligible attention from workers. It is very similar in appearance to *M. monoceros* and commercially these two species are probably lumped together. Although it has been found in the offshore fishing grounds, the quantities are small and do not significantly affect the catch statistics of *M. monoceros.*

All the data referring to *M. stebbingi* was collected from sampling stations within Maputo Bay (Fig. III-28) and by frequent and detailed analyses of commercial catches. During the fieldwork for this study a total of 84 091 individuals of this species were caught and 29 938 were analysed in more detail.

No data is available from central Mozambique and *M. stebbingi* is very scarce on the Tugela Bank and, as yet, has not been recorded from the estuaries of Natal.

Reproduction

Maturity: As yet, no study has been made of the anatomy of the male and female reproductive system of *M. stebbingi.* As in other penaeids, the maturation of the ovary is accompanied by distinctive changes in colour and size. No previous studies on ovarian maturation in this species are known and, and up now, the colour changes of the ovary have not been described. From the examination of 12 017 females ranging from carapace length 5 mm to 33 mm the following stages were distinguished:

Stage I:	*Undeveloped*	— Translucent, smooth and threadlike.
Stage II:	*Developing*	— Opaque; cream to light yellow; somewhat distended but surface still smooth.
Stage III:	*Mature*	— Fully distended; lime to light green; finely granular.
Stage IV:	*Ripe*	— Fully distended; green to olive green; individual ova visible.
Stage V:	*Spent*	— Flaccid; lime to light green.

The data collected in Maputo Bay from February 1968 to December 1973, indicates that all females smaller than Lc = 9-10 mm have undeveloped ovaries and that the largest females with undeveloped ovaries measured Lc = 33-34 mm. Most probably those females larger than Lc = 27-28 mm with undeveloped ovaries are individuals with gonads in the process of regeneration after spawning. The smallest females with mature (III), ripe (IV) or spent ovaries were found to measure Lc = 11-12 mm and the majority (50% or more) of females first showed mature or rine ovaries at Lc = 23-24 mm (Fig. III-50).

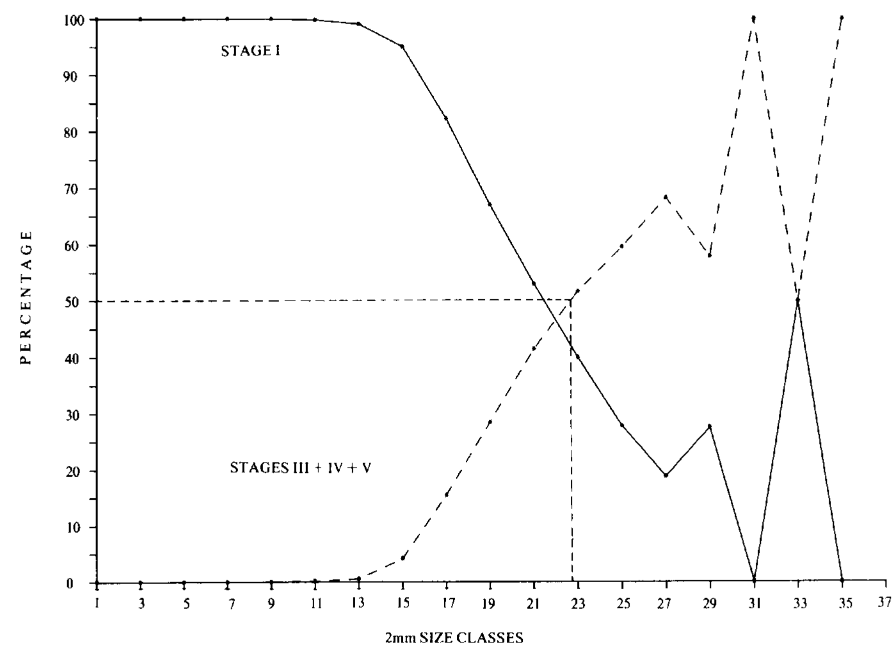

Fig. III-50 Size frequency distribution of *M. stebbingi* females with gonadal stages I and III + IV + V (Maputo Bay 1968-1973).

Unfortunately it is not possible to determine, macroscopically, sexual maturation in the males of this species. Histological studies of the testes of *M. stebbingi* are not known. However, one can indirectly get some idea of the maturation of the male by knowning the size at fusion of the petasmal halves (Tuma 1967).

Of the 7 010 males examined, no individual smaller than Lc = 3-4 mm was ever found to have fused petasmal endopodites. The size at which the majority (50% or more) of the individuals have fused petasmal halves proved to be at Lc = 7-8 mm. All males larger than Lc = 21-22 mm have fused petasmas (Fig. III-51). Of the males found in the backwater areas, 15.4% had unfused petasmas while in the open bay this condition was found on 2.6% of the males.

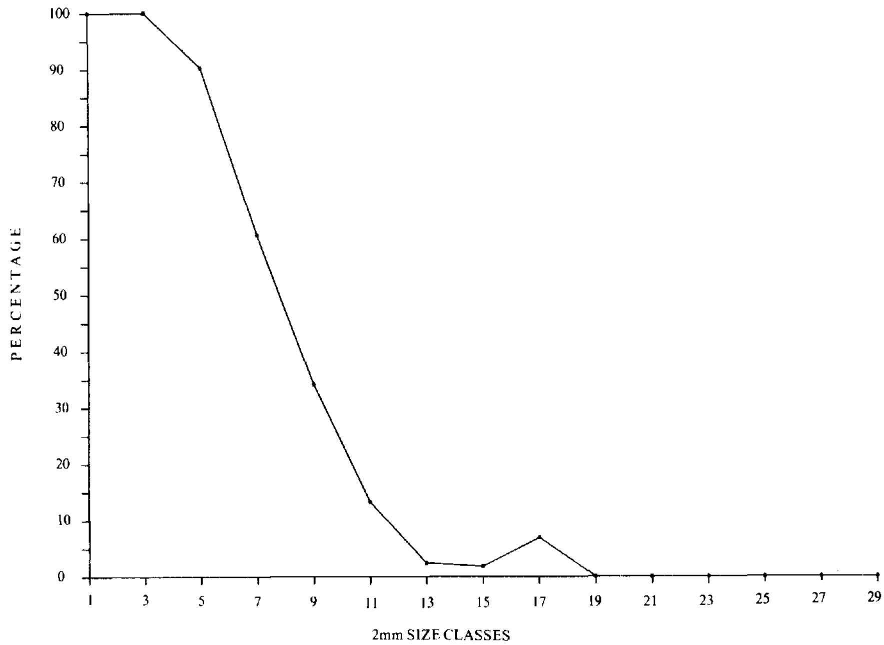

Fig. III-51 Percentage of *M. stebbingi* males within each class with unfused petasmal endopodites (Maputo Bay 1968-1973).

Mating: As in other penaeoids fertilization is external, the sperms being dispensed from the spermatophores as the eggs are shed. The presence of impregnated females and, in particular, the presence of impregnated ripe females could be considered as an index of mating. However, of the 17 934 females sampled only one female of Lc = 21-22 mm was found impregnated, in September 1971.

Spawning: The presence of ovaries in advanced stages of maturation is taken as indication of spawning activity. There seems to be very little variation in the mean monthly size distribution of ripe and spent females. The smallest females found in these advanced maturation stages measured Lc = 11-12 mm and were caught in November, December and January (Fig. III-52). Table III-6 summarises the situation found in Maputo Bay from 1968 to 1973 and sets out the monthly percentage of ripe and spent females in relation to the total number of females as well as in relation to the number of females of Lc = 11 mm and larger, the smallest class of ripe and spent females.

