The Black Clam, *Villorita cyprinoides*, Fishery in the State of Kerala, India

N. SUJA and K. S. MOHAMED

Introduction

The State of Kerala (Fig. 1) leads India in the production of clams with estimated annual landings of about 66,000 tons (t) in 2008–09. The black clam, *Villorita cyprinoides* (Family, Corbiculidae) (Fig. 2) contributes 45,000 t, or about two-thirds of this total (Narasimham et al., 1993; CMFRI Annual Report, 2009). Most of the annual production of black clams, about 25,000 t, comes from Vembanad Lake where almost 4,000 fishermen harvest them. The other clams harvested in the lake are the grey clam, *Meretrix casta*, and to a much lesser extent, the yellow clam, *Paphia malabarica*, and another, the *Sunetta scripta*. Vembanad Lake also has large sub-fossil deposits of black clam shells that are mined for commercial use (Kripa et al., 2004). The lake also has commercially-important finfish. The fisheries for the clams and the finfish provide the major livelihood for coastal communities around the lake (Sathiadhas et al., 2004).

This paper provides an overview of the black clam fishery in Kerala including descriptions of the habitats, biology and ecology, demography of the fishing families, and the harvesting, processing, and marketing of the live clams and also the shell deposits. The information provided in earlier papers on these subjects by Laxmilatha and Appukuttan (2002), Sathiadhas et al. (2004), Arun (2005), Ravindran et al. (2006), and others are summarized. We conducted a survey to collect more detailed descriptions of these subjects and supplement them with photographs.

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ABSTRACT—The black clam, Villorita cyprinoides*, is the most important clam species landed in India. The State of Kerala has been, by far, the leading producer of the species. Nearly all the landings, about 25,000 tons (t)/year are harvested in Vembanad Lake, the largest estuary, 96 km (54 mi) long, on the west coast of India. Nearly 4,000 fishermen harvest the black clams year-round. They harvest most by hand while diving in waters from 2.1–2.7 m (7–9 ft) deep. Each collects 150–200 kg (3–5 bushels)/day. Upon returning from the harvesting beds, the fishermen and their families cook the clams and separate their meats from their shells using simple sieves. Fishermen's wives sell the meats within their local villages and save some for their families to eat. The shells are sold through organized fishermen societies to various industries. A substantial quantity of sub-fossil black clam shells lies buried from 22–50 cm (9–20 in) beneath the lake sediments. They are dredged in a controlled manner and sold to the same industries. The stocks of black clams seem to be declining slowly in the southern part of the lake because the water has been getting fresher, but they are not declining in the northern half. A likely threat to the landings may be a lack of fishermen in the future.*

Survey Methods

Our observations were made of the activities in eight villages in Vembanad Lake and in the lake itself. The villages are where most of the families that are supported by the black clams live. The villages were Chempu, Vaikom, Vechoor, Kuthiathodu, Thycattussery, Muhamma, Aaryad, and Kavalam distributed among the districts of Kottayam and Alappuzha (Fig. 1). Our survey was conducted by making observations and interviewing the fishermen and their families using standard techniques (Fowler, 2002) and further documenting the observations with photographs. The villagers said that this was the first survey of its kind related to them.

Vembanad Lake and Black Clam Habitats

Vembanad Lake is the largest brackish water lake on the west coast of India. Narrow and sinuous in the north and much broader in the south, the lake parallels the coast of the Arabian Sea. It is 96 km (54 mi) long and 14 km (8 mi) wide at its widest point and has a surface area of 24,000 km^2. It consists of estuaries, lagoons, some man-made canals, marshes, and mangroves (Ravindran et al., 2006). The salinity ranges from 0.3 at the lower end of the southern part to 18 ppt near the inlets. The water temperature ranges from 26° to 33.5°C. Aside from some shipping channels that are maintained to a 10–13 m depth, the major portion of the lake has a depth range of 2–7 m (Menon et al., 2000). Two major rivers, the Pamba and the Periyar, and four smaller rivers that all originate in the Sahya Mountains to the east, flow into the lake. The lake opens to the Arabian Sea in two locations, one at Azheekode, which is at least 100 m (325 ft) wide and fairly deep, and the other at Cochin Gut, which is 450 m wide (Menon et al., 2000). At the two openings, the rise and fall of tide is from 0.6 to 0.9 m. The bottom sediments where the black clams occur are a mixture of fine sand, clay, and silt, and they extend over wide areas. Broad wetlands surround the lake. They are included in the Wetlands of International Importance, as defined by the Ramsar

Convention for the Conservation and Sustainable Utilization of Wetlands in 2002, in part because they support more than 20,000 waterfowl in the winter. The lake also has a wide variety of finfish and invertebrates (Table 1).

