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THE COMMERCIAL *CYPRAEA* (MOLLUSCA: GASTROPODA) OF KENYA: THEIR ZOOGEOGRAPHY AND THE IMPLICATIONS TO CONSERVATION

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Introduction

Many conservationists are worried about the massive collection of marine mollusc shells in Kenya. This is made possible by the various recently invented equipment which have increased the efficiency of exploitation of marine resources. Availability of modified diving equipment and snorkelling gears have tremendously helped in the hunting of shells.

Available technology has improved communications and transport so much so that it is now possible to take to far away markets aesthetic collections and souvenirs. More importantly, modern technology has made us understand that marine mollusc shells are not inexhaustible. It is now known that marine organisms are not homogeneously dispersed, but live successfully in particular areas. The majority of species of molluscs live in the shallow coastal waters. Thus overexploitation of the shallow coastal waters may lead to extinction of many species. Likewise overexploitation of the oceanic species may lead to their extinction. However, it is the shallow water forms that face the heaviest exploitation.

Presently, marine mollusc shells sell at exorbitant prices which have logically made many conservationists worried about the possible extinction of all molluscs in our lifetime.

Trade in molluscs is of great interest to conservationists in Kenya. Knowledge of its trend especially the commercial values of the various species helps to potray the more relatively coveted species by shell collectors and can consequently indicate which species are likely to be overexploited. In conservation it is necessary to know whether an organism is endemic or non-endemic to a particular region. A study of their zoogeography is therefore essential.

This paper deals with the family Cypraeidae: their market prices, ecology, zoogeography and conservational implications.

The survey was carried out in Mombasa where many tourists visit every year. The price ranges per piece for each species are shown in tables 1-5. These are approximate prices a Kenyan resident would likely pay to a licensed shell dealer. However, a tourist may often pay double and in extremes even triple the prices shown here.

The identification aids used were those of Emerson, Burges, Oliver, Spry and Abbott[1]. The authoritative book of Burgess was very useful in the description of the zoogeography of the various species[2]. Initial species lists of Cypraea of East Africa are those of Spry, Verdcourt and Robson[3]. Robson gave the most detailed species list covering Kenya and Tanzania (East Africa).

Ecology of *Cypraea*

The *Cypraea* occupy various habitats not only extending from the lower eulittoral to sublittoral zone but also the deep waters of the outer reefs[4]. They are slow moving grazers which feed at night, hiding under rocks during the day although *C. annulus* *C. tigris* and *C. moneta* have been observed moving about during day light. *Cypraea* species give parental care to their eggs after spawnings[5].

Zoogeography

East Africa is endowed with one of the richest variety of tropical species of fauna in the western Indian Ocean[6]. The East Africa stock is thought to have originated from the Indonesian stock which is regarded as the parent stock for all tropical Indo-pacific fauna[7].

In discussing zoogeography and even conservation, the knowledge of distribution and dispersal of species are of paramount importance because among other advantages they help to

1. Show how far we need international cooperation in research and management and
2. Show which species are relatively able to live successfully and tolerate various contrasting environments.

The more tolerant a species is to various abiotic and biotic factors the better its ability to occupy various environments[8]. Less tolerant species which are confined only to particular areas need greater management attention, otherwise they can easily be wiped out. To appreciate the zoogeography of the species, it is essential to know something about the marine environment in the geographical area considered which is that between latitudes 10°N and 30°S, including the East African

islands. The marine environment of the states in this area are basically under the influence of common current systems. The environment can conveniently be divided into the following parts: nature of the reef; nature of the currents; cyclones; and nature of the tides.

Nature of the reef

The region is endowed with well developed coral reefs in most coastal areas. The coral reef, one of the most productive areas of the shallow coastal waters offer among the best habitats to marine organisms.

All corals are found in warm water with temperature ranging from 15°C to 39.5°C with optimum growth occuring between 25°C and 29°C and salinity range from 30‰ to 45‰ with optimum growth occuring in the range of 34‰-36‰[9]. Corals do not flourish at the mouths of rivers because of the low salinities created by the fresh-water inputs and the sediments they bring along with them which injure the corals. Thus the reefs are discontinued at the mouths of rivers along the coasts.

