THE ZOOPLANKTON OF MGAZANA, A MANGROVE ESTUARY IN TRANSKEI, SOUTHERN AFRICA

T WOOLDRIDGE
Department of Zoology, University of Port Elizabeth

Accepted: March 1977

ABSTRACT

Mgazana, a mangrove estuary in Transkei, was investigated from May 1972 to March 1973 at six-week intervals. Salinities were consistently above 25 parts per thousand in the middle and lower estuary. In the upper estuary the salinity varied between 4 and 29 parts per thousand. Water temperatures varied between 15,5°C and 28°C. One hundred and fifteen taxa of zooplankton organisms were recorded in the samples. The copepods *Acartia natalensis* and *Oithona brevicornis* reached high population densities and numbers exceeding 100 000/m^3 of water were recorded. Mysids were major contributors to zooplankton biomass. A maximum biomass of 1 200 mg/m^3 was recorded in February in the middle estuary and was attributed to the mysid *Mesopodopsis africana*. Species of mysids showed clear seasonal and spatial patterns of distribution in the estuary.

INTRODUCTION

Mgazana is a mangrove estuary located a short distance south of Port St Johns, Transkei, at latitude 31° 42′ S. These mangroves form one of the most extensive forests (40ha) on the south-east coast and are amongst the most southern in distribution on the African continent. The estuary is in an excellent state of preservation and all three species of mangrove trees which occur south of Kosi Bay (26° 54′ S) are recorded here (*Avicennia marina, Bruguieria gymnorhiza* and *Rhizophora mucronata*). Mgazana also represents one of the few remaining undisturbed mangrove habitats on the south-east coast of southern Africa. The only other detailed work on the zooplankton from a mangrove habitat in this region is for Richards Bay (Grindley & Wooldrdidge 1974) which has since undergone large changes through the construction of a new harbour in the northern sector.

The work reported here began in May 1972 and terminated in March 1973. Samples were also taken in February 1971 and December 1975.

METHODS

Field methods

Zooplankton samples were taken on eight occasions at each of eleven stations, at intervals of six weeks. Station positions are shown in Figure 1.

A conical net with a mouth diameter of 36 cm and a 12,5 cm diameter Clarke-Bumpus plankton sampler Model No. 012 WA 300 were used. Both nets were constructed of St Martins nylon mesh with aperture size 124 μm. The two nets were operated concurrently at each station from a small boat equipped with an outboard motor. Stations were always worked in the same order, beginning in the mouth of the estuary.

Sampling commenced about half an hour after dark on an incoming tide so as to negotiate shallow areas above Station 7 at high water.

Towing speed did not exceed 3-4 knots and nets were always positioned in advance of the motor in the bow of the boat. In this way contamination of the catch by benthic organisms when the motor passed over shallow areas was avoided. At each station one four-minute tow was made in an oval pattern, sampling just below the water surface.

Hydrographic observations were made at each station before zooplankton sampling commenced. Water samples for temperature and salinity data were collected from the