Kerala has a tropical climate with two rainy seasons, the heavy southwest monsoon from June to September and the lighter northeast monsoon from October to November. The total annual rainfall is about 300 cm (120 in). The maximum water temperature, at least 30°C, occurs during pre-monsoon and the minimum is 24°C which occurs in August (Ravindran et al., 2006). During the monsoon, the flood discharge from the rivers can reach 2,500 m^3/sec (Ravindran et al., 2006). Outside of the monsoons, the weather is dry and winds are light. Known for its scenic beauty, Vembanad Lake and its surroundings attracts many tourists.

The lake has both brackish and nearly freshwater environments. They are separated from each other by a man-made bund or barrier, the Thanneermukkom, which runs across the middle of the lake (Fig. 3). Constructed in 1974 and functional since 1976, it is about 2 km (1.25 mi) long. The government keeps it open to allow brackish water to flow to the southern part of the lake for six months, but then closes it for six months, December to May, each year. Its purpose is to prevent the entry of substantial amounts of salt water to the southern area because it would reduce the production of rice in paddy fields off the southeast side of the lake. The paddy fields are extensive, totaling about 50,000 acres in area. When the water remains fresh or nearly fresh (less than 0.5 ppt), two crops of rice can be produced each year. In some of the lowest land areas in this part of the lake, rice is grown for half a year for one crop, and then shrimp are grown in the same location for half a year. The shrimp larvae swim into the areas during the highest tides and remain to feed and grow to harvestable sizes. However, the black clams cannot reproduce well in low salinity and large areas in this southern region, otherwise suitable for the clams, cannot support them now. The average size of the black clams has