The female population has the highest incidence of spawning during spring and summer, from September to March, when 24.2% to 40.6% of the females of Lc = 11 mm and larger and 22.7% to 33.1% of the total female population were found to be ripe or spent. Of all the females examined only 32 (0.2%) were classified as spent. These measured Lc = 19-29 mm and were found from August to January, with the largest number (11) being caught in October. The highest incidence of spawning females was found in October (Fig. III-53), the number decreasing thereafter to June when only 1.6% of the female population were spawning.

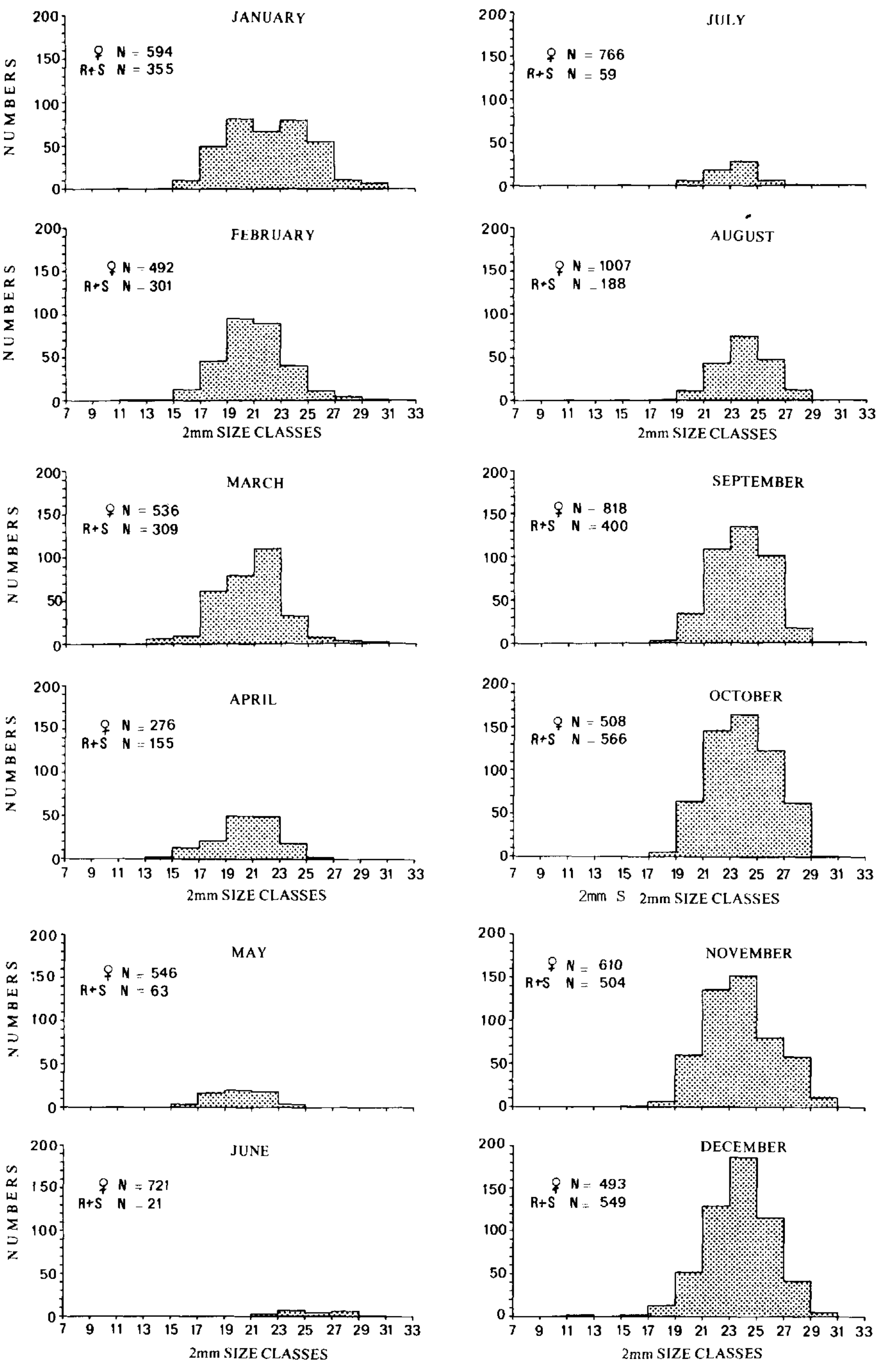

Fig. III-52 Monthly size frequency distribution of ripe + spent females of *M. stebbingi* in Maputo Bay from 1968-1973.

Table III-6 *M. stebbingi.* Monthly percentage of ripe + spent females in relation to total numbers of females and numbers of females larger than Lc = 11mm.

Month	Total No	Individuals > 21 mm		Stages IV + V		% IV + V of Tot.
		No.	%	No.	%	
JAN.	1 562	1 441	92.2	355	24.6	22.7
FEB.	1 255	1 036	82.5	301	29.1	24.0
MAR.	1 366	1 192	87.3	309	25.9	22.6
APR.	909	788	86.7	155	19.7	17.1
MAY	1 150	1 053	81.6	63	6.0	5.5
JUN.	1 338	1 253	93.6	21	1.7	1.6
JUL.	1 617	1 587	98.1	59	3.7	3.6
AUG.	1 922	1 790	93.1	188	10.5	9.8
SEP.	1 718	1 654	96.3	400	24.2	23.3
OCT.	1 632	1 611	98.7	566	35.1	34.7
NOV.	1 808	1 690	93.5	504	29.8	27.9
DEC.	1 657	1 352	81.6	549	40.6	44.1
	17 934	16 447	91.7	3 470	21.1	19.3

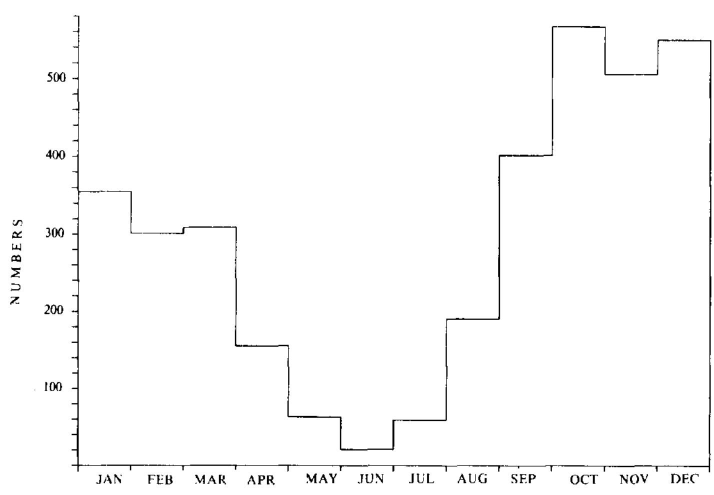

Fig. III-53 Monthly frequency of ripe + spent females of *M. stebbingi* from Maputó Bay (1968-1973).

Nursery areas

No work was carried out in Mozambique on the planktonic stages of *M. stebbingi.* However, Gurney's (1927) study is very complete on this aspect. The Bitter Lakes of the Suez Canal where

Gurney found the eggs, larvae and postlarvae of this species is a fairly protected area with little or no wave action.

In a survey carried out along the northwest margin of Maputo Bay (de Freitas 1986), early juvenile stages of *M. stebbingi* (Lc < 9 mm) were found in only three stations; namely the primary mangal channel with a muddy sand substratum, and on two stations in the swash zone of sandy beaches. In fact this was the only penaeid species found in the two swash zone stations. Of the 49 individuals caught, 61% were caught in the swash zone, where salinities ranged between (16.3‰ — 22.0‰) (de Freitas 1986).

