Western Indian Ocean J. Mar. Sci. Vol. 3, No. 2, pp. 143–150, 2004

Composition, Abundance and Distribution of Brachyuran Larvae in Mida creek, Kenya

James Mwaluma[1] and José Paula[2]

[1]*Kenya Marine and Fisheries Research Institute, P.O.Box 81651, Mombasa, Kenya;* [2]*IMAR-Laboratório Marítimo da Guia, Faculdade de Ciências da Universidade de Lisboa, 2750-642, Cascais, Portugal*

Key words: Brachyuran larvae, abundance, composition, Mida creek, Kenya

Abstract—The composition, abundance and distribution of brachyuran larvae were analysed from plankton hauls collected in four stations at Mida creek, Kenya, from May 1996 to April 1997. Simultaneously, hydrological parameters such as temperature and salinity were measured. Maximum surface-water temperature and salinity were 31 °C and 37 ppt respectively, recorded in March, during the dry season. In May, during the rainy season, temperature and salinity were 24.6°C and 32 ppt respectively. Maximum abundance of brachyuran larvae occurred in February during the dry season. Nine major families of larvae were identified, with the most abundant being the Ocypodidae, Grapsidae and Xanthidae. Abundance of brachyuran larvae was significantly positively correlated with total zooplankton abundance ($r^2 = 0.8$) and salinity ($r^2 = 0.71$).

INTRODUCTION

Decapod crustaceans are the among the most conspicuous fauna associated with mangrove ecosystems, in which they play a major role (Jones, 1984; Lee, 1998; Smith, 1991). The life cycle of these animals is complex, and includes a planktonic larval period with two phases: an initial dispersive and a critical return migration phase (Paula et al., 2001).The dynamic processes of dispersal and recruitment of the larval stages of macrobenthic species influence the distribution and abundance of adult populations (Roughgarden et al., 1988).

Recently, a number of references described key dynamic processes of brachyuran larvae in mangroves of the eastern African region, such as the relation of larval fluxes to cycles of tidal amplitude, tidal and diel phases (Paula et al., in press), the long-term migration by megalopae (Paula et al., 2001) or stratified settlement within the mangroves (Paula et al., 2003a).

Larval development in brachyuran crabs in the eastern African region remains poorly understood (Paula, 1998), but recently a number of descriptive accounts have been published (Clark & Paula, 2003; Dornelas et al., 2003; Flores et al., 2003). Taxonomic and ecological data on brachyuran larvae from the Kenyan coast are particularly rare, and consist mainly of general zooplankton studies, lacking in detailed descriptions and with identifications limited to higher taxonomic levels. These studies include Wickstead (1961, 1962), Reay & Kimaro (1984), Kimaro (1986), Okemwa & Revis (1986), Revis (1988), Kimaro & Jaccarini (1989), Okemwa (1989), Okemwa (1990), Osore (1992, 1994, 1997), Mwaluma et al. (1993, 1997) and Kasyi (1994).

The study reported here describes the composition, abundance and distribution of brachyuran larvae from Mida creek, during one annual cycle and along a spatial gradient. This study forms part of a wider multidisciplinary effort to assess the biodiversity of the creek for management purposes.

Corresponding Author: MSK.
E-mail: jmwaluma@kmfri.co.ke *or* jpaula@fc.ul.pt

MATERIALS AND METHODS

Study site

Mida Creek (Fig. 1) is located in the north coast of Kenya, at 03°22' S and 39°58' E. The total area of the creek, including that covered by mangroves, is 32 km^2. There is no river drainage into the creek, but ground water enters it thorough seepage along the shores and within the channel bed (Kitheka et al., 1999). In addition to ground water, there is also surface runoff during the rainy season. The dominant water circulation is the astronomical semi-diurnal tide with a tidal average range of 3.2 m at the entrance and 2.0 m in the middle sections of the creek (Kitheka et al., 1999). The dominant climatic seasons are the Southeast (April–October) and the Northeast monsoon (November–March). Annual rainfall is 600–1000 mm (G.O.K, 1989), with the highest monthly rainfall normally recorded in May. Air temperature ranges between 24°C in July and 32°C in February and evaporation rate is 200 mm per year, with a monthly range of 160–210 mm. The dominant mangrove species include *Rhizophora mucronata, Ceriops tagal, Avicennia marina, Sonneratia alba* and *Bruguiera gymnorrhiza* (Kairo et al., 1998). Mida creek is part of the Watamu Marine National Park and Reserve, an important nature conservation site managed by Kenya Wildlife Service.