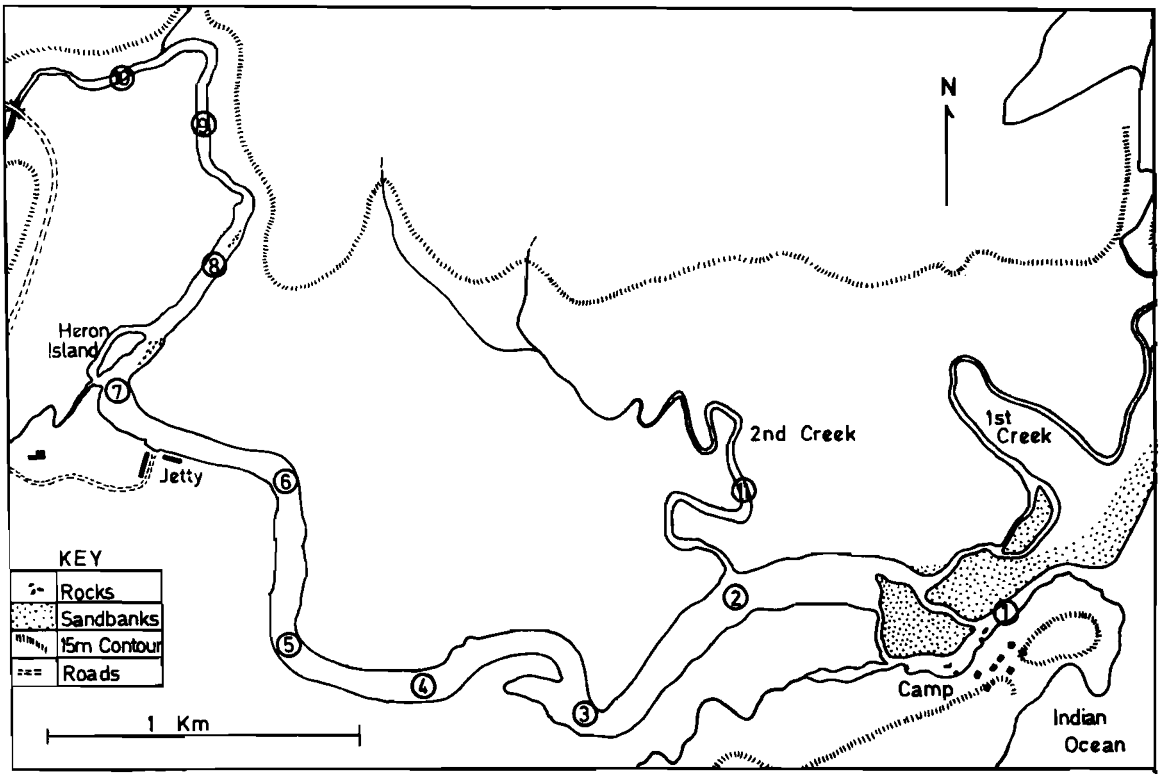

FIGURE 1

Map of Mgazana estuary showing the locations of the zooplankton sampling stations.

surface and from near the bottom using a Van Doorn XRB 135 Water sampler. Salinity was determined by hydrometer and Knudsen's Tables to an accuracy of 0,5 parts per thousand.

Laboratory methods

Clarke-Bumpus plankton samples were analysed by a method of sub-sampling. Each sample was made up to a known volume by the addition of fresh water and then thoroughly mixed by passing a stream of air through the sample. A known volume was removed with the aid of a wide-mouth pipette and placed in a gridded petri dish for examination under a binocular microscope. The size of each sub-sample was determined so that 400-600 of the dominant organisms were counted. Results for a particular species were expressed as the number of individuals per m^3 of water.

The Clarke-Bumpus plankton sampler did not sample the larger animals such as the mysids efficiently, probably due to avoidance action. A discussion on the reaction of schooling mysids to a sampling net is given by Clutter & Anraku (1968).

Mysids were important contributors to the zooplankton biomass and a measure of their abundance was desirable. The 36 cm net samples were used for this purpose. The volume of water filtered by the 36 cm net at each station can be calculated by using available data on the volume of water filtered by the Clarke-Bumpus sampler and the ratio $\frac{r^2}{R^2}$ where $r =$ radius of the Clarke-Bumpus mouth aperture and $R =$ radius of the mouth aperture of the 36 cm net. The mesh aperture size, time and speed of towing were equal for each net and the method was considered suitable for quantitative data for the Mysidacea.

No Clarke-Bumpus data were available for September at any station, nor for October in the upper estuary. The average volume of water filtered by the 36 cm net during a four-minute tow was used in these cases.

Both the Clarke-Bumpus samples and the 36 cm net samples were examined under a binocular microscope. The relative abundance of species which occurred in low numbers and which did not occur in Clarke-Bumpus samples was recorded from the 36 cm net samples.

Biomass data for different regions of the estuary were calculated from dry mass determinations using approximately 50 per cent of each 36 cm net sample after all microscope work had been completed. The size fraction of each sample used in determining dry mass was accurately calculated by settled volume measurements.

Samples were dried at 60°C and the results expressed in milligrams per m^3 of water (Table 6).

PHYSIOGRAPHY

The Mgazana River drops 35 km to the sea and has a catchment area of 275 km^2. The estuary is 5,6 km in length (Figure 1) and meanders over a broad valley entering the sea close to a short rocky promontory. Two important creeks are located close to the mouth of the estuary and have their origin in the low foothills on the eastern side. The two tributaries are fairly shallow and are less than 1,5 m in depth over most of their length.

Mangroves occur along much of the length of the estuary and are mainly located on the inner bends where they play an important role in the stabilization of the river banks. In the middle and lower reaches they form broad expanses of mangrove woodland.

Sandbanks occur in the lower estuary, but a permanently open channel to the sea is maintained by a large tidal exchange and the geomorphology of the mouth region. At low tide the depth at Station 1 is about 2,5 metres. The depth increases to a maximum of 3-4 metres in the middle estuary, particularly on the outer bends. Above Station 7 in the region of Heron Island a shallow ford or drift occurs where depth may be less than 0,25 m at low tide. Above the island the depth gradually increases to a maximum of about 1 metre at low tide.

Tidal exchange in the estuary is considerable and a tidal range of 1,5 m was recorded a short distance below Station 7 during a spring tide. A range of over 1 m was recorded at Station 10.

Rainfall

No rainfall data are available from the Mgazana area, but records from the Port St Johns lighthouse indicate an average annual rainfall of about 1 035 mm along the coast for the ten-year period prior to 1972. The average annual rainfall increases to about 1 445 mm along the coastal escarpment (recorded over a 30-year period at Ntsubane Forest Station 40 km NE of Mgazana). The rainfall decreases rapidly inland and in the catchment area of the Mgazana River the annual rainfall is about 850 mm.

The volume of water-flow in the Mgazana river is relatively low. No evidence of rapid or sudden flushing was apparent although surface salinities above Station 7 were markedly affected during times of heavy rainstorms.

Maximum rainfall occurs during the summer with the highest monthly rainfall in November (average 139 mm for 10 years at Port St Johns lighthouse). In November 1972, 229 mm of rain was recorded. Rainfall was average in mid-summer, but fell below average in February and March. Minimum rainfall was recorded in July (43 mm over 10 years at Port St Johns lighthouse).