The coral reefs on the coasts of the African mainland facing the Indian Ocean are not distributed uniformly along the entire coastline[10]. The Somali coast besides lacking developed mangrove environments has the poorest, patchy developed coral reefs. The poor coral growth is caused by the upwelling of cold waters which depress coral growth[11]. The reefs are well developed in the coasts of East Africa and in parts of Mozambique. The southern most coral reef on the eastern Africa coast is at Inhaca, Mozambique, though scattered ones occur as far south as Port Elizabeth, latitude 34°S[12]. The coral reefs are also well developed in western Madagascar but poorly developed on the eastern side of the island. Seychelles and Mauritius have developed coral reefs but with small lateral extents into the sea[13]. The lateral extent of the coral reef platform tends to be narrow around Mozambique and increases towards Tanzania where it achieves its widest size. In Kenya it becomes narrow and practically disappears at the Somali coast[14].

Nature of currents

According to Newell[15], the African continental coast in the south receives the south equatorial current (SEC), which branches into the northward and southward currents at 10°S. The northward flowing current called East African coastal current (EACC) begins moving northwards from Tanzania reaching as far north as the Somali coast where it is also called the Somali current during the southeast (SE) monsoon. During the northeast (NE) monsoon the EACC does not reach the Somali coast because it meets with the reversed Somali current from the Indian subcontinent which is also called the north equatorial current (NEC) near Lamu to form the equatorial counter current (ECC). ECC flows seaward (away from the continent) and exists only during the NE monsoon, the time when it is formed.

The other current formed after the SEC diverts and flows southwards at 10°S is called the Mozambique current. It begins moving southwards from Mozambique. The zoogeographical significance of these currents will be mentioned later (figure 1).

Cyclones

East Africa's position is outside the cyclone zones which are 10°S - 30°S and 10°N - 30°N[16]. Cyclones are known to cause a lot of turbulence and make water turbid. Although cyclones do not stop reef growth the sediments which they stir up along the corals and the resulting turbidity stops the photosynthetic processes of the zoo-xanthellae, retarding coral growth. The absence of cyclones in East Africa may have, therefore, encouraged better development of the coral reefs.

The sea surface conditions of East Africa are however under the influence of the seasonal SE and NE monsoon winds. During the SE monsoon when the winds are stronger there is heavy wave action and the sea becomes rough, whereas during NE monsoon when the winds are relatively weak there is low wave action and the sea surface is calm.

Nature of tides

According to Stoddart the tides on the African continental coast facing the Indian Ocean between the equator and the Tropic of Capricorn have been described as semi-diurnal[17]. The same types of tides occur at Aldabra, the Comoros and the western coast of Madagascar. Other remaining portions of the continental coast experience mixed tides, mainly semi-diurnal, for example, at Seychelles, Mauritius and the eastern coast of Madagascar.

Lowest low tides occur during the hottest part of the day which is around midday in East Africa[18]. The low tides occuring during the NE monsoon around midday are the lowest: Thus they coincide not only with the hottest part of the day but also the hottest season. However, the long-term effects of these types of exposures to littoral organisms are yet to be investigated.

From the above, it is clear that there are three contrasting marine environmental zones along the African coast facing the Indian Ocean. These are:

1. The Somali marine environment;
2. East African marine environment; and
3. The east southern Africa marine environment.