Associated species, predators and parasites

Based on the work done from 1971 to 1973 it appears that the most common penaeid species associated with *M. stebbingi* within Maputo Bay was *Parapenaeopsis acclivirostris, Penaeus indicus* and *M. monoceros.* To a lesser degree, where the adult is concerned, *P. semisulcatus, P. monodon* and *P. japonicus* may compete with *M. stebbingi.*

The goby, *Gobius nebulosus* is probably a common predator of postlarval *M. stebbingi* especially in those nursery areas in the vicinity of mangals and with a muddy sand substratum. Very few fish stomachs were analysed and although remains of penaeids were common, no positive identification of *M. stebbingi* was made.

Although some penaeoids, e.g. *M. monoceros* and *H. triarthrus* are often infected by an unknown bopyrid, none were ever found on *M. stebbingi.*

Schooling

Although some penaeids are believed to form large schools while migrating (Kirkgaard, Tuma & Walker 1970) there is no evidence that *M. stebbingi* behaves in this way at any stage.

Migration

Both male and female *M. stebbingi* smaller than Lc = 8.9 mm were seldom found in the open bay (Fig. III-54). From Lc = 10-11 mm the percentage found in the open bay increased and

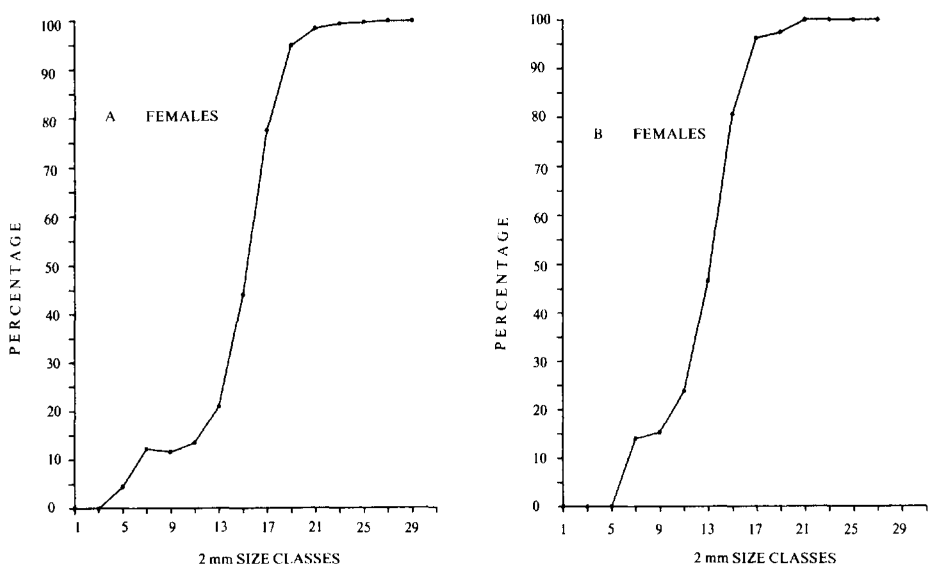

Fig. III-54 Percentage of each size class of *M. stebbingi* found in the open bay areas of Maputo Bay from 1968-1973.

individuals of Lc = 20-21 mm and above were seldom found in backwater areas. The size group which was found 50% in each area was Lc = 16-17 mm for the females and Lc = 12-13 mm for the males.

Burying

Not many individuals were observed in aquaria, but the few juveniles and adults were never seen to bury themselves in the substratum.

Population

Sex ratio: There are no published data on the sex ratio of *M. stebbingi.* The analysis of the Maputo Bay population shows that, of 9 569 individuals examined from the backwater areas, 5 916 (61.8%) were females and 3 652 (38.2%) were males, giving a ratio of 16:10. In the open bay the position changed little, because of 20 369 individuals examined, 12 018 (59.0%) were females while 8 351 (41%) were males; that is a ratio of 14:10.

The monthly variation in the female components as a percentage of the total population in backwater and open bay areas of Maputo Bay is shown in Figure III-55. No information is available for central Mozambique and the scarcity of this species (only two females found) on the Tugela Bank make it impossible to give the sex ratio in this regions.

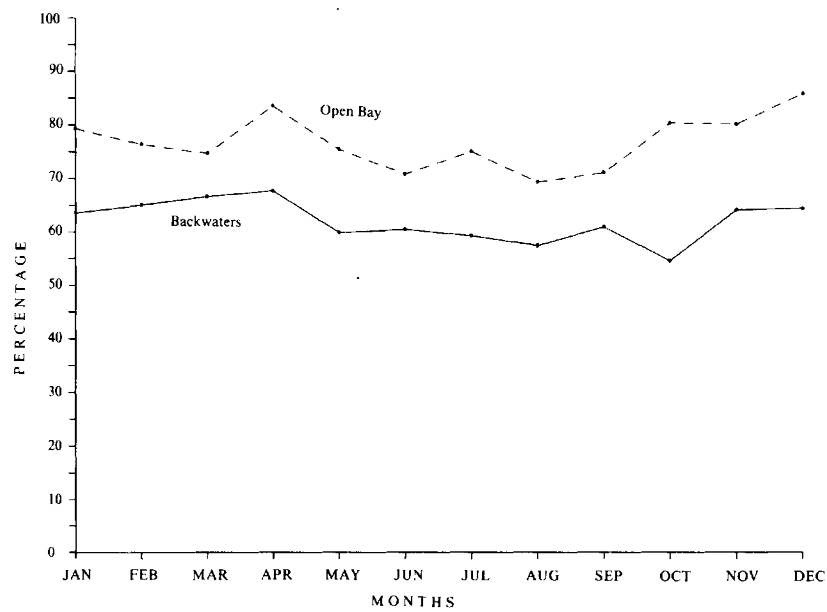

Fig. III-55 Monthly sex ratio of *M. stebbingi* in backwater and open bay areas of Maputo Bay given in percentage of females.

Morphometrics: The carapace length/total length, carapace length/weight and total length/weight relationships were calculated from 1970-1973. All specimens were measured while fresh and no formalinised individuals were used. The range of carapace lengths was from 8.0-28.0 mm in the males and 8.1-31.0 mm in the females.

For the carapace length/total length relationship both the power curve and the straight line relationships were determined. Weight was related to the carapace length as well as to the total length. The carapace lengths and total lengths were measured in mm and weight in grams.

The power curve carapace length (C)/total length (T) relationships were expressed by the equations:

Males: $T = 6.697C^{0.895}$ with $r = 0.982$
Females: $T = 5.666C^{0.947}$ with $r = 0.987$
Sexes combined: $T = 6.115C^{0.924}$ with $r = 0.985$

The straight line carapace length (C)/total length (T) relationships are expressed by the equations:

Males: $T = 4.272C + 11.530$ with $r = 0.977$
Females: $T = 4.515C + 6.122$ with $r = 0.988$
Sexes combined: $T = 4.415C + 8.506$ with $r = 0.985$
with an F value of 19.1, 20.9 and 20.1 respectively.