Salinity

Salinities recorded below Station 7 were consistently high and did not drop below 25 parts per thousand (Figure 2). In the upper estuary surface salinities decreased rapidly and varied between 4 and 29 parts per thousand at Station 10. In February salinities were relatively high throughout the estuary and maximum values of 37 parts per thousand were recorded. At that time rainfall was below average.

Vertical gradients of salinity tended to develop in the upper estuary, particularly in summer. In March for example, surface and bottom salinities of 4 and 30 parts per thousand respectively were recorded at Station 10. Below Station 7 surface and bottom waters were relatively well mixed.

Temperature

The temperature range during the period of study was greatest in the upper estuary and varied between 15,5°C in July and 28,0°C in February at Station 10 (Figure 3). At this station surface temperatures were generally lower than those recorded near the bottom. The lower temperatures were associated with the inflow of cooler fresh water.

In the middle region of the estuary the water temperatures varied between 17°C in winter and 27°C in summer. Large temperature differences between the surface and bottom were recorded on a number of occasions, particularly in the deeper areas. In March for example, a temperature difference of 4°C was recorded at Station 4.

In the mouth of the estuary temperatures varied between 17,8°C and 24,7°C.

Temperatures recorded in 2nd Creek (Station 11) often varied considerably from

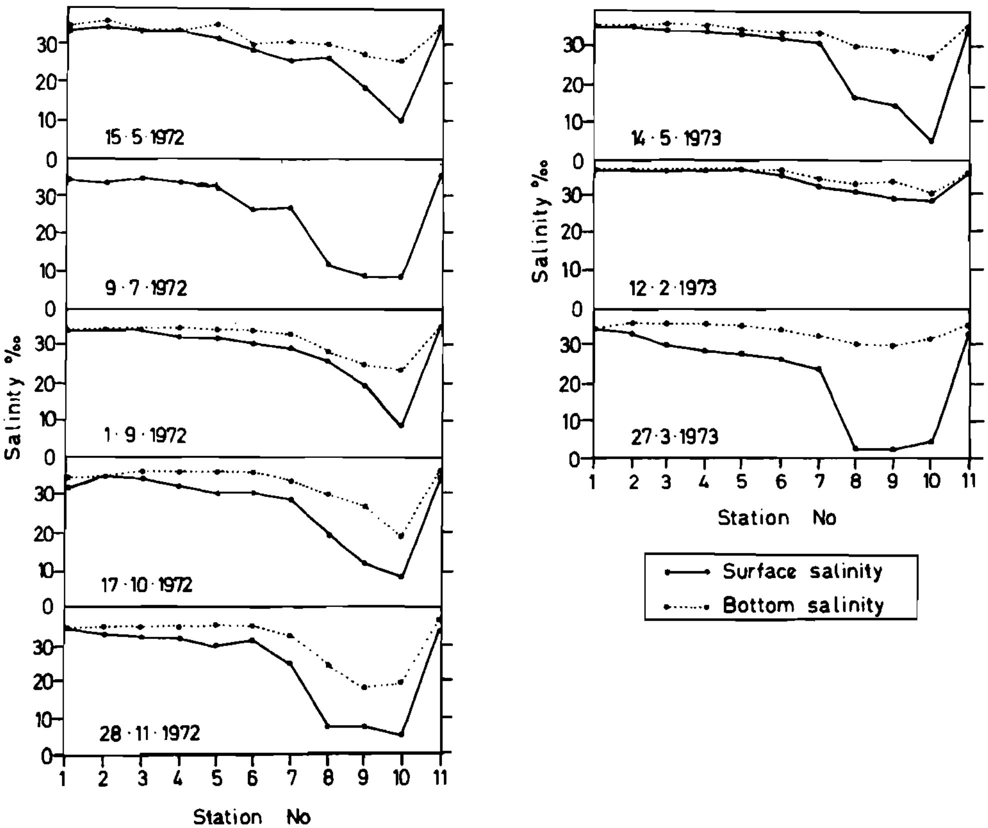

FIGURE 2

Surface and bottom salinity data recorded for 11 stations on Mgazana estuary, May 1972 - March 1973. Station 10 is the uppermost station on the main estuary. Station 11 is located on 2nd Creek.

temperatures recorded at the lower stations in the main estuary. The temperatures at Station 11 were probably the result of the relatively shallow water and were similar to the bottom temperatures recorded in the upper estuary.