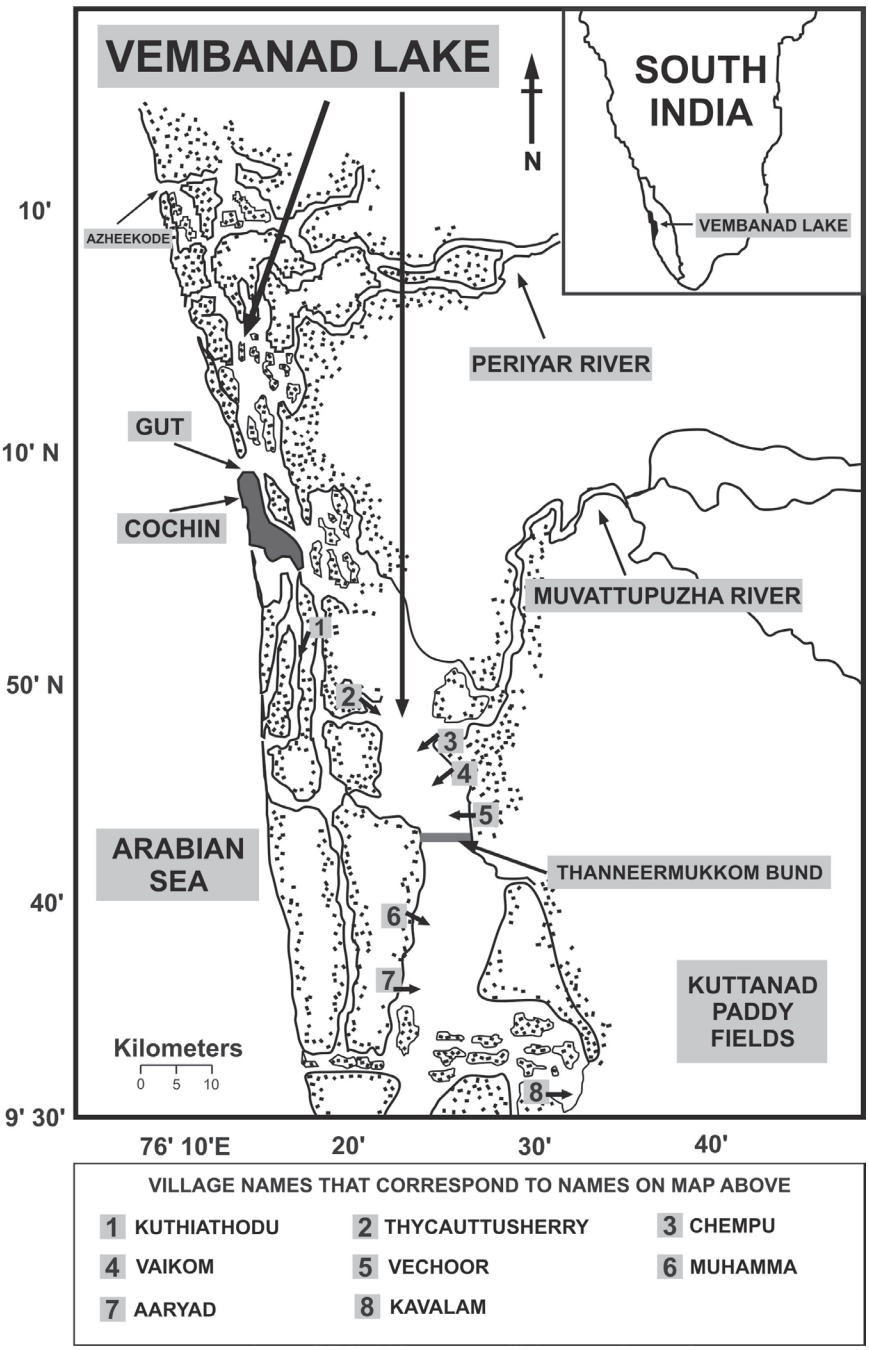

Figure 1.—Vembanad Lake showing the locations of its black clam fishing villages. The location of the State of Kerala in India and Vembanad Lake are shown to the upper right.

diminished also. In the northern region, salinities from 8 to 18 ppt are usual in March to May but the water salinity can be as low as 0 ppt during the monsoon.

The floodwaters during the monsoon rains carry silt and clay into the lake. Especially in the southern section of the lake, live black clams in some habitats have been buried by the sediments. Over the centuries, this annual process has led to the accumulation of large deposits of black clam shells. The

Figure 2.—The surface of a pile of black clams, *Villorita cyprinoides*. The clams have a height of 30 to 40 mm (1.2 to 1.5 in).

Figure 3.—The Thanneermukkom Bund (barrier), 2 km (1.25 mi) long, that divides Vembanad Lake into two sub-equal halves. A roadway for automobiles runs along its top.

shells, black when the clams are alive, become white after being buried. The deposits are found varying in thickness from 22 to 50 cm (9 to 20 in) and are under a sediment burden of 20 to 60 cm (8 to 24 in). The shells are also found under some lands that surround parts of the lake including the rice paddy fields. This shows that the lands were once part of the lake, but were covered by sediments (Rasalam and Sebastian, 1976).

The estuarine finfishes consist of 3 groups of species, 1) those originating from the sea, 2) true estuarine species, and 3) freshwater species (Table 1).

Table 1.—The most important commercial species of fish, crustaceans, and mollusks in Vembanad Lake (Ravindran et al., 2006).