Sampling site

The main channel of Mida creek is 11-km long. Four stations were established approximately 2 km apart, from the mouth of the creek to the backwaters (Fig. 1). Station 1 was in the oceanic zone located at the creek mouth, with an average depth of 5.5 m. Station 2 was located 2 km from Station 1 inside the channel, with depths ranging from 5–11 m. The bottom substratum was covered with the seagrass *Thalassodendron ciliatum* (Uku et al., 1998). Station 3 was in the central part of the channel and was surrounded by dense cover of mangrove *R. mucronata* and the seagrass *Halodule uninervis*, and had a mean depth of 7 m. Station 4 was located at the northern end of the channel in the wide basin, and was mainly shallow (4 m) with a muddy bottom substratum.

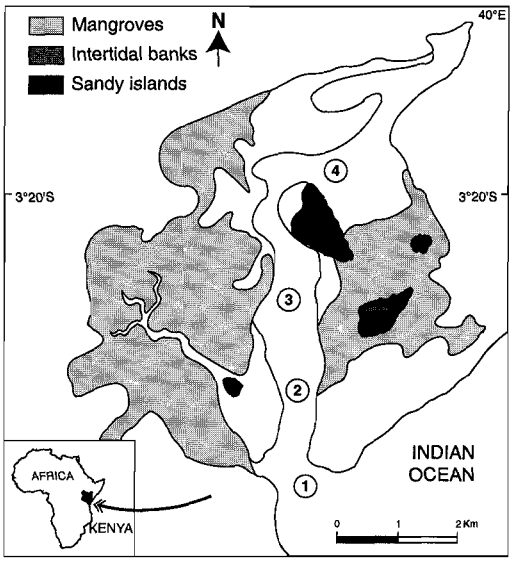

Fig. 1. Mida creek, Kenya, with plankton sampling Stations 1–4 marked

Field sampling

Plankton samples were collected monthly from May 1996 to April 1997 during both spring and neap tides. Towing for zooplankton was done at 0.5 m/s during high tide, using a 1.5-m-long Bongo net with a mouth radius of 45 cm and 332 μm mesh size. The volume of water flowing through the net was measured using a digital Hydrobios flowmeter, tied across the mouth of the net. At each station, salinity was measured using an Artago hand refractometer and temperature was measured on a mercury thermometer. Samples were preserved in buffered 5% formalin pending analysis.

Laboratory procedures

In the laboratory, brachyuran larvae were separated from the plankton samples and identified to the lowest taxonomic level possible, using the keys of Newell (1956) and Wickstead (1965, 1976), descriptions by Clark & Paula (2003, Xanthoidea), Dornelas et al. (2003, Hymenosomatidae) and Flores et al. (2003, Grapsoidea), and our unpublished accounts (especially for families Ocypodidae and Majidae). After subsampling, identification and counting were done using a stereomicroscope. Following data normalization

Pearson product correlations were performed to compare abundance of brachyuran larvae with abiotic (temperature and salinity) and biotic (total zooplankton) parameters. Cluster analysis of the samples was also performed.

RESULTS

Hydrographic parameters

The highest mean surface-water temperature recorded was 31.0 ± 0.5 °C in March 1997, during the dry Northeast monsoon season. July 1996, during the cool inter-monsoon period, was the coldest month (24.6 ± 0.1 °C). Salinity was highest during the dry spell in February, with a mean of 37.3 ± 0.0 ppt, and lowest in May during the rainy season, with a mean of 32.0 ± 3.2 ppt (Fig. 2a). During this season, salinity in the inner creek at Stations 3 and 4 ranged between 27.8 and 31.4 ppt, which was lower than the 34.5 ppt recorded in the outer Stations 1 and 2. The temperature and salinity conditions along Mida creek are, however, usually relatively homogeneous.

Brachyuran larvae

Figure 2b shows the mean variation of total brachyuran larvae in Mida creek from May 1996 to April 1997. Monthly average abundance of larvae varied considerably, with peak abundance occurring from February to April 1997. The highest abundance was 508 ± 122/m^3, recorded in February 1997. In March and April 1997 average abundance was 300 ± 237/m^3 and 360 ± 190/m^3 respectively (Fig. 2b). The lowest abundance was 2.0 ± 0.8/m^3, recorded in June, during the cooler inter-monsoon period. Abundance was significantly ($p < 0.05$) positively correlated to total zooplankton abundance ($r^2 = 0.8$) and salinity ($r^2 = 0.71$). The correlation between brachyuran larvae with temperature was positive ($r^2 = 0.5$), but non-significant at $p > 0.05$.