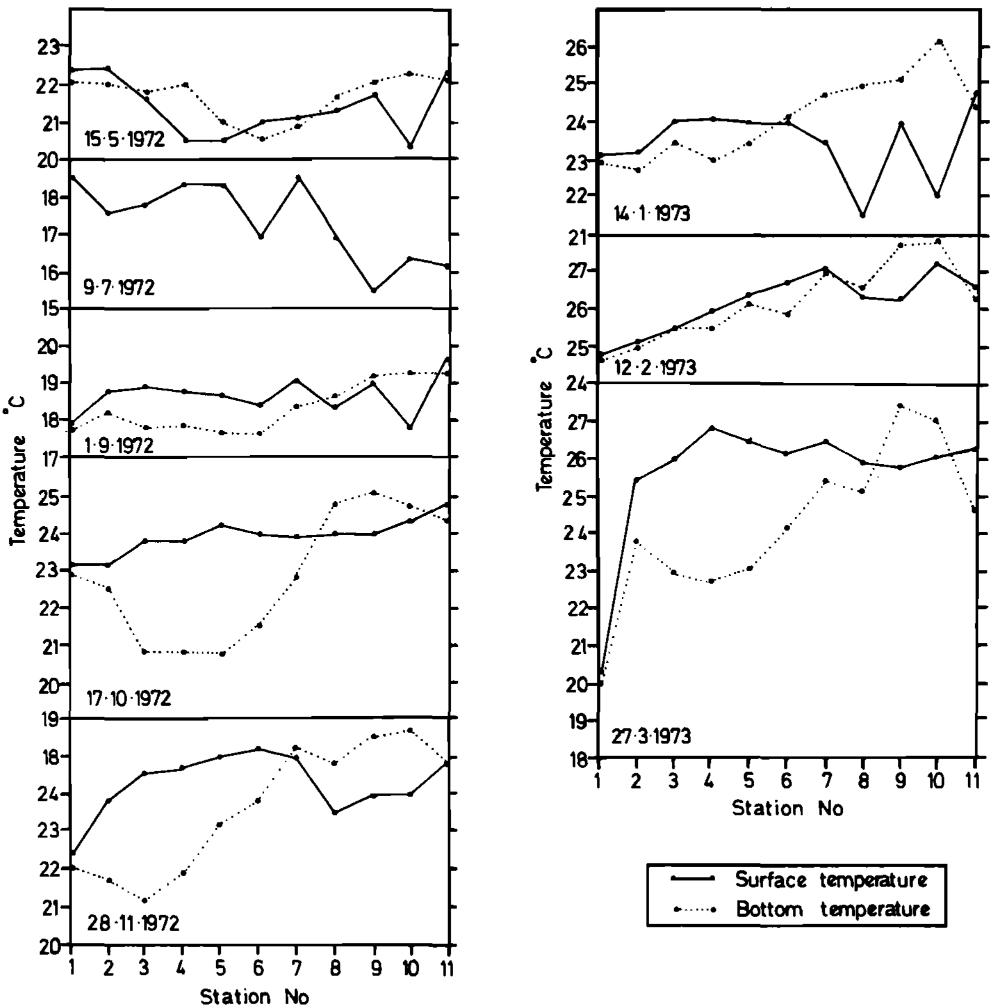

FIGURE 3

Surface and bottom temperature data recorded for 11 stations on Mgazana estuary, May 1972 - March 1973. Station 10 is the uppermost station on the main estuary. Station 11 is located on 2nd Creek

RESULTS

The zooplankton is rich and abundant and over 115 taxa were recorded in the estuary. Two major groups with distinct patterns of distribution were apparent.

In the mouth of the estuary the zooplankton was very diversified. Copepoda were dominant and 45 taxa were identified from the lower two stations. The copepod species include *Acartia danae, Amphiascus sp., Bradyidius hirsutus, Calanoides carinatus, Calanopia elliptica, Canthocalanus pauper, Centropages chierchiae, Clytemnestra scutellata, Eucalanus attenuatus, Eucalanus sp., Euchaeta concinna, Labidocera acutum, Mecynocera clausii, Oithona fallax, Oncaea media, Oncaea venusta, Pontella sp., Pseudodiaptomus nudus, Rhincalanus cornutus, Rhincalanus nasutus, Sapphirina sp., Temora discaudata* and *Undinula vulgaris.* These species are purely marine. A number of copepod species generally associated with marine waters were also recorded from Stations 3 and 4 and include *Acartia negligens, Corycaeus africanus, Corycaeus asiaticus, Corycaeus longistylis, Corycaeus sp., Euterpina acutifrons, Labidocera sp., Macrosetella gracilis, Microsetella norvegica, Monstrilla sp., Oithona nana, Oithona rigida, Oncaea mediterranea, Oncaea minuta, Oncaea sp., Paracalanus crassirostris, Paracalanus aculeatus, Paracalanus parvus* and *Temora turbinata.*

Typical estuarine zooplankton species were dominant above Station 2. Although marine species were recorded at Stations 3 and 4, they were present in low numbers only. Above Station 4 the zooplankton was characterized by relatively few euryhaline species and high levels of abundance were recorded. The most important species and their seasonal abundance in the estuarine zooplankton are discussed below. No quantitative data from Clarke-Bumpus samples are available in September, nor in October for the upper estuary. The 36 cm net samples were used to determine relative abundance of these copepod species and to indicate their patterns of distribution.

a) *Copepoda*

Acartia natalensis was present at all stations. Highest population numbers were recorded in the middle and upper estuary (Table 1). Below Station 4 numbers decreased markedly, except in February when relatively high numbers were present near the mouth. Seasonal changes in numbers were more marked at Station 11 and in the upper estuary. At Station 10 numbers exceeded 50 000 per m^3 throughout the summer and in March reached over 106 000 per m^3. In July minimum population numbers were recorded. Relatively low numbers were recorded in all seasons at Station 11.