The carapace length (C)/weight (W) relationships are expressed by the equations:

Males: $W = 1.966 \times 10^{-3}\ C^{2.658}$ with $r = 0.985$
Females: $W = 1.600 \times 10^{-3}\ C^{2.774}$ with $r = 0.994$
Sexes combined: $W = 1.600 \times 10^{-3}\ C^{2.726}$ with $r = 0.991$

The total length (T)/weight (W) relationships are expressed by the equations:

Males: $W = 8.0 \times 10^{-6}\ T^{2.935}$ with $r = 0.991$
Females: $W = 10.3 \times 10^{-6}\ T^{2.887}$ with $r = 0.992$
Sexes combined: $W = 9.1 \times 10^{-6}\ T^{2.910}$ with $r = 0.992$

Size composition: The size composition of the *M. stebbingi* population found in the backwater and open bay areas of Maputo Bay are summarized in Table III-7.

Table III-7 *M. stebbingi.* Average monthly carapace size range and mean carapace length from backwater and open bay stations (1968-1973).

	BACKWATERS				OPEN BAY			
	Male		Female		Male		Female	
Month	Range	Mean	Range	Mean	Range	Mean	Range	Mean
JAN.	7-15	10.7	5-25	12.3	7-25	14.3	5-29	19.4
FEB.	5-15	9.8	5-21	10.5	7-23	12.4	9-29	18.0
MAR.	5-23	9.6	5-19	10.9	9-19	13.1	7-29	18.5
APR.	7-19	10.3	5-15	10.5	9-21	12.8	9-27	18.3
MAY	5-15	10.9	5-19	11.7	11-21	13.5	5-25	17.5
JUN.	7-19	12.3	5-21	13.3	9-27	14.7	7-29	19.1
JUL.	9-17	12.8	7-23	14.4	7-25	15.3	7-29	20.1
AUG.	5-17	11.6	3-25	12.7	7-27	15.2	7-29	20.3
SEP.	7-17	11.8	5-25	13.1	7-25	14.7	7-29	20.7
OCT.	7-19	12.3	5-21	13.6	9-25	15.8	7-29	21.7
NOV.	7-19	11.9	7-25	12.7	9-23	15.8	7-29	21.8
DEC.	7-15	10.7	7-21	11.0	7-23	14.3	5-29	21.4
YEAR	5-23	11.4	3-25	12.3	7-27	14.6	5-29	20.1

In the backwaters the annual average size range for male *M. stebbingi* was Lc = 5-23 mm (Fig. III-56) with an annual mean of Lc = 11.4 mm. The range for females was Lc = 3-25 mm (Fig. III-57) with an annual mean of Lc = 12.3 mm. In the open bay the average annual size range was Lc = 7-27 mm for males (Fig. III-56) and Lc = 5-29 mm for females (Fig. III-57) with the annual mean carapace lengths being Lc = 14.6 mm and Lc = 20.1 mm for males and females respectively.

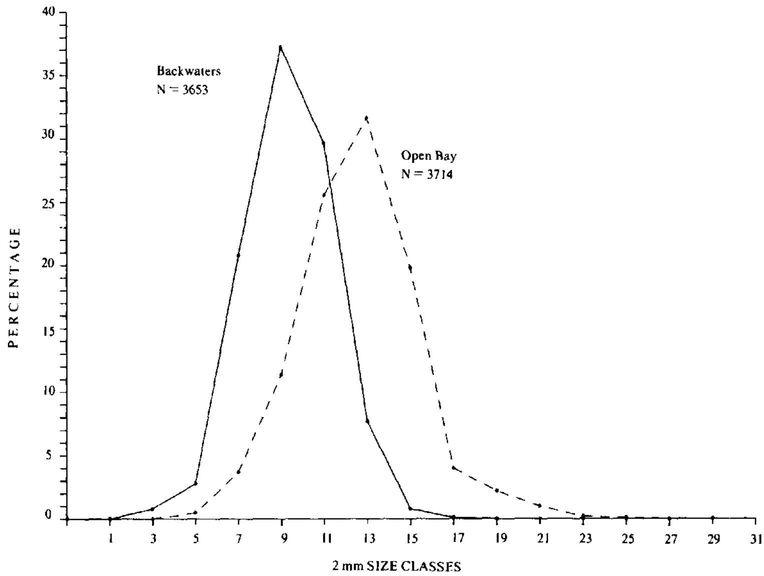

Fig. III-56 Mean annual size distribution of *M. stebbingi* males in backwater and open bay areas of Maputo Bay (1968-1973).

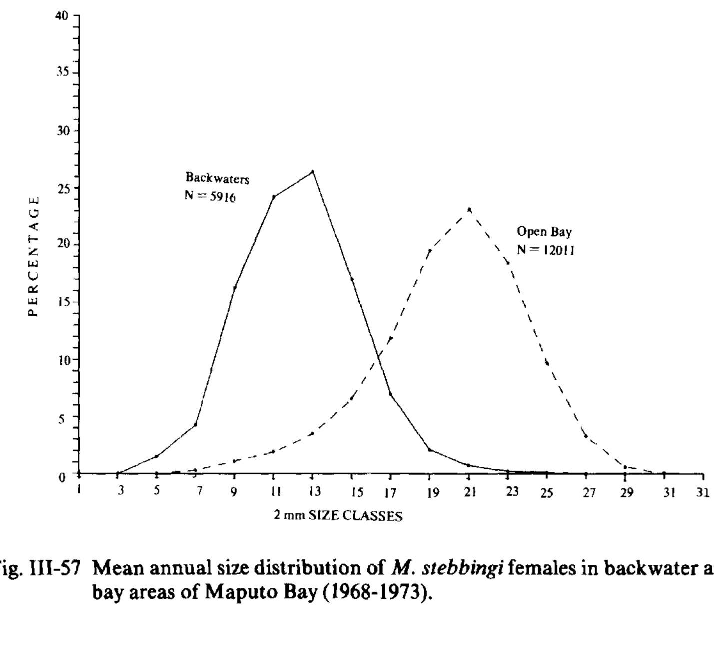

Fig. III-57 Mean annual size distribution of *M. stebbingi* females in backwater and open bay areas of Maputo Bay (1968-1973).

The annual average size group migrating from the backwaters to the bay was constituted of males of Lc = 7-18 mm and females of Lc = 7-23 mm. The size group found 50% in the backwaters and 50% in the open bay, was Lc = 13-14 mm for males and Lc = 15-16 mm for females (Fig. III-54).

The monthly variation in size composition of the male and female populations of the backwaters (Fig. III-58) are composed of individuals of very similar size range, the monthly modes being, almost always, identical. In the open bay (Fig. III-59), however, the males are found in the company of considerably larger females. The male modes vary from Lc = 11-12 mm (February) to Lc = 17-18 mm (October), while the modes of the females vary from Lc = 19-20 mm (January-June) to Lc = 23-24 mm (December).

Abundance

The mean monthly abundance of *M. stebbingi* given in numbers of individuals caught by the sampling net in a 15 minute drag for four backwater areas of Maputo Bay (Table III-8) showed that the most productive area for this species proved to be the Machangulo channels where an annual mean of 49.5 individuals per 15 minutes were caught. The least productive of the four zones was, as with *M. monoceros,* the Xefina Seagrass which yielded on the average 6.3 individuals per 15 minutes.

Table III-8 Monthly abundance of juvenile *M. stebbingi* in four backwater areas of Maputo Bay (1971-1973).