Fish
Grey mullets, *Mugil* spp. and *Liza* spp.
Sciaenids, *Daysciaena albida*
Sea bass or Cock-up, *Lates calcarifer*
Milkfish, *Chanos chanos*
Marine catfish, *Tachysurus* spp.
Half beaks, *Hemiramphus* spp.
Tarpon, *Megalops cyprinoides*
Pearl spot, *Etroplus suratensis*
Crustaceans
Penaeid prawns
Palaemonid prawns, *Macrobrachium* spp.
Edible crab, *Scylla serrata*
Mollusks
Black clam, *Villorita cyprinoides*
Grey clam, *Meretrix casta*
Yellow clam, *Paphia malabarica*
Sunetta scripta

The estuarine and freshwater species reproduce in the estuary, whereas the marine finfish and the shrimp reproduce in the saline, cooler water of the Arabian Sea, but migrate back to the estuary after completing their pelagic development. Finfish distribution thus is related to salinity. During the monsoons, the salinities decline and the estuarine fish catches dwindle, but in the pre-monsoon and post-monsoon periods, marine finfishes move into the upper reaches where good salinity prevails for them (Ravindran et al., 2006).

Some industrial wastes pollute areas in the southern region. Some comes from the retting (soaking in water to remove soluble chemicals) of coconut coir. Sewage pollution from urban and semi-urban townships along the banks also causes pollution especially by coliform bacteria. The spread of the African weed, *Salvinia auriculata*, and the water hyacinth, *Eichhornia crassipes*, in several areas of the lake hampers the clam fishermen for nearly 2–3 months each year (Laxmilatha and Appukuttan, 2002).

The wind-protected nature and shallowness of Vembanad Lake permits clam harvesting and finfishing throughout the year. About 21,000 fishermen use stake nets and dip nets to catch the finfish. These two types of nets catch about 70% of the finfish. Most finfishing is done at night when larger catches can be made. The total annual production of finfish are 3,300 t, prawns 3,500 t,

paleamonids 100 t, and crabs 300 t for a total of 7,200 t, of which 6,700 t came from north of the barrier and 500 t from south of the barrier. Marketing of finfish is done through mini on-the-spot auctions in the main landing centers or by direct sales by fishermen (Ravindran et al., 2006).

Black Clam Biology and Ecology

The black clam attains sexual maturity at a length of 11 to 15 mm (0.4 to 0.6 in). It does not show sex reversal or hermaphroditism. It spawns twice a year, from May to August, and from January to late March. A change in salinity is the most important factor that triggers spawning, while temperature is not a factor. The optimum salinity for spawning is about 10–12 ppt. Induced spawning is possible by a sudden drop in salinity or an increase in pH. The construction of the Thanneermukkom Bund has drastically affected its reproduction pattern (Arun, 2005). The black clam attains a length of 30 mm by the end of its first year, and during its second year it grows an additional 11 mm (Nair, 1975). Most black clams are taken in salinity zones from 2 to 10 ppt (Ravindran et al., 2006).

Population densities of some small black clams, 2–8 mm (0.08–0.3 in) in height, were measured in October 1969. The densities were 4,620 clams/m^2 and 2,860 clams/m^2 in Veluthully Kayal and Vayalar, respectively (Rasalam and Sebastian, 1976). The black clams are located just below the surface of the soft bottom sediments.

Clam Fishermen

Demography

There are 32 fishing villages around Vembanad Lake. About 6,500 people are involved in the black clam fishery, 3,658 of these are fishermen and the remainder are their wives, children, and grandparents (Kripa et al, 2004; Sathiadhas et al., 2004). This fishery is their main source of income; some have other part-time jobs. Fishermen families are permanent residents of their villages. Among them, 52% live jointly with their parents and grandparents, while the remaining 48% belong to nuclear families.

Many fishermen have harvested black clams all their working lives and most have harvested for at least 25 years. The clam fishermen range in age from 24 to 48 years, but few young men have been entering the clam fishery. About 30% of fishermen had been harvesting for 10 to 25 years and 12% for less than 10 years. The oldest male fisherman was 79 years old, and the oldest woman harvester was 70 years old. About 58% of the fishermen were in the age group >44 years old, 40% in the group from 35 to 43 years old, and 2% in the group from 24 to 34 years old. The lack of interest in this occupation is mainly due to the hard work involved and the relatively low incomes that the clammers receive. Besides, young people have been receiving better education and can obtain other types of work that provide higher earnings and social status. Their fathers and forefathers had to do this type of fishing for survival and sustenance. Some had to take up clamming when the head or earning member of their family died.