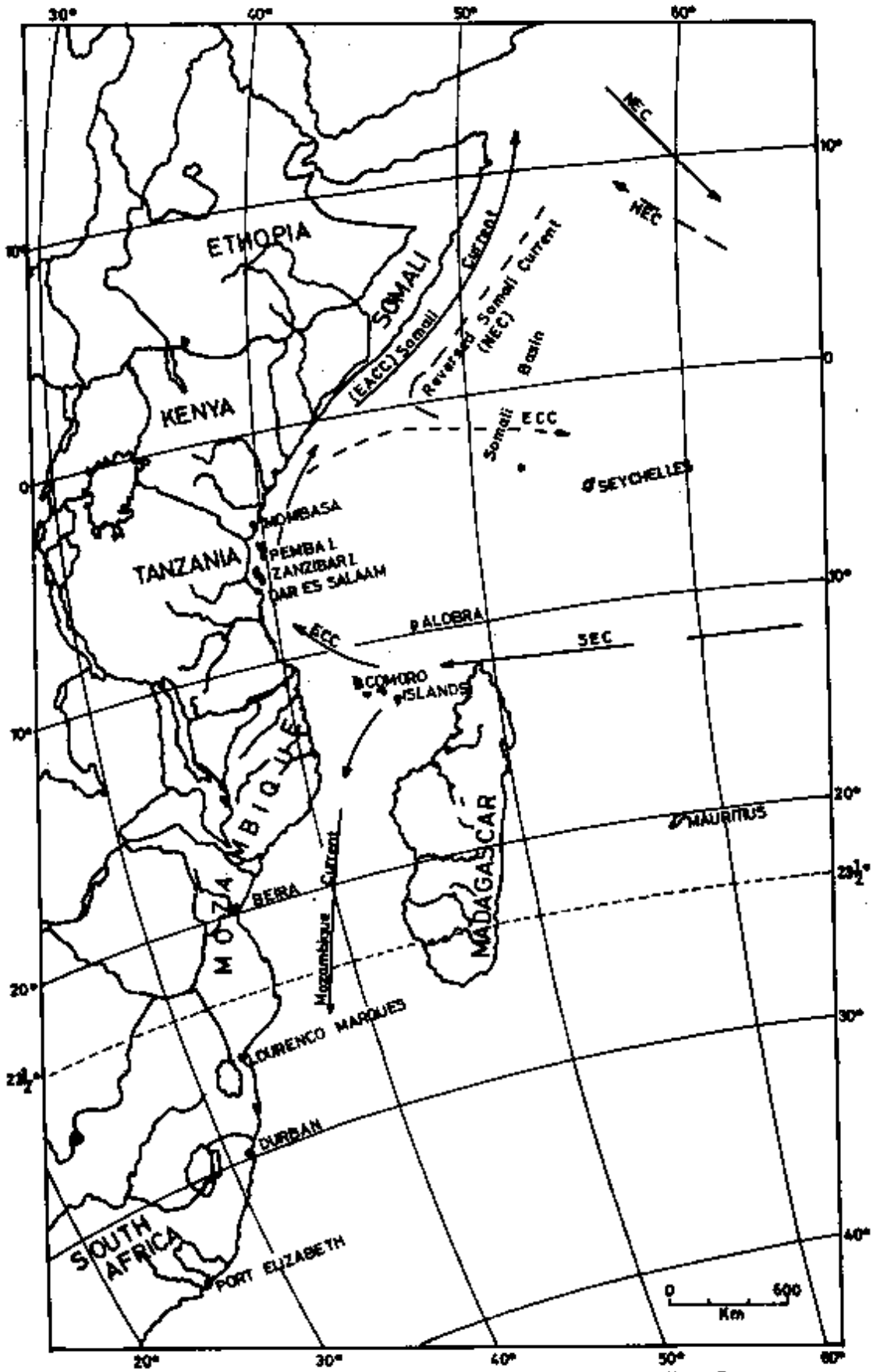

Figure 1. Current system in the African region facing the Indian Ocean.