MONTH (1971 — 1973)	Yield in numbers caught per 15 mins.			
	Espirito Santo Estuary	Machangulo	Xefina Sea-Grass	Incomati Estuary
STATION	1, 2, 3, 4, 5, 6	18, 19	7, 8, 13	9, 10, 11, 12, 14
JAN.	31.4	63.6	4.4	17.9
FEB.	56.4	55.7	12.9	66.7
MAR.	57.4	9.0	4.7	44.4
APR.	34.0	22.0	2.8	11.0
MAY	24.2	33.0	7.1	8.1
JUN.	25.6	37.7	7.3	3.9
JUL.	20.1	84.6	1.7	1.8
AUG.	14.0	117.8	3.5	6.6
SEP.	10.1	18.2	5.7	10.1
OCT.	7.3	35.0	4.8	4.1
NOV.	13.3	35.8	4.0	2.7
DEC.	52.8	19.6	19.1	9.5
MEAN	28.8	49.5	6.3	15.9

In a breakdown by sampling stations (Fig. III-60) one sees that station 18, in the Machangulo sack, yielded the best results (89.9 individuals per 15 minutes), followed by station 5, within the Espirito Santo Estuary (58.9 ind./15 min). The poorest results were registered from station 7 which was in an area of muddy sand substratum, partially covered with macrophytes. It is of interest to note that whereas station 10 in the Montanhana River, yielded an average of 520 individuals per 15 minutes of *M. monoceros,* it produced only 5.6 individuals/15 minutes of *M. stebbingi.*

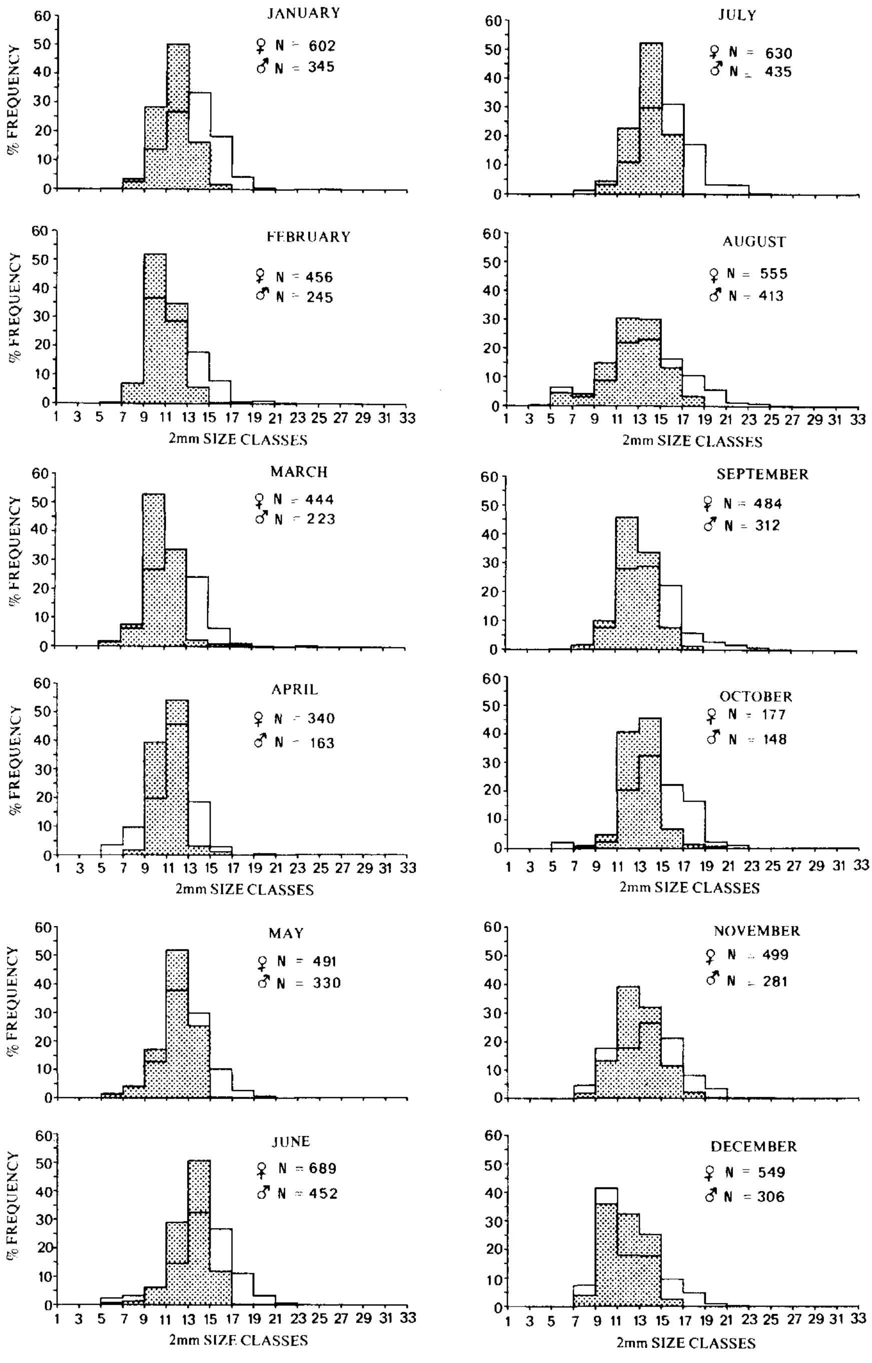

Fig. III-58 Monthly size frequency distribution of *M. stebbingi* males (shaded) and females (unshaded) in backwater stations of Maputo Bay (1968-1973).