Oithona brevicornis was present in greatest numbers in the middle and lower estuary (Table 2). At times it was numerically more abundant than *Acartia natalensis* and in October and November numbers exceeding 75 000 per m^3 were recorded. In November over 123 000 per m^3 were recorded at Station 3. Population numbers at Station 11 were relatively low and did not exceed 9 000 per m^3 except in November when over 84 000 per m^3 were recorded.

Pseudodiaptomus hessei was numerically the third most important copepod in the estuary although numbers were relatively low in the early and mid-winter months (Table 3). Samples collected in September with the 36 cm net indicate a marked increase in population numbers. In October over 28 500 per m³ were recorded at Station 11. In the main estuary maximum numbers of nearly 17 000 per m³ were recorded in November at Station 4.

TABLE 1

Numbers of *Acartia natalensis* per m³ of water for each station on Mgazana estuary, May 1972–March 1973. Data from Clarke-Bumpus samples. (0) indicates no specimens and (—) no C.B. sample. Station 10 is the uppermost station on the main estuary. Station 11 is located on 2nd Creek.

Date	*Station 1*	*11*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
15/16-5-72	4	0	2	7	342	6 202	25 870	11 050	23 422	22 671	8 913
9-7-72	0	313	1 066	875	3 888	2 728	—	1 334	3 273	824	124
1-9-72	—	—	—	—	—	—	—	—	—	—	—
17-10-72	4	2 185	157	4 474	26 282	21 979	39 127	—	—	—	—
28-11-72	<1	1 349	173	1 363	9 984	5 069	4 874	34 560	28 773	7 466	67 528
14-1-73	11	9 160	0	2 195	12 601	19 641	13 301	9 839	15 935	19 028	55 881
12-2-73	4 429	3 999	19 384	10 648	17 424	7 267	9 153	8 420	11 736	15 130	51 068
27-3-73	0	12 107	273	5 331	9 781	26 407	19 468	9 656	8 155	11 641	106 129

TABLE 2

Numbers of *Oithona brevicornis* per m³ of water for each station on Mgazana estuary, May 1972–March 1973. Date from Clarke-Bumpus samples. (0) indicates no specimens and (—) no C.B. sample. Station 10 is the uppermost station on the main estuary. Station 11 is located on 2nd Creek.

Date	*Station 1*	*11*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
15/16-5-72	89	22	14	249	3 352	6 031	3 407	473	5 338	4 934	1 570
9-7-72	99	702	6 462	4 243	2 302	595	—	164	200	50	6
1-9-72	—	—	—	—	—	—	—	—	—	—	—
17-10-72	61	8 476	1 520	35 373	80 914	36 632	76 840	—	—	—	—
28-11-72	52	84 790	2 189	123 494	90 763	9 851	4 660	6 328	5 371	413	296
14-1-73	55	389	275	1 670	3 828	4 041	7 091	3 583	588	491	267
12-2-73	2 229	3 564	9 360	2 787	8 193	4 014	4 015	3 837	637	765	1 729
27-3-73	0	1 510	290	23 384	14 154	6 531	6 206	704	171	61	0

The seasonal pattern of distribution of nauplii larvae was similar to the distribution of *P. hessei* (Table 4). Maximum numbers of over 43 000 per m^3 were recorded in October at Station 6.

TABLE 3

Numbers of *Pseudodiaptomus hessei* per m^3 of water for each station on Mgazana estuary, May 1972–March 1973. Data from Clarke-Bumpus samples. (0) indicates no specimens and (—) no C.B. sample. Station 10 is the uppermost station on the main estuary. Station 11 is located on 2nd Creek.

Date	*Station 1*	*11*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
15/16-5-72	0	66	0	0	7	13	505	1 724	239	267	953
9-7-72	15	302	20	124	150	337	—	749	1 431	116	271
1-9-72	—	—	—	—	—	—	—	—	—	—	—
17-10-72	115	28 572	2 953	3 855	4 259	2 878	6 246	—	—	—	—
28-11-72	366	11 246	5 818	8 724	16 942	1 721	1 339	2 676	3 326	473	1 773
14-1-73	0	1 221	250	239	508	1 175	1 553	2 300	1 177	273	375
12-2-73	90	237	664	643	1 967	381	2 066	1 492	1 009	382	532
27-3-73	0	1 387	119	1 210	947	1 553	296	2 462	1 296	3 062	6 257

TABLE 4

Numbers of nauplii larvae per m^3 of water for each station on Mgazana estuary, May 1972–March 1973. Data from Clarke-Bumpus samples. (0) indicates no specimens and (—) no C.B. sample. Station 10 is the uppermost station on the main estuary. Station 11 is located on 2nd Creek.