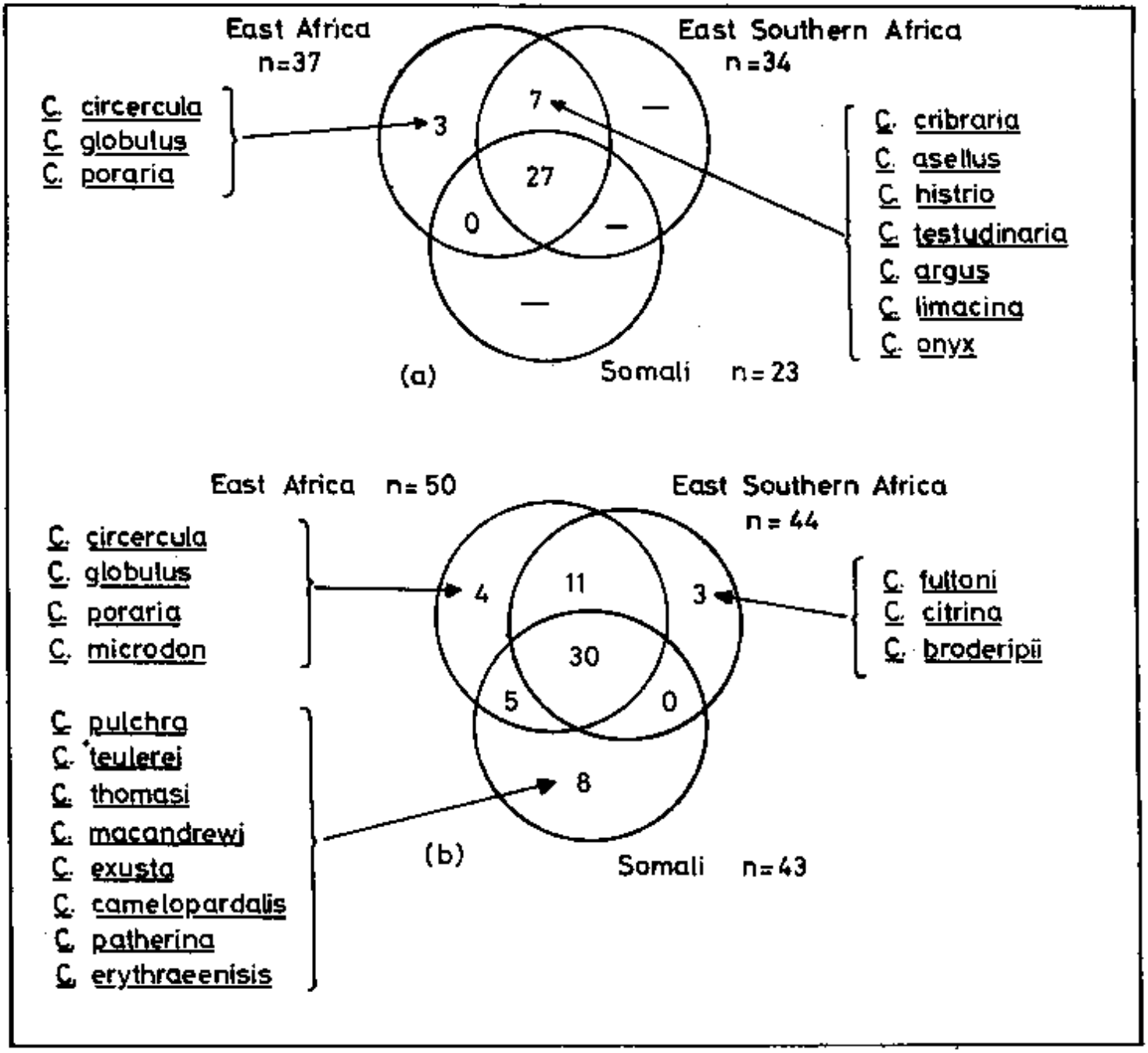

Figure 2. Distributions of the species of *Cypraea* along the African region facing the Indian Ocean:

(a) Distribution of Kenya commercial species.
(b) Distribution of the 61 species according to Burgess.

Table 1. Price range KShs. 1—5/- at Mombasa in 1982

Scientific name	Common name
Cypraea helvola	Linne Star cowry
C. *annulus* Linne	Ringed cowry
C. *caurica* Linne	Thick edge cowry
C. *isabella* Linne	Isabelline cowry
C. *moneta* Linne	Money cowry
C. *lynx* Linne	Lynx cowry
C. *poraria* Linne	Porous cowry
C. *caputserpentis* Linne	Snakes head cowry
C. *felina* Gmelin	Cat cowry
C. *teres* Gmelin	Long cowry
C. *kieneri* Hildago	False shallow cowry

Table 2. Price range KSh. 5—10/- at Mombasa in 1982

Scientific name	Common name
Cypraea carneola Linne	Flesh coloured cowry
*C. *tigris* Linne	Tiger cowry
C. *erosa* Linne	Margined cowry
C. *vitellus* Linne	Fallow deer cowry
C. *diluculum* Reeve	

*The species marked with an asterisk is also exported at a value Ksh. 1120/- per 1000 pieces

Table 3. Price range KSh. 10—20/- at Mombasa in 1982

Scientific name	Common name
*Cyprea *histrio*	Gmelin Harlequin cowry
C. *talpa* Linne	Mole cowry
C. *nucleous* Linne	Wrinkled cowry
C. *globulus* Linne	Globular cowry
C. *clandestina*	Linne False three banded cowry
C. *cicercula* Linne	—

*Exported at a value Ksh. 600/- per 100 pieces.