Table 1 shows the seasonal occurrence of all brachyuran larvae collected during the study. Species from nine families, namely Ocypodidae, Portunidae, Grapsidae, Xanthidae, Pinnotheridae, Majidae, Callapidae, Leucosiidae and Hymenosomatidae, were identified. The most

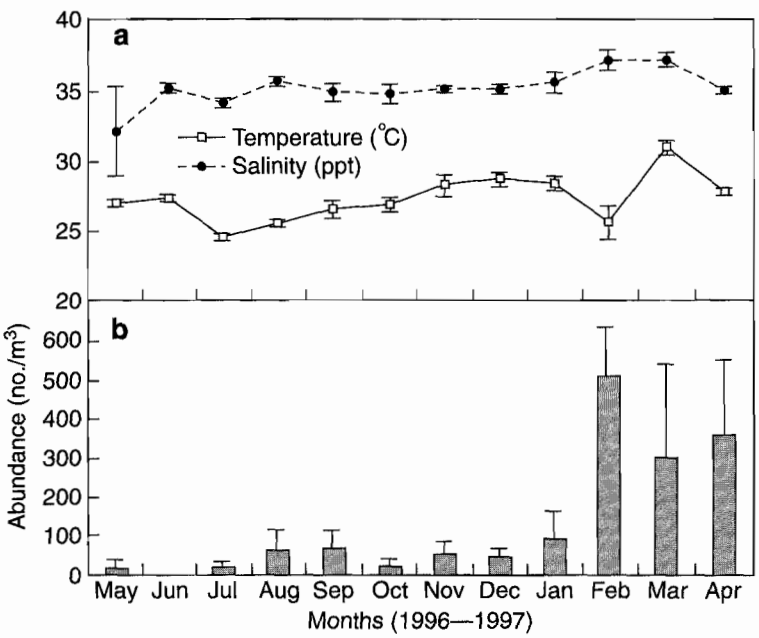

Fig. 2. Mean monthly variation in water temperature and salinity (a) and abundance of brachyuran larvae (b) in Mida creek from May 1996–April 1997

Table 1. Seasonal occurrence of brachyuran larvae in Mida creek from May 1996 to April 1997

Family	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April
Ocipodidae												
Uca vocans	**	–	–	–	–	–	–	–	–	**	–	**
Uca annipules	–	–	–	–	–	–	–	–	–	*	–	–
Uca spp.	*	*	–	–	**	**	–	–	–	*	****	–
Dotilla fenestrata	*	–	–	*	–	**	–	–	–	**	****	***
Macrophthalmus spp.	*	–	–	*	–	**	–	–	–	**	****	***
Grapsidae												
Grapsinae	–	–	–	–	–	–	–	*	*	***	–	*
Grapsus spp.	–	–	**	–	–	–	–	–	–	*	–	–
Metapograpsus spp.	–	–	–	–	–	–	–	–	–	*	–	*
Sesarma guttatum	–	–	–	–	–	–	–	–	–	*	–	–
Sesarma spp.	–	–	–	–	–	–	–	–	–	*	*	–
Portunidae	–	–	–	–	–	–	–	–	–	–	**	*
Xanthidae												
Xanthinae	*	–	–	–	–	*	–	*	–	***	–	*
Xanthid spp.	*	–	–	–	–	–	–	–	–	*	–	–
Pinnitheridae												
Pinnixa spp.	–	–	–	–	–	–	–	–	*	–	*	–
Pinnotherid spp.	–	–	–	*	–	–	–	–	–	–	*	–
Majidae												
Inachinae	–	–	–	–	–	–	–	–	–	*	–	–
Majid spp.	–	–	–	–	–	–	–	–	–	–	*	*
Callapidae	–	–	–	–	–	–	–	–	–	*	–	–
Leucosiidae												
Phylira spp.	–	–	–	*	–	–	–	–	*	*	**	*
Leucosid spp. 1	–	–	–	*	–	–	–	–	–	–	–	*
Leucosid spp. 2	–	–	–	–	–	–	–	–	–	*	*	–
Hymnosomatidae												
Trygonoplax spp.	–	–	–	–	–	–	–	–	–	–	*	–
Hymnosomatid spp.	–	–	–	–	–	–	–	–	–	–	*	–

*, rare; **, common; ***, abundant; ****, most abundant

abundant family was the Ocypodidae, which formed 83% of total collected larvae. The dominant taxa of brachyuran larvae identified were *Dotilla fenestrata*, *Uca* spp. and *Macrophthalmus* spp. (Table 1).