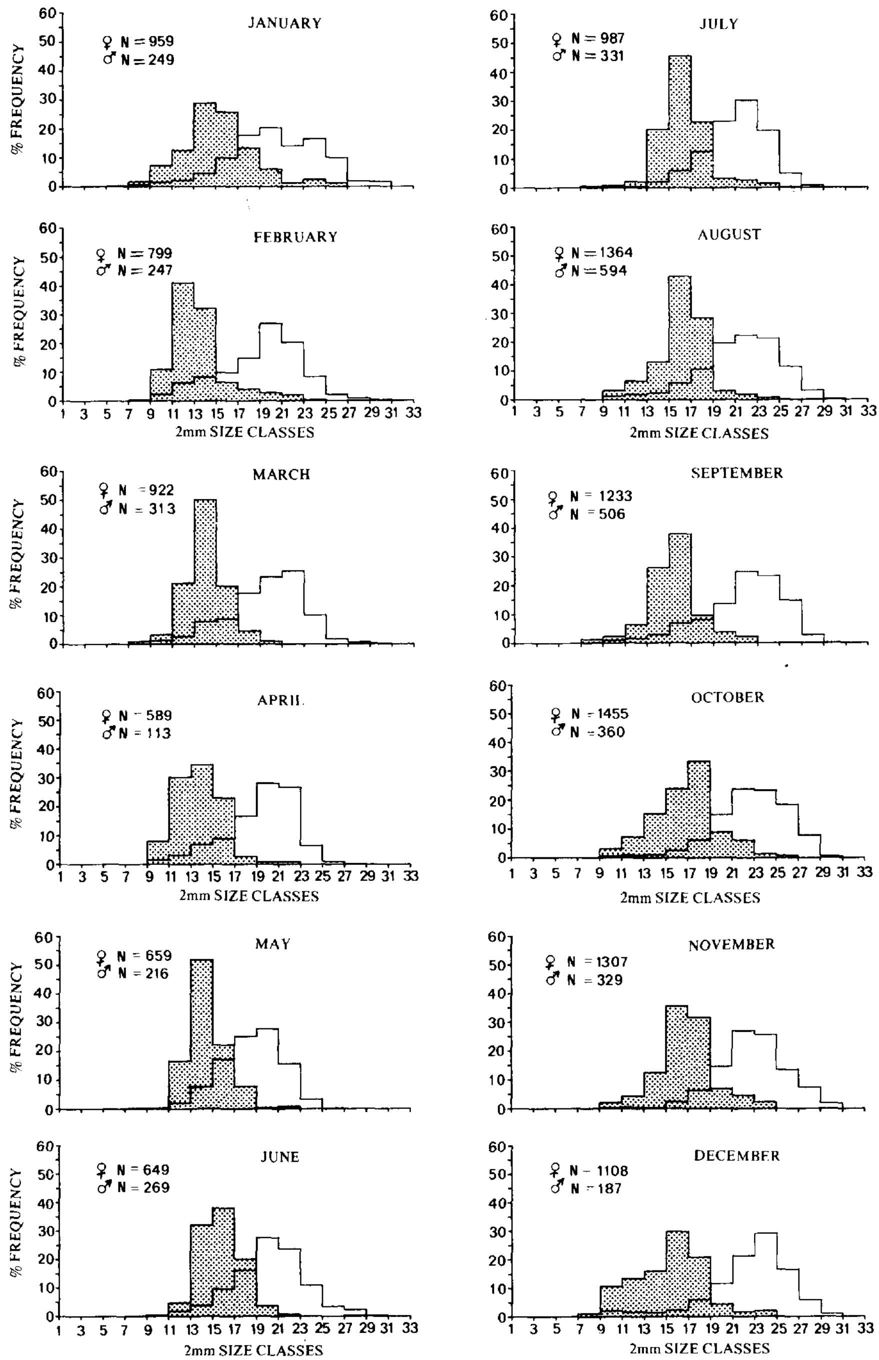

Fig. III-59 Monthly size frequency distribution of *M. stebbingi* males (shaded) and females (unshaded) in open bay stations of Maputo Bay (1968-1973).

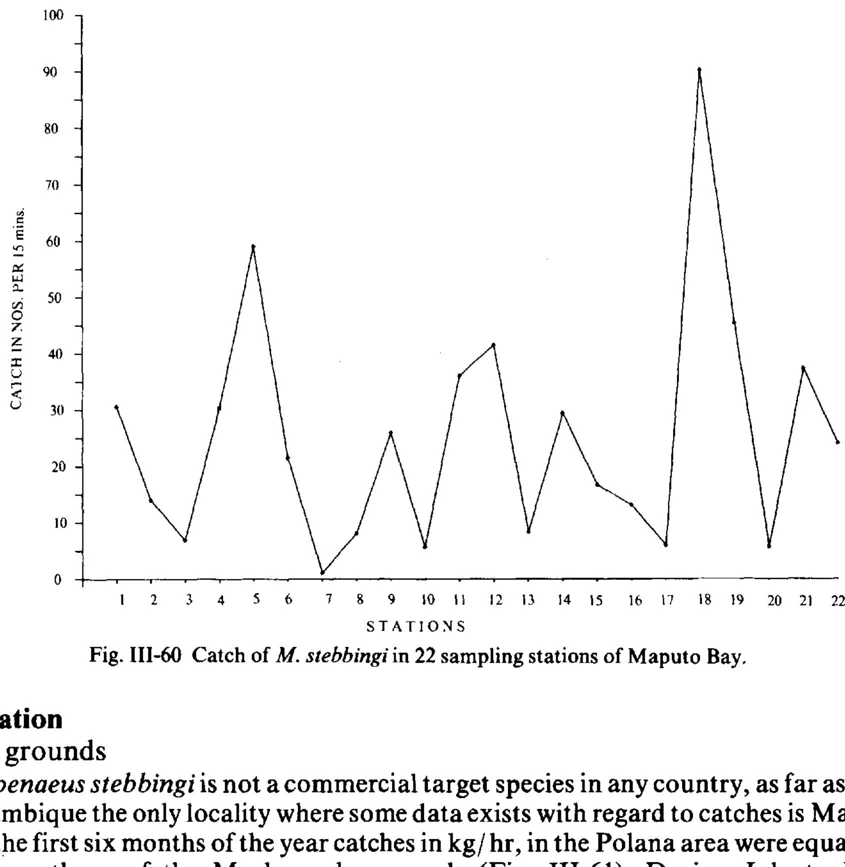

Fig. III-60 Catch of *M. stebbingi* in 22 sampling stations of Maputo Bay.

Exploitation

Fishing grounds

Metapenaeus stebbingi is not a commercial target species in any country, as far as is known. In Mozambique the only locality where some data exists with regard to catches is Maputo Bay. During the first six months of the year catches in kg/hr, in the Polana area were equal to or just better than those of the Machangulo grounds (Fig. III-61). During July to December Machangulo proved somewhat more favourable. Although *M. stebbingi* is caught in central Mozambique, not enough information exists to determine whether any particular area is more favourable.

Fishing activity

Season: Although *M. stebbingi* appears in the penaeid catches of Maputo Bay throughout the year, the best yields are during spring (Fig. III-62). An analysis of the monthly catches from 1968 to 1973 (Fig. III-63) shows that from 1968 to 1971 there was generally a regular pattern, with the weak months from about April to August, while the best months proved to be from September to January. During 1972 and 1973 this pattern changed considerably and no reason is apparent.

Catch: From February 1968 to December 1973 *M. stebbingi* constituted an average of 3.5% of the total penaeid shrimp catch from the exploited stock of Maputo Bay. During the study period *M. stebbingi* generally formed a very small component of the monthly catch (Fig. III-64) and only in September and November did it form over 10% of the catch.

M. stebbingi was caught both during the day and night and daytime fishing was only marginally better (Fig. III-65).

As this species was never specially selected, packed and marketed separately, it is not possible to give a breakdown of the catch in commercial size categories. Generally due to its small size, only a very small percentage of the catch of this species could be classified as anything but medium sized.

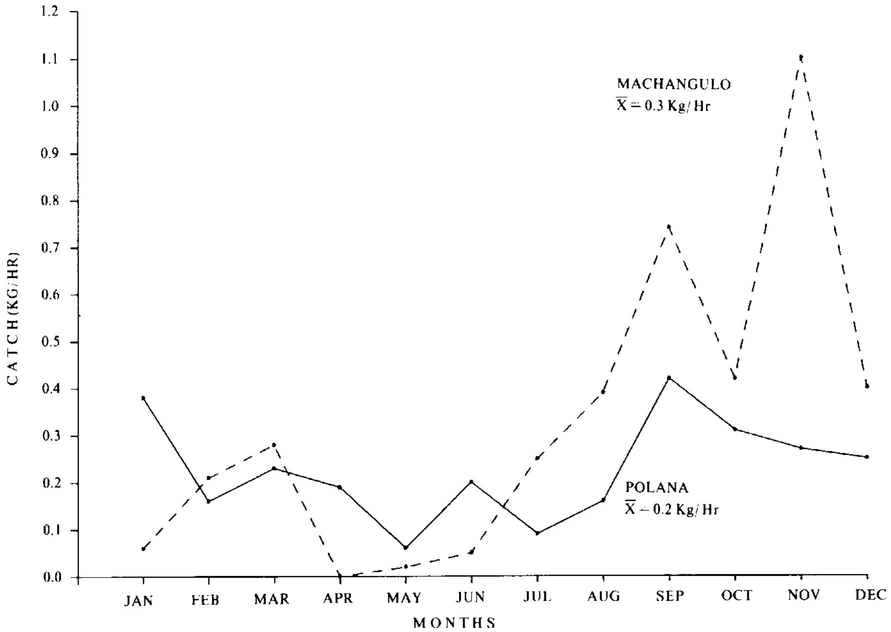

Fig. III-61 Catch in kg/hr of *M. stebbingi* in the Polana and Machangulo fishing grounds made by commercial vessels in Maputo Bay (1968-1973).