Date	*Station 1*	*11*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
15/16-5-72	33	73	30	111	30	342	6 310	4 123	1 832	1 067	1 962
9-7-72	52	64	479	354	1 970	1 220	—	400	865	153	0
1-9-72	—	—	—	—	—	—	—	—	—	—	—
17-10-72	2 752	33 029	13 456	36 958	29 080	37 679	43 370	—	—	—	—
28-11-72	366	20 017	864	3 817	11 194	5 260	3 053	4 746	1 407	325	148
14-1-73	0	333	0	477	779	818	828	535	107	55	160
12-2-73	1 724	2 534	3 317	3 145	2 676	380	827	1 865	956	492	266
27-3-73	1 466	1 294	0	672	496	318	185	1 368	341	121	695

b) *Mysidacea*

Mysids were represented by seven species in the estuary. Low numbers of a *Siriella sp.* were collected on three occasions at the mouth. In September two specimens of an unidentified species of *Gastrosaccus* were present in the plankton at Station 1, while in October immature specimens of the genus *Heteromysis* were recorded at the same station.

Gastrosaccus brevifissura was present in the lower estuary throughout the period of study. It was recorded above Station 4 in winter only and numbers did not exceed 1 per m³. A single specimen was collected in November at Station 6. Highest numbers were recorded in September at Station 1 (65 per m³) and in November and March at the same Station (12 per m³).

Mesopodopsis slabberi was not recorded above Station 7, except in November and January when low numbers were present at Station 8 ($<$ 1 per m³). Winter population numbers were relatively low and did not exceed 7 per m³ (September, Station 3). In November 19 per m³ were recorded at Station 4, while in February 25 per m³ were recorded at Station 2.

Mesopodopsis africana was numerically the most important mysid in the estuary and showed a well-marked seasonal and spatial pattern of distribution (Table 5). In winter numbers of less than 1 per m³ were recorded, except in October when numbers had increased to 5 per m³ at Station 8. Numbers increased rapidly in early summer, particularly in the upper estuary. In February highest numbers occurred in the middle estuary with a maximum of over 10 000 per m³ at Station 7. By the end of summer maximum numbers were recorded in the lower estuary (over 2 700 per m³ at Station 2).

Rhopalophthalamus terranatalis was present in low numbers and was the largest mysid encountered. Numbers did not exceed 1 per m³. It was more common in the middle and upper estuary, particularly during summer.

TABLE 5

Numbers of *Mesopodopsis africana* per m³ of water for each station on Mgazana estuary, May 1972–March 1973. Data from 36 cm net samples. (0) indicates no specimens. Station 10 is the uppermost station on the main estuary. Station 11 is located on 2nd Creek.

Date	*Station 1*	*11*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
15/16-5-72	0	0	0	<1	0	0	<1	<1	<1	0	<1
9-7-72	0	<1	<1	<1	<1	<1	<1	<1	<1	0	<1
1-9-72	0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
17-10-72	0	0	0	0	<1	<1	1	3	5	3	<1
28-11-72	0	2	0	1	1	17	17	47	174	232	141
14-1-73	0	563	29	178	348	280	202	711	1 247	2 318	2 462
12-2-73	0	1 085	409	1 679	2 283	3 525	4 838	10 191	1 213	4 490	1 820
27-3-73	1	1 328	2 722	1 813	1 170	323	295	770	376	499	271

c) *Cumacea*
The cumacean, *Iphinoe truncata* occurred in low numbers, particularly in the lower estuary. Numbers per m³ exceeded 250 in November at Station 1, but generally they were not recorded in numbers greater than 10 per m³.

d) *Isopoda and Amphipoda*
These groups were well represented and over 20 species were present in the plankton. *Cirolana fluviatilis, Corophium triaenonyx, Melita zeylanica* and *Parorchestia rectipalma* were more abundant at the upper stations. *Grandidierella bonnieroides* was common throughout the estuary while *Eurydice longicornis, Urothoe pulchella* and *Jassa falcata* were recorded from the lower estuary only.

Other species present in low numbers include *Cyathura carinata, Caprella equilibra* and *Orchestia ancheidos;* while a gnathid species, *Munna* sp., *Aora typica, Gitanopsis* sp., *Lysianassa ceratina* were tentatively identified in the plankton. Species of Hyperiidea were present in the plankton but were not identified.

e) *Decapoda*
Decapods and decapod larval stages were well represented and include *Acetes natalensis, Lucifer penicillifer*, penaeid juveniles, *Betaeus jucundus, Palaemon* larvae, *Palaemonetes* sp., *Callianassa kraussi* post larvae, *Upogebia africana* larvae, megalopa and zoea larvae.

Biomass
Total zooplankton biomass was relatively low in winter, but increased markedly from October. This increase was particularly apparent at Station 11 (Table 6). In November the

TABLE 6

Dry mass in mg per m³ of water for different regions of Mgazana estuary. Stations grouped as shown. May 1972–March 1973. Data from 36 cm net samples.

Date	*Station 1*	*2–3*	*4–7*	*8–10*	*11*
15/16-5-72	14,2	11,4	67,9	129,2	24,4
9-7-72	2,3	3,1	12,8	10,1	28,3
1-9-72	2,9	3,4	13,0	10,5	30,3
17-10-72	13,0	75,6	118,4	94,9	299,2
28-11-72	66,0	200,0	231,7	249,0	223,8
14-1-73	16,6	41,2	129,2	395,3	88,2
12-2-73	33,7	354,6	765,5	388,7	491,1
27-3-73	62,1	405,2	256,0	149,6	311,5

biomass was highest in the upper estuary (249 mg/m^3). A shift in biomass maxima towards the lower estuary was apparent in summer and was closely correlated with the distribution of *Mesopodopsis africana* during that time. Highest total biomass of 766 mg per m^3 was recorded in February in the middle estuary with a maximum of 1 200 mg per m^3 at Station 7. The high summer biomass was mainly attributed to the mysid *M. africana*.