The spatial distribution of brachyuran larvae in Mida creek was patchy, showing a mosaic of different larval patches (Fig. 3). During the peak period of abundance Station 3 showed consistently higher densities, but Stations 1 and 2 at the lower creek also presented high density peaks. Station 4 in the inner creek had the lowest average density, although it had the highest values during August 1996. The highest density for total crab larvae was >1000 larvae/m^3, recorded at Station 3 in March 1997.

The quantitative spatial distribution of the most abundant species is presented in Fig. 4, for the peak period of February to April 1997. *Dotilla fenestrata* was the most abundant species, and occurred at maximum density in Station 3, in March and April. *Macrophthalmus* spp., Grapsinae n.d. and *Uca vocans* were abundant in Stations 1 and 2 in February, whereas Xanthinae n.d. were abundant in Station 1 during the same month. Portunidae n.d. and *Phylira* spp. presented highest densities in March and April, in Stations 2 and 3.

Analysis of the dendrogram of correlation between taxa (Fig. 5), showed complexity, which reflects seasonal and spatial affinities of different larval patches. Species were associated

considering their similar specific larval periods in the plankton and coincidence of maximum abundances. The taxa *Uca* spp. and Leucosiidae 1 separated strongly from all other taxa, followed by *Grapsus* spp. The remaining taxa divided into 2 main groups, the first one composed of *Dotilla fenestrata*, *Phylira* spp. and Portunidae as most abundant taxa, plus 4 others, and second composed of the abundant taxa *Uca vocans*, Xanthinae n.d., *Macrophthalmus* spp., Grapsinae, plus 9 others.

DISCUSSION

The abundance of brachyuran larvae in Mida creek showed a distinct seasonal pattern similar to that observed in other creeks around the coastal waters of Mombasa. Kimaro (1986), who studied the composition, distribution and abundance in near-surface zooplankton in Tudor creek, reported peak abundance of brachyuran larvae in December and March, while Okemwa (1990), studying in the same creek, observed peak abundance in December,

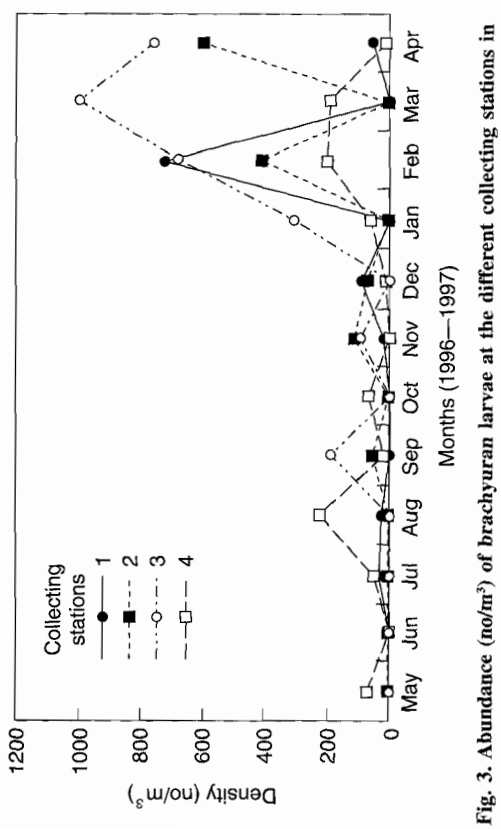

Fig. 3. Abundance (no/m³) of brachyuran larvae at the different collecting stations in Mida creek, from May 1996–April 1997