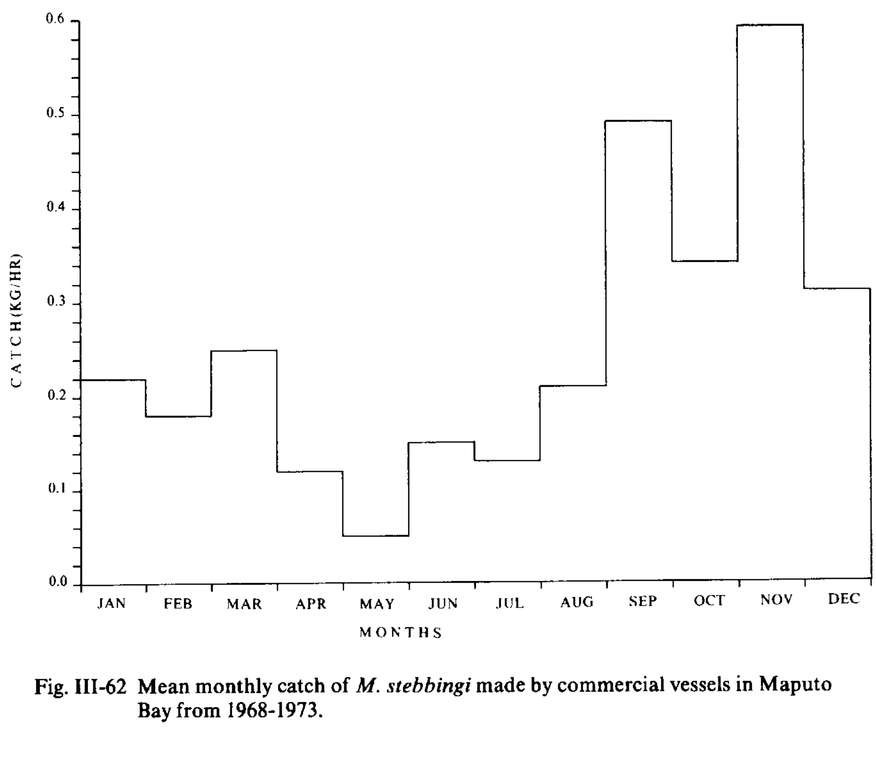

Fig. III-62 Mean monthly catch of *M. stebbingi* made by commercial vessels in Maputo Bay from 1968-1973.

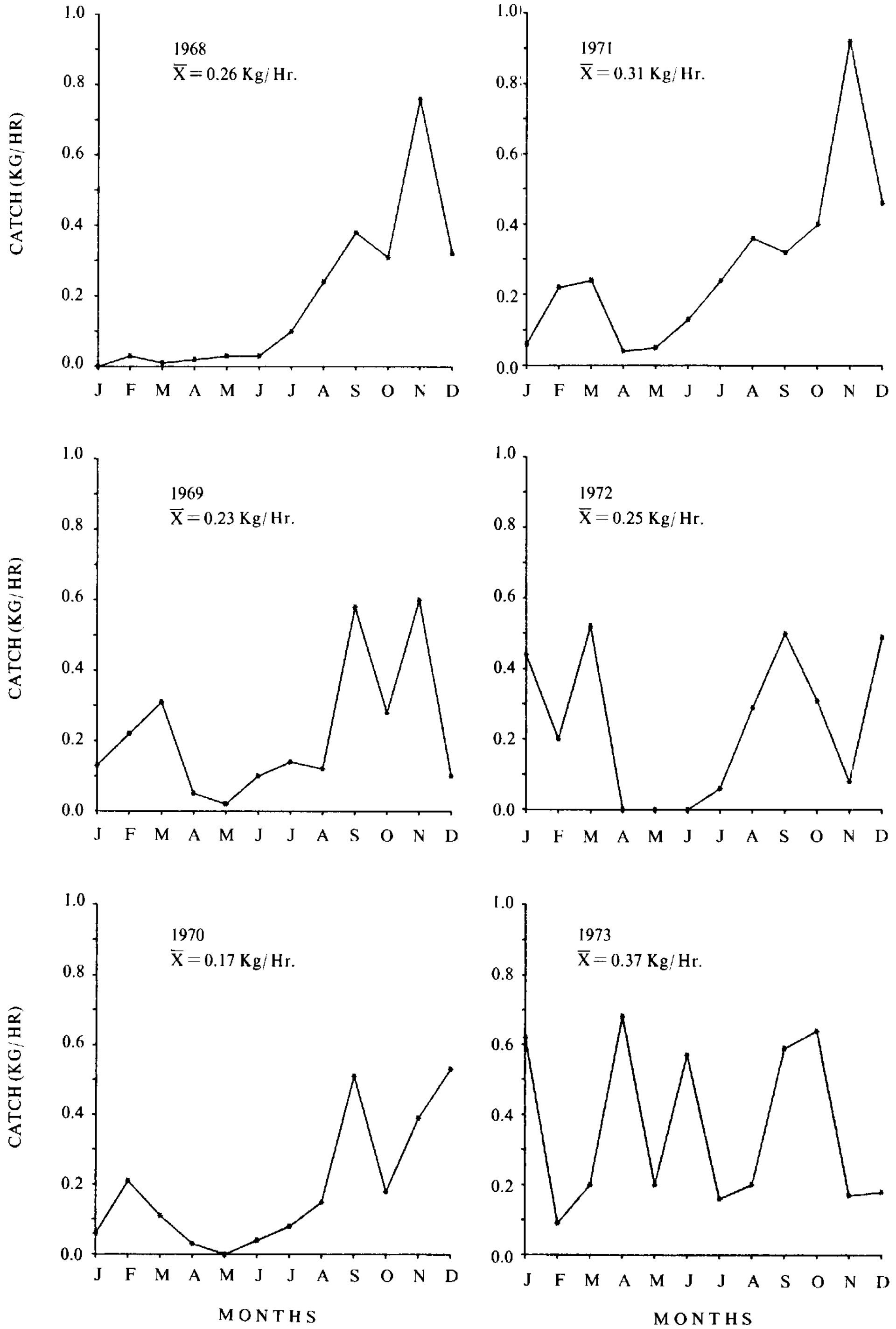

Fig. III-63 Monthly catch of *M. stebbingi* in Maputo Bay from 1968-1973.

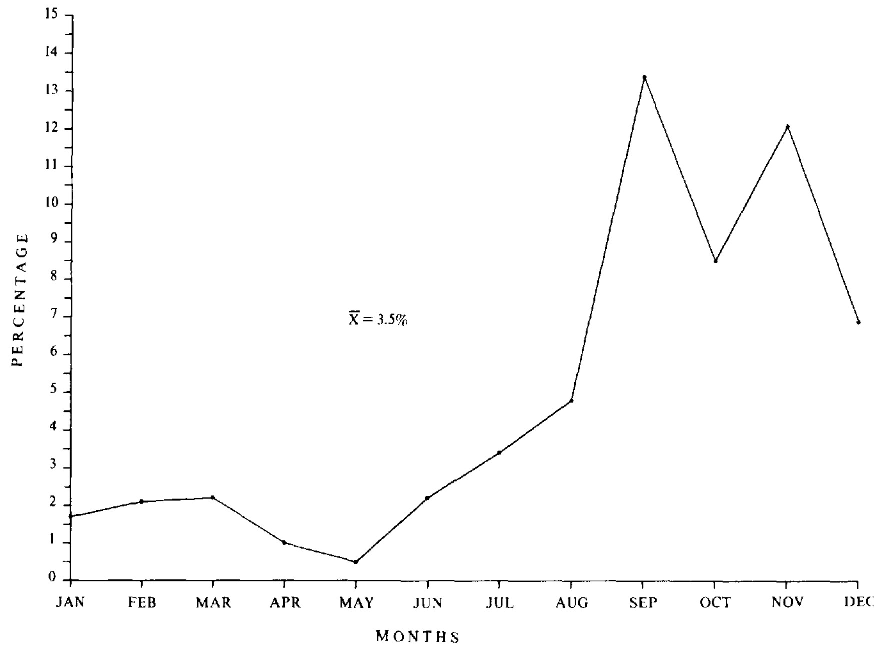

Fig. III-64 Monthly relative abundance of *M. stebbingi* as a percentage of the total catches in Maputo Bay (1968-1973).