Table 4. Price range KSh. 20—30/- at Mombasa in 1982

Scientific name	Common name
Cypraea asellus Linne	Three banded cowry
C. *cribraria* Linne	Spotted cowry
C. *stolida* Linne	Square spotte cowry
C. *arabica* Linne	Arabica cowry
C. *mappa* Linne	Map cowry
C. *ziczac* Linne	Pale zigzag cowry
C. *limacina* Lamarck	False groved cowry
C. *chinensis* Gmelin	Violet spotted cowry
C. *scurra* Gmelin	Jester cowrie
C. *punctata* Linne	

The Somali marine environment is characteristically influenced by the annually reversing Somali current, cold upwelling and the northern high salinity waters it receives from the Indian subcontinent waters through the NEC. The latter waters do not reach too far into East Africa because they are deviated seawards (away from the continental coast) at about 2°S when the reversed Somali current meets with the EACC to form the ECC (figure 1).

The East African coast lies predominantly in the region between the ECC and SEC. Unlike the Somali coastal environment, the East African coastal environment between the latitudinal positions of the ECC and SEC is under the influence of the same warm SEC, namely, Madagascar current which flows southwards. However, much of the east southern Africa is in the cyclone zone. Towards Port Elizabeth, South Africa, the climate becomes more subtropical. All these make the east southern Africa coast environment different from the others. The implication of these facts on the zoogeography will be discussed later.

Dispersal of marine organisms

Currents, ships, floating objects and cyclones distribute various species to various areas. Currents are the major distributors of species by transporting their various larval stages[19]. Species dispersal by movement of non-planktonic adults from one area to another is not an efficient way because such adults may be blocked by barriers like sandy shores, rocky shores, mangrove swamps or creeks if they are not adapted for such habitats[20]. Since each species is adapted to occupy a particular habitat this has sometimes restricted them from occupying others successfully as in the following case. A rocky shore-adapted organism faces numerous problems in occupying a sandy shore and the latter will therefore always be a physical barrier for adults to cross. Creeks are also barriers for a shelled adult because the

Table 5. Price range KSh. 30—40/- at Mombasa in 1982

Scientific name	Common name
Cyraea mauritiana Linne	Black humped cowry
C. onyx Linne	Onyx cowry
C. args Linne	Pleasant cowry
C. testudinaria Linne	Tortoise cowry
C. turdus Lamarck	—

shell makes it to sink to the bottom where it may die from anoxic conditions.

Interest has grown for a relatively long period on how the marine flora and fauna species reached and colonised the East African marine habitats.

Taylor suggested that mollusc fauna on the African Indian Ocean continental coast were the result of larval transport by the SEC and were then transported along the coasts by the EACC which flows northwards and by the Mozambique current which flows southwards[21]. Later, Hartnoll also suggested that common occurence of some ocypodid and grapsid crabs in Tanzania and Madagascar resulted from the transport of larval stages of the crabs of the SEC[22] It is therefore widely believed that the current systems shown in figure 1 were responsible for the distribution of the species.

Zoogeography of Cypraea

Burgess described the geographical distribution of the cowries of the world. From his descriptions almost all cowries found in Tanzania are also found in Kenya.

According to Burgess 61 species of *Cypraea* are found along the entire coast from Somalia to Durban, South Africa, 37 of which are of commercial significance (figure 2). Of the 37 commercial species, 3 namely, *C. cicercula*, *C. globulus* and *C. poraria* occur in East Africa (Kenya and Tanzania) and 7 others namely, *C. assellus*, *C. oribraria*, *C. histrio*, *C. testudinaria*, *C. argus* *C. limacina* and *C. onyx* occur commonly in East Africa and east southern Africa.

The distribution of the 61 species in the three contrasting environments, i.e., Somali coast, East African coast and east southern Africa coast reveals a very interesting pattern. Despite the contrasts in the environments, the following 30 species commonly occur throughout the three coastal environments: *C. helvola*, *C. annulus*, *C. moneta*, *C. caurica*, *C. isabella*, *C. diluculum*, *C. caputserpentis*, *C. lynx*, *C. tigris*, *C. erosa* *C. felina*, *C. talpa*, *C. vitellus*, *C. mauritiana*, *C. nucleus* *C punctata*, *C. chinensis*, *C. kieneri*, *C. teres*, *C. scurra*, *C. stolida*, *C. clandestina*, *C. owenii*, *C. marginalis*, *C. fimbriata*, *C. staphylaea*, *C. ziczac*, *C. arabica*, *C. mappa* and *C. turdus*.