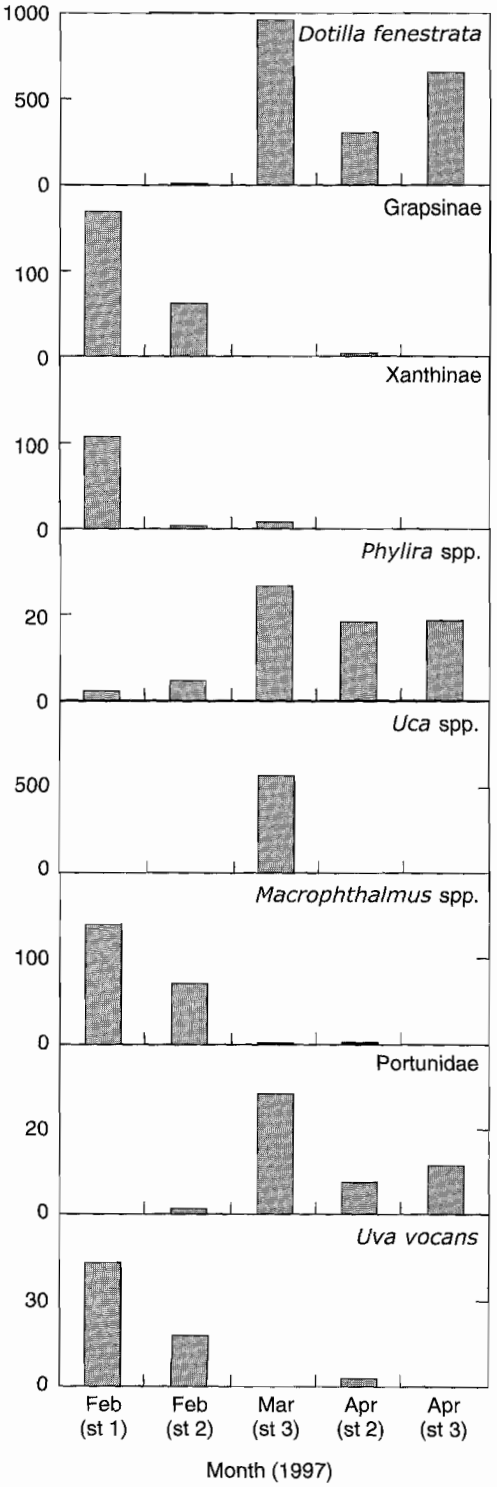

Fig. 4. Quantitative (no/m³) spatial distribution of dominant taxa of brachyuran larvae in Mida creek, February–April 1997 (peak season)