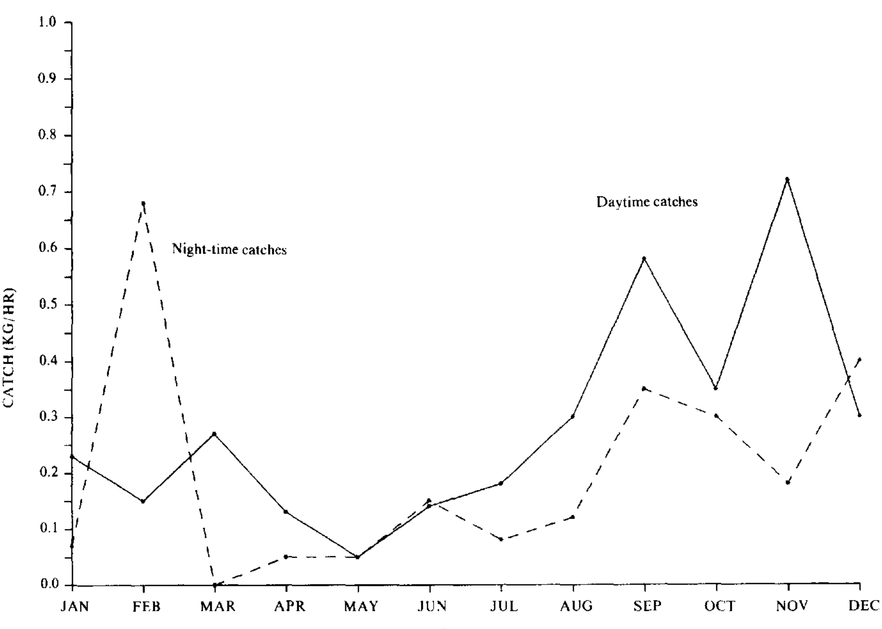

Fig. III-65 Daytime and night-time catches of *M. stebbingi* in Maputo Bay made by commercial vessels from 1968-1973.

Discussion

Metapenaeus stebbingi is a species of very limited commercial value along the east coast of Africa, Madagascar, the Red Sea and the Persian Gulf. In Pakistan, however, it is considered as commercially important (Miquel 1982).

From the gonadal studies carried out during 1968-1973, it was found that the majority of the females may be considered mature when they reach a size of Lc = 23-24 mm and probably all are mature by the time they reach Lc = 29-30 mm. The presence in the population of Stage I females of Lc = 29-30 mm and larger is probably indicative of the fact that females spawn several times after maturity.

The maturity of the males is difficult to determine macroscopically. However, an indiction of male adulthood is given by the fusion of petasmal halves (Tuma 1967). Generally, therefore, one can accept that the males of *M. stebbingi* can be considered juveniles and incapable of copulation at sizes smaller than Lc = 7-8 mm. From this size to about Lc = 13-14 mm (which is the size group migrating out of the backwaters) one can consider the individuals as immature males. At this size, although 2.4% of those still in the backwaters have unfused petasmas, only 0.6% of those out in the open bay are in this condition. Almost all males larger than Lc = 13 mm have fused petasmas and may then be considered as adults. That is to say that 34% of the total population and 60% of the population of the open bay may be considered as mature males.

Tirmizi and Javed (1970), studying the development of the genitalia of male *M. stebbingi* stated that at their fourth stage (with Lc = 12.5 mm) "... the two halves of the petasma are joined together." This agrees well with the findings of this present study.

As in most penaeid prawns, mating occurs at night between soft-shelled females and hard-shelled males (Hudinaga 1942; Eldred 1958). Only one of the 17 934 females analysed was found to be impregnated. This, however, is ascribed to the fact that the simple open thelycum of this species is inefficient in retaining the spermatophore during the mechanical action of the trawl, rather than being indicative of an offshore migration for mating and spawning.

The incidence of ripe and spent females in a population has generally been accepted as indicative of spawning activity. With the exception of a study of the larval development of *M. stebbingi* carried out by Gurney (1927), no further work has been done on the reproduction of this species. It appears from the analysis of ripe and spent females, that the peak spawning seasons are spring and summer, particularly during October.

In spite of the lack of impregnated females already mentioned, the relatively high number of ripe and spent females found within Maputo Bay seems to indicate that this species may very well breed within the bay. *M. stebbingi* was observed by Gurney (1927) to breed in the Bitter Lakes of the Suez Canal.

The fact that the period of spawning activity is fairly long, and as the size range of spawning individuals is quite wide, it seems probable that once mature, a female spawns several times during her life. This would explain the presence of large individuals (Lc = 33-34 mm) with undeveloped (Stage I) ovaries (Fig. III-50). These are probably gonads in the process of regeneration.

In his study of the larval stages of this species, Gurney (1927) described the egg, three stages of the nauplius, three of the protozoea and three mysid stages. Only one specimen of a postlarva was found. *M. stebbingi,* as is the case with most shelf penaeids, spend the postlarval and juvenile periods of their life history in nursery areas situated in backwaters along the coast. In Maputo Bay the most favoured areas serving as nurseries for this species seem to be in calm, protected beaches and mangal channels, with a muddy sand substratum. The juveniles seem to occupy particularly the swash zone.

As in all typical shelf penaeids, the larvae of *M. stebbingi* move from deeper waters into backwater nursery areas, assisted by the winds, currents and tides. Here, protected from predators, they grow rapidly. Movement out of these areas probably occurs, as with *M. monoceros,* during spring ebb tides.

Young adults of *M. stebbingi* start migrating out at a size of Lc = 7-8 mm and by the time they reach Lc = 13-16 mm the majority are out of the nursery area environment (Fig. III-54). Migration out of the nursery areas seem to occur throughout the year although there is some evidence that during summer both sexes are smaller during peak outward movement.

There is no information with regard to the movements of adult members of this species. Menon (1951) obviously basing himself on the findings of Gurney (1927) believes that *M. stebbingi* breeds in the backwaters such as the Bitter Lakes. However, adults have been found on the offshore fishing grounds of central Mozambique. Although not in large quantities this evidence may indicate that when large landlocked bodies of water such as the Bitter Lakes and Maputo Bay do not exist, *M. stebbingi* does migrate to offshore waters to be found together with adult *M. monoceros* and *P. indicus.*

The sex ratios slightly favour females both among the juveniles (1:1.6) and among the adults (1:1.4). The structure of the juvenile populations is similar for males and females with the mean sizes being Lc = 11.4 mm for males and Lc = 12.3 mm for females. In the deeper water occupied by adults the mean sizes are Lc = 14.6 mm for males and Lc = 20.1 mm for females.

In Maputo Bay, this species occurs only incidentally in the prawn fishery and forms only 3.5% of the total penaeid catch. In the Persian Gulf, *M. stebbingi* forms a small part of the artesenal fishery and in Kuwait it constitutes about 3% of the catches (Miquel 1982). It is also a species of some economical importance in Pakistan.

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