DISCUSSION

The zooplankton of the lower region of Mgazana estuary consisted partly of euryhaline and stenohaline marine forms, whose distribution was linked to tidal influence and extended as far as Station 4 at high tide.

Above Station 4 the zooplankton community was dominated by typically estuarine species. Extremely high population densities of several of these were recorded. Their distribution in the estuary appeared to bear little relation to changing salinity and temperature patterns although seasonal variation in numbers was considerable. For example, numbers of *Oithona brevicornis* varied from less than 10 to 123 000 per m^3.

High rainfall did not appear to be a serious factor affecting distribution patterns. At times of high rainfall increased river-flow could result in a major loss in numbers from the estuary. Maximum numbers of *Oithona brevicornis* and *Pseudodiaptomus hessei* were present in November when the highest monthly rainfall was recorded. In the same month the maximum number of *Acartia natalensis* was present at Station 10 in the uppermost reaches of the estuary.

Seasonal and spatial patterns of distribution may also be affected by predation. Rippingale & Hodgkin (1975) have suggested that the observed distribution patterns of *Gladioferens imparipes* in estuaries of south-west Western Australia were due to predation effects of *Sulcanus conflictus* and *Acartia clausii* upon nauplii of *Gladioferens*. A predator population entering a prey population could grow rapidly and exclude the prey species from a particular region of the estuary.

In the Murray estuary in Western Australia *Gladioferens* and *Sulcanus* were observed to co-exist in low densities or in areas of marked salinity stratification for lengthy periods of time. "In low densities the predator would not completely prevent recruitment into the *Gladioferens* population and where a layer of low salinity water occurs, *Sulcanus* tend to remain beneath it, providing *Gladioferens* with a predator free zone." (Rippingale & Hodgkin 1975).

Many cyclopoids including *Acartia* are predatory feeders (Kaestner 1959). *Acartia natalensis* was abundant in Mgazana and predation may have been a factor affecting distribution patterns in the estuary. Decreasing proportions of a prey species such as the juvenile stages of *Pseudodiaptomus hessei* could be associated with increasing numbers of a predator, possibly *A. natalensis*. A high degree of predation could also exclude a prey species from a particular region of the estuary.

The quantitative data for the species present in Mgazana (including juvenile and nauplii stages of *P. hessei* and the mysid *M. africana)* were closely examined for possible indications of such a relationship. No evidence of predation was apparent, but it is possible that more than one prey species was present, thus masking the effect on any particular species. Exploitation may also be at a low level, due to the availability of alternative foods. Recruitment to a prey population could therefore be relatively high in a region of the estuary where a predatory population was abundant.

Mysids were important members of the zooplankton and showed clear patterns of spatial distribution. *Gastrosaccus brevifissura* occurred in greatest numbers near the mouth of the estuary. Its distribution in the Mgazana estuary and in other estuaries investigated (Wooldridge 1976 and unpublished data) suggests that it occurs in greatest numbers in water of high salinity. Connell (1974) recorded maximum numbers of *G. brevifissura* in the lower reaches of the Mtentu estuary, while stations at which they were recorded by Tattersall (1952) would further support this. Grindley & Van Rensburg (unpublished data) recorded maximum numbers of *G. brevifissura* during the summer in the upper reaches of the Swartkops estuary, but at that time salinities in the upper reaches of the estuary were above 35 parts per thousand.

Mesopodopsis slabberi was present in summer and winter in Mgazana estuary. In Mbotyi estuary it was present in winter only (unpublished data). High rainfall reduced the salinity to below 10 parts per thousand during the summer in Mbotyi and water temperatures of above 26° C were recorded. Preliminary salinity-temperature tolerance experiments suggest that *M. slabberi* has a reduced salinity tolerance at high temperatures. Thus it would appear that high summer temperatures combined with low salinities are unfavourable for the species and that a combination of these factors contribute to its absence from the summer plankton in Mbotyi. In Mgazana it is present in summer in relatively high numbers in the middle and lower reaches where relatively high temperatures and salinities were recorded. The distribution of *M. slabberi* in South African estuaries would seem to indicate that it is more temperate in its distribution and that it is replaced by *M. africana* in warmer East Coast estuaries.

M. africana was at times recorded in high numbers. During the winter it occurred in low numbers (< 1 per m^3) but increased to over 10 000 per m^3 in February at Station 7. The rapid increase in the population in the summer suggests a short development time. Nair (1939) working on a closely related species, *M. orientalis,* in the estuary of the Adyar River in India, found that the young left the brood-pouch approximately 96 hours after the eggs had been extruded. Females then moulted and immediately produced a further batch of eggs. Conditions in the Adyar estuary are similar to those pertaining to many of the subtropical estuaries in Transkei, but more intensive sampling coupled with experimental work is essential before the number of generations produced by *M. africana* and the fate of females after brood release can be stated with certainty.