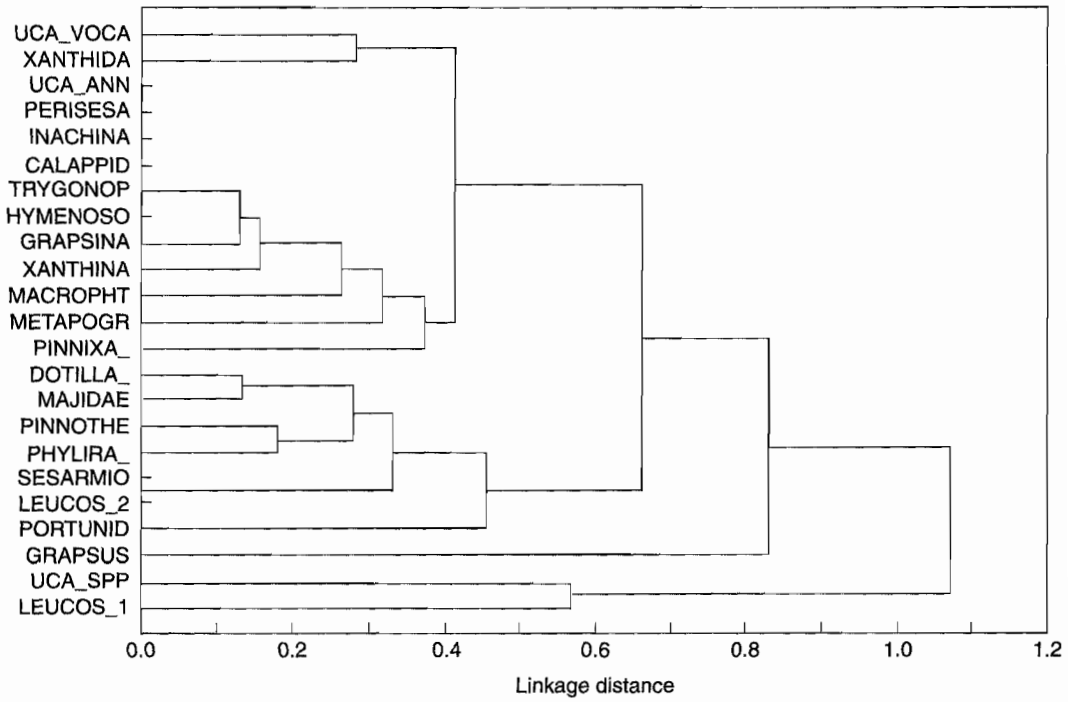

Fig. 5 Correlation dendrogram for brachyuran larvae in Mida creek

January and April. Osore (1994), who studied community structure and seasonal variation of zooplankton from Gazi bay, observed peak abundance in March and April. The densities of larvae in Mida creek were higher than in Tudor creek and Gazi bay, also located along the Kenya coast. During the peak season, densities of larvae in Mida could reach up to 1000/m^3, as compared to 885 /m^3 in Tudor (Okemwa, 1990) and 90 /m^3 in Gazi bay (Osore, 1994). However, the different methodological approaches used in the different studies, and especially the temporal and spatial design of the different sampling schemes preclude detailed comparisons. In fact, brachyuran larvae are known to exhibit patterns of occurrence in relation to short-term phenomena, such as tidal, diel and semi-lunar cycles (Paula et al., in press), and intertidal and mangrove crabs in East Africa also have patterns of hatching rhythmicity (e.g. Gove & Paula, 2000; Gove & Mambonhe, 2000). Nevertheless, the results from this study compare favourably with those carried out by the above-mentioned workers in the same geographical area. Peak period of abundance of brachyuran larvae were noted to occur during the warm (28 °C), dry NE monsoon from November to March, as compared to the cooler (24.6°C) SE monsoon from April to October (Fig. 2b). Larvae distribute according to their origin and dispersal, but also maximise their confinement to water masses that are most favourable to their survival. Each species has its particular optimal conditions, which may be more or less narrow. For instance, Paula et al. (2003b) noted that the growth and survival of the mangrove crab *Parasesarma catenata* in controlled conditions was optimal at around 27 °C and normal seawater salinity of about 35 ppt.

Brachyuran larval abundance in Mida creek was closely correlated (r^2 = 0.8) to total zooplankton abundance (Mwaluma et al., 2003). During the study period, two peaks in phytoplankton abundance occurred in Mida creek—in January and May (Wawiye, 1998)—while zooplankton abundance peaked in February and April. Salinity was more positively correlated (r^2 = 0.71) to brachyuran larvae abundance, than was temperature (r^2 = 0.5).

The majority of the larval brachyuran taxa encountered in Mida creek thrived in Station 3, possibly as a result of the dense mangrove and

seagrass cover adjacent to the Station, which provided food and shelter to the larvae, but more likely because these areas are the origin of most larvae. Osore (1994) observed a similar trend in Gazi bay, where high numbers of brachyuran larvae were found in Stations close and adjacent to the mangroves.

CONCLUSIONS

Brachyuran larvae of Mida creek are abundant and seasonal. This seasonality was found to be closely associated with both biotic and abiotic factors, most significantly salinity and zooplankton abundance. Peak abundance occurred from February–April, concomitant with peak phyto- and zooplankton abundance during the NE monsoon season. The dominant group of brachyuran larvae in Mida was the family Ocypodidae, which contributed up to 83% of total brachyuran larvae fauna. *Dotilla fenestrata*, Grapsinae n.d. and *Macrophthalmus* spp. were the most dominant species.

It is believed that the luxuriant mangrove forest at Mida creek, which provides a nursery ground and habitat for birds, fish, and crabs, is partly sustained by ground water, which supplies nutrients and fresh water (Kitheka et al., 1999). The contribution of ground water outflow during the dry season was crucial to preventing hypersalinity. Moragwa et al. (1998) showed that a number of migrant birds use Mida creek as a stopover point during their breeding season, as a feeding and roosting ground. Of the food types found in the guts of the birds, crabs were the most abundant. Therefore, the survival of brachyuran larvae in Mida, and their subsequent recruitment into the adult population, is critical in ensuring the availability of food to the higher trophic levels, including birds and humans.

Acknowledgements—This study was made possible by funding from The Netherlands Wetland Program through Kenya Wildlife Service. The taxonomical analysis of the samples was performed at Guia Marine laboratory of University of Lisbon in Portugal, and made possible by funding from WIOMSA (MARG II). The authors are also grateful for the assistance provided by the wardens and the rangers of Watamu Marine National Park and Reserve. We would also like to thank Dr Else Martens, co-ordinator of the Netherlands Wetland Program, and Dr Nyawira Muthiga, formerly of Kenya Wildlife Service, who greatly assisted with logistics.