The presence of some of these species in the Somali coast suggests that they may not be entirely coral reef-associated. The high number of the species (49.2%) that

Table 6. Categories to show how common or rare the *Cypraea* spp. are based on the natural history records and current preliminary investigations

Very rare	Rare	Fairly rare	Common	Very common
*C. hirundo**	*C. owenii**	*C. Chinensis*	*C. caurica*	*C. annulus*
*C. microdont**	*C. punctata*	*C. onyx*	*C. mauritiana*	*C. moneta*
*C. bistrinotata**	*C. marginalis**	*C. clandestina*	*C. lynx*	*C. tigris*
*C. contaminata**	*C. depressa**	*C. teres*	*C. histrio*	
*C. nebrites**	*C. cicercula*	*C. asellus*	*C. vitellus*	
*C. gracilis**	*C. globulus*	*C. erosa*	*C. carneola*	
	C. turdus	*C. cribraria*	*C. caputserpentis*	
	C. poraria	*C. arabica*	*c. helvola*	
	C. ziczac	*C. scurra*	*C. diluculum*	
	C. staphylaea	*C. mappa*	*C. isabella*	
	*C. lamarkii**	*C. testudinaria*	*C. talpa*	
	*C. gangranosa**	*C. argus*	*C. felina*	
	*C. fimbriata**	*C. limacina*		
		C. nulceus		
		C. kieneri		
		C. stolida		

*Not seen during the commercial survey.

commonly occur in the entire area suggests that they exhibit uniformity[23].

Eleven species are commonly found in East Africa and east southern Africa: *C. argus, C. asellus, C. contaminata, C. cribraria C. depressa, C. histrio, C. larmackii, C. limacina, C. onyx, C. owenii and C. testudinaria*, while five are commonly found in the East African and the Somali coasts: *C. bistronotata, C. gangranosa, C. gracilis, C. hirundo* and *C. nebrites*.

East Africa and east southern Africa commonly share more species than do East Africa and the Somali coast. The differences in number of species commonly shared may be due to the time veligers are released. Those species whose veligers are released during the NE monsoon and fail to find suitable substrates before the currents meet, may be deflected away by the ECC. The same is true of veligers moving southwards through the Somali region during the NE monsoons. Thus whether a species releases its planktonic reproductive stages during either the SE or the NE monsoons it is important to know whether it has any bearing on its zoogeography. Throughout the year, Kenya may receive through the EACC the northward bound larvae from Tanzania. Local inshore currents predominantly tidal currents and active swimming of veligers may disperse the larvae against the direction of the major currents but this may not be possible on a wider geographical scale. It is not yet clear how the interaction of inshore and offshore currents (Madagascar current, EACC and Somali current) influence veliger settlement in the inshore waters.

Kenya and Tanzania have many species in common possibly because they are in the same environmental zone that allows larvae carried northward from Tanzania to survive and settle.

Conservation

The successful occupation of a habitat by a species is as a result of a long-term process, involving a lot of tolerance. There is, therefore, a need to ensure that these community structures are maintained over time, taking care that there is no uncontrolled exploitation.

Shell collection is a time immemorial activity that has over recent years grown from basically a non-commercial business to a lucrative profit making activity. According to Endean[24] global mollusc shell collection for sale rose rapidly after the Second World War, encouraged by increasingly attractive prices. There is, therefore, an imminent danger that mollusc communities and their related chains may be depleted if not properly managed.

Although there may be a recovery, some habitats will only be successfully colonised after the complex biotic and abiotic processes are completed. Such a colonisation will also depend on the availability of veligers. The fewer the veligers, the lesser the chances of full recovery. Due to the limitations caused by habitat restrictions to adults, both the endemic and non-endemic forms require careful exploitation.

Since the veligers released are carried by currents and may even settle across political boundaries, there is a need to ask ourselves about the effectiveness of our management programmes if neighbouring countries do not carry out any conservation measure.

Such questions are important in as far as we know that Kenya is a recipient of various larvae from Tanzania through the EACC which continually flows northwards[25]. Due to the fact that Tanzania and Kenya have very many species in common and are in a similar environmental zone, both countries should jointly prepare conservation strategies to ensure that the East African species stock is not depleted. Such strategies should ensure among other things that there are enough adults to produce the veligers. Conservation measures should also ensure the protection of corals because it is corals that support the rich variety of species[26].

Kenya is keenly interested in conserving national resources and this is evidenced by the creation of relevant ministries and institutions that deal with environmental issues: creation of parks and reserves: formation of voluntary organisations or societies, e.g., Wildlife Clubs of Kenya and East African Natural History Society of Kenya. There is therefore, the necessary potential to encourage and determine the endangered or threatened species (table 6).

Acknowledgements

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