M. africana is predominantly a summer breeder with a well-marked pattern of spatial distribution. In November peak population numbers were recorded in the upper estuary. During the summer there was a general down-the-estuary movement with maximum numbers in March at Station 2. This seasonal pattern of distribution did not appear to relate to any of the environmental parameters investigated (e.g. rainfall, temperature, salinity). During this time (November to March) *M. africana* was the major contributor to the zooplankton biomass in the estuary and exceeded 75 per cent of total biomass at many stations. Connell (1974) gives conversion factors for equating numerical counts of species of zooplankton with approximate *Acartia natalensis* equivalents (dry mass 105°C). Thus 10 000 *M. africana* (mature, immature and juvenile classes determined) per m^3 of water recorded in February at Station 7 are equivalent to 159 000 *A. natalensis* or 40 000 *Pseudodiaptomus hessei*. Average numbers of *M. africana* per m^3 for all stations in February was about 3 250. *Acartia* and *Pseudodiaptomus* equivalents are about 49 000 and 12 250 per m^3 respectively for each station.

In the Mbotyi estuary, the seasonal pattern of distribution of *M. africana* was similar to the pattern observed in Mgazana. *M. africana* was most abundant in February with low numbers recorded in the winter (unpublished data).

Data collected in February 1971 and in December 1975 are also available for Mgazana estuary. In February 1971, *R. terranatalis* and *M. slabberi* were the major contributors to zooplankton biomass. In December 1975, *M. africana* was the most abundant mysid and the pattern of distribution was similar to the pattern of distribution observed in November 1972 (Table 5).

Data for mysids are also available for other Transkei estuaries, although these were sampled at irregular intervals. Mysids contributed as much as 75 per cent of the total zooplankton biomass in the Ntafufu estuary. *M. africana* was dominant in the middle reaches whilst *Rhopalophthalamus terranatalis* was dominant in the upper reaches. This distribution pattern was observed during February 1970 (unpublished data).

Mysids made the major contribution to zooplankton biomass in February 1971 in the Sinangwana estuary. *G. brevifissura* was abundant at the mouth. Above the mouth *M. slabberi* was the more important species.

These data emphasize the importance of mysids as contributors to zooplankton biomass in the sub-tropical estuaries investigated. Four species were commonly recorded and showed marked seasonal and spatial patterns of distribution. However, the numerical abundance of a species may vary from year to year in a particular estuary. For example, in the Mgazana estuary *M. africana* may be replaced by *M. slabberi* and/or *Rhopalophthalamus terranatalis* as the dominant mysid in the following summer. Factors affecting such patterns of distribution are unclear and require further investigation.

Biomass

Comparative zooplankton biomass data are available for a number of estuaries in South Africa. Seasonal means for different regions of Richards Bay ranged from approximately 4 to 344 mg per m^3 (Grindley & Wooldridge 1974). In the Msikaba estuary a maximum zooplankton biomass of 35 mg per m^3 was recorded (Wooldridge 1976) while a maximum of 279 mg per m^3 was recorded in Mbotyi estuary (Wooldridge unpublished).

The present study shows that zooplankton biomass reaches extremely high levels in Mgazana estuary (1 200 mg per m^3). The samples collected in February 1971 and in

December 1975 support the suggestion that a high summer biomass is characteristic, although the contribution of a particular species to the total biomass may be variable, for example, the replacement of *Mesopodopsis africana* by *M. slabberi* and/or *Rhopalophthalamus terranatalis* as the dominant mysid in the following summer.

ACKNOWLEDGEMENTS

Financial support from the South African National Committee for Oceanographic Research is acknowledged. This work was started under the directorship of Dr J R Grindley and continued at the University of Port Elizabeth.

My thanks are also due to Dr D Baird for commenting on the manuscript and to my colleagues who assisted on numerous occasions in the field.

My thanks are also due to Dr D Baird for commenting on the manuscript and to my colleagues who assisted on numerous occasions in the field.

A grant in aid of publication from the University of Port Elizabeth is gratefully acknowledged.

REFERENCES

CLUTTER, R I & ANRAKU, M 1968. *Avoidance of samplers.* Monographs on oceanographic methodology 2, Zooplankton sampling, Unesco.

CONNELL, A D 1974. Mysidacea of the Muntu River estuary, Transkei, South Africa. *Zool. afr.* 9: 147-159.

GRINDLEY, J R & WOOLDRIDGE, T H 1974. The plankton of Richards Bay. *Hydrobiol. Bull.* 8: 201-212.

KAESTNER, A 1970. *Invertebrate zoology.* New York: Interscience publishers.

NAIR, K B 1939. The reproduction, oogenesis and development of *Mesopodopsis orientalis* (Tattersall). *Proc. Indian Acad. Sci.* 9: 175-223.

RIPPINGALE, R J & HODGKIN, E P 1975. Predation effects on the distribution of a copepod. *Aust. J. mar. Freshwat. Res.* 26: 81-91.

TATTERSALL, O S 1952. Report on a small collection of Mysidacea from estuarine waters in South Africa. *Trans. R. Soc. S. Afr.* 33: 153-188.

WOOLDRIDGE, T H 1976. The zooplankton of Msikaba estuary. *Zool. afr.* 11: 23-44.