REFERENCES

Clark, P. F. & Paula, J. (2003) Descriptions of ten xanthoidean (Crustacea: Decapoda: Brachyura) first stage zoeas from Inhaca Island, Mozambique. *Raffles Bull. Zool.* 51(2): 323-378.

Dornelas, M., Paula, J. & Macia, A. (2003) The zoeal stages of the crab *Hymenosoma orbiculare* (Crustacea, Hymenosomatidae). *J. Nat. Hist.* 37(21): 2579-2597.

Flores, A., Paula, J. & Dray, T. (2003) First zoeal stages of grapsid crabs (Crustacea: Brachyura) from the East African coast. *Zool. J. Linnean Soc.* 137: 355-383.

G.O.K. (1989) Kilifi District Development Plan 1989-1999. Ministry of Planning and National Development, Nairobi, Kenya. 224 pp.

Gove, D. & Paula, J. (2000) Rhythmicity of larval release in three species of intertidal brachyuran crabs (Crustacea: Brachyura) from Inhaca island (Mozambique). *Mar. Biol.* 136: 685-691.

Gove, D. & Mambonhe, R. (2000) Larval emission in crab species (*Uca annulipes*, *Uca vocans*, *Uca chlorophthalmus* and *Sesarma guttatum*) from Saco da Inhaca mangrove, Inhaca Island, southern Mozambique. *In:* Vannini, M. (ed.) Macrobenthos of Eastern African mangroves: life cycles and reproductive biology of exploited species. Final report ERBIC 18-CT96-0127, Part B. Florence. pp. 13-30.

Jones, D. A. (1984) Crabs of the mangal ecosystem. *In:* Por, F. D. & Dor, L. (eds.) Hydrobiology of the mangal. The Hague, W.Junk. pp. 89-109.

Kairo, J. G. & Gwada, P. O. (1998) Mangrove forests of Mida creek, Kenya. *In:* Mwatha, G. K., Fondo, E., Uku, J. & Kitheka, J. (eds.) Biodiversity of Mida creek, Kenya. Final Report. pp. 150-183.

Kasyi, J. N. (1994) Relationship between nutrient levels, phytoplankton biomass and zooplankton composition, biomass and abundance in Tudor creek. MSc. Thesis, University of Nairobi. 99 pp.

Kimaro, M. M. (1986) The composition, distribution and abundance in near-surface zooplankton of Tudor creek, Mombasa. Msc. Thesis, University of Nairobi. 95 pp.

Kimaro, M. M. & Jaccarini, V. (1989) The cycle of near-surface zooplankton abundance in Tudor creek, Mombasa. *Kenya J. Sci. Tech. Ser. B.* 10: 7-30.

Kitheka, J. U., Mwashote, B. M. & Kamau, J. (1999)

Water circulation, groundwater outflow and nutrient dynamics in Mida creek, Kenya. *Mang. and Salt. Marsh.* 3: 135-146.

Lee, S. Y. (1998) Ecological role of grapsoid crabs in mangrove ecosystems: a review. *Mar. Freshwater Res.* 49: 335-343.

Moragwa, G., Fondo, E. & Okondo, J. (1998) Birds of Mida creek. *In:* Mwatha, G. K., Fondo,.E., Uku, J. & Kitheka, J. (eds.) Biodiversity of Mida creek, Kenya. Final Report. pp. 135–150.

Mwaluma, J. (1997) Distribution and abundance of zooplankton off the Kenya coast during the monsoons. MSc. Thesis, University of Nairobi. 90 pp.

Mwaluma, J., Osore, M. & Kamau, J. (1998) Zooplankton of Mida creek. *In:* Mwatha, G. K., Fondo, E., Uku, J. & Kitheka, J. (eds.) Biodiversity of Mida creek, Kenya. Final Report. pp. 66-87.

Mwaluma, J., Osore, M., Kamau, J. & Wawiye, P. (2003) Composition, abundance and seasonality of zooplankton in Mida creek, Kenya. *Western Indian Ocean J. Mar. Sci.* 2: 147-155.

Newell, G. E. & Newell, R.C. (1956) Marine Plankton. A practical Guide. Hutchinson, London.. 244 pp.

Okemwa, E. N. & Revis, N. (1986) Planktonic copepods from coastal and inshore waters of Tudor creek, Mombasa. *Kenya. J. Sci. Ser. B* 7: 27-34.

Okemwa, E. N. (1989) Analysis of six 24 hours series of zooplankton sampling across a tropical creek, the Port Reitz, Mombasa, Kenya. *Trop. Zool.* 2: 123-138.

Okemwa, E. N. (1990) A study of the pelagic copepods in a tropical marine creek, Tudor, Mombasa, Kenya, with a special reference to their community structure, biomass and productivity. Ph.D thesis, Vrije University, Brussels. 225 pp.

Osore, M. K. (1992) A note on zooplankton distribution and diversity in a tropical mangrove creek system, Gazi, Kenya. *Hydrobiologia* 247: 119-120.

Osore, M. K. (1994) A study of Gazi Bay and the adjacent waters: Community structure and seasonal variation. M.Sc. Thesis, Vrije Universiteit, Brussels. 104 pp.

Osore, M. K., Tackx, M. L. M. & Daro, M. H. (1997) The effect of rainfall and tidal rhythm on the community structure and abundance of the zooplankton of Gazi Bay, Kenya. *Hydrobiologia* 356: 117-126.

Paula, J., Pinto, I., Guambe, I., Monteiro, S., Gove, D. & Guerreiro, J. (1998) Seasonal cycle of planktonic communities at Inhaca island, southern Mozambique. *J. Plankton Res.* 20: 2165-2178.

Paula, J., Dray, T. & Queiroga, H. (2001) Interaction of offshore and inshore processes controlling settlement of brachyuran megalopae in Saco mangrove creek, Inhaca island (South Mozambique). *Mar. Ecol. Prog. Ser.* 215: 251-260.

Paula, J., Dornelas, M. & Flores, A. (2003a) Stratified settlement and moulting competency of brachyuran megalopae in Ponta Rasa mangrove swamp, Inhaca Island (Mozambique). *Estuar. Coast. Shelf Sci.* 56: 325-337.

Paula, J., Mendes, R. N., Mwaluma, J., Raedig, C. & Emmerson, W. (2003b) Combined effects of temperature and salinity on larval development of the mangrove crab *Parasesarma catenata* Ortman, 1897 (Brachyura: Sesarmidae). *Western Indian Ocean J. Mar. Sci.* 3: 57-63.

Paula, J., Bartilotti, C., Dray, T., Macia, A. & Queiroga, H. (in press) Patterns of temporal occurrence of brachyuran crab larvae at Saco mangrove creek, Inhaca Island (South Mozambique): implications for flux and recruitment. *J. Plankton Res.*

Reay, P. J. & Kimaro, M. M. (1984) Surface zooplankton studies in Port Mombasa during the N. East Monsoon. *Kenyan J. Sci. & Tech. Ser. B* 5: 27-48.

Revis, N. (1988) Preliminary observations on the copepods of Tudor creek, Mombasa, Kenya. *Hydrobiologia* 168: 343-350.

Roughgarden, J., Gaines, S. & Possingham, H. (1988) Recruitment dynamics in complex life cycles. *Science* 241: 1460-1466.

Smith, T. J. (1991) Distribution of macrofauna on a Malayan mangrove shore. *J. Anim. Ecol.* 43: 51-69.

Uku J., Wakibya, J., Ndirangu, S., Muthama, C. & Kimanthi, A. (1998) Macroalgae and seagrasses of Mida creek. *In:* Mwatha, G. K., Fondo, E., Uku, J. & Kitheka, J. (eds.) Biodiversity of Mida creek, Kenya. Final Report. pp. 99-114.

Wawiye, P. (1998) Microphytoplankton distribution in Mida creek. *In:* Mwatha, G. K., Fondo, E., Uku, J. & Kitheka, J. (eds.) Biodiversity of Mida creek, Kenya. Final Report. pp. 49-66.

Wickstead, J. H. (1961) Plankton of the northern Kenyan banks. *Nat. Lon.* 192: 890-891.

Wickstead, J. H. (1962) Plankton from the coastal stripes of Kenya and Tanzania area of the Indian Ocean. *Nat. Lon.* 196: 1224-1225.

Wickstead, J. H. (1965) An Introduction to the Study of tropical plankton. Hutchinson & Co., London. 160 pp.

Wickstead, J. H. (1976) Marine zooplankton. The Camelot Press Ltd., Southampton. 59 pp.