Some outsiders who have no other work have come into the fishery recently. The number of workers in rice farming is declining because more work is becoming mechanized, and the production of coir is shrinking. Some of the excess workers have been working as clammers.

A lack of formal education is common in the clam fishing villages because the educational opportunities are relatively poor, mainly because the schools do not have sufficient teachers. Fishermen who completed the lower grades totaled 23%; high school, 12%; and college, 3%. A fisherman's family cannot afford to have sons and daughters in school through high school. Their sons tend to remain in school, whereas the education of most girls ends at the primary level. Girls are confined to household work until adulthood and marriage. Only 2% of fishermen have attended training or seminars relating to the clam fisheries and only 3% of the fishermen are aware of the government's research and development organizations.[1]

The families rarely send or receive letters or other types of mail. They contact distant relatives or friends by telephone using public booths. The villages do not have movie theaters or other entertainment facilities.

Socio-economic Conditions

The families live under the clutch of low incomes. The problems for the fishermen include: low literacy, low productivity, and little mobility (Sathiadhas et al., 2004). Black clam fishermen support their families on earnings of Rs.150–200(US$3.33–4.44)/day. These are lower than the earnings of tradesmen (Carpenters, masoners, and plumbers), who earn about Rs.300(US$6.67)/day. With their meager earnings, few fishermen have bank deposits or other forms of savings, and many have debts as large as Rs.14,000 (US$311). A large part of their earnings can go for repayment of large interests charged by moneylenders.

The dwellings of the fishing families are located near the lake shores (Fig. 4). The fishermen earn sufficient money for adequate shelter, clothing, and simple foods, but none have automobiles and extra money for entertainment or travel. Most families have their own houses with at least 200 sq ft of living space (Sathiadhas et al., 2004); others rent their homes. The houses are constructed of cement: about 65% of houses have tile roofs, 17% have concrete roofs, and 14% have thatched roofs, and 65% are

[1]Several organizations are associated with research and development in fishery related subjects. For example, The Central Marine Fisheries Research Institute (CMFRI), Central Institute of Fisheries Technology (CIFT), Central Inland Fisheries Research Institute (CIFRI), Central Institute of Brackish Water Aquaculture (CIBA), and Central Institute of Freshwater Aquaculture (CIFA), all under the Government of India have developed certain technologies for fishing, aquafarming, and product development. The CMFRI developed and popularized the hatchery technology of green mussels, *Perna viridis*, and brown mussels, *P. indica*; pearl oyster, *Pinctada fucata*; edible oyster, *Crassostrea madrasensis*; and the shrimp, *Penaeus indicus*. Hatchery technologies for clown fish, *Apogon* spp., and sea cucumber, *Holothuria scabra*, have also been perfected. The CIFT develops fishery technology and new products. The technologies developed are passed on to the fisheries by their extension departments.

electrified (Kripa et al., 2004). About half of the families have a television, a refrigerator, and a radio. Villagers relieve themselves in cement out-houses. A pit dug between two wooden bars kept parallel on the sand collects the wastes. Flushing toilets are rare (Sathiadhas et al., 2004).

The fishermen's families have limited personal possessions. Their furniture consists of 1–2 wooden tables, and 2–3 plastic or wooden chairs. Most houses have a few photographs of relatives and a religious picture on the wall. Women possess 3–4 good saris to attend social gatherings or functions and 2–3 dresses to go to market to sell the clam meat. Men have two shirts to go clam harvesting and 2–3 good shirts to attend social functions. Most people wear sandals while some go barefoot. Families purchase 1–2 new dresses for their children each year, mainly during the festival season or to attend the marriage of relatives. Toys rarely are given to children. Fishermen do not have the money to purchase items such as women's sanitary napkins, hearing aids, spectacles, or vitamin supplements. Some fishermen have bicycles. Men obtain haircuts in neighborhood barber shops for the fee of Rs.8 (US$0.17) and women get haircuts by their relatives or neighbors free of cost.

Food is prepared in aluminum or steel pans using firewood or sawdust purchased at the rate of Rs.19 (US$0.42)/bundle or kilo, which lasts for 2 days. About 22% have gas or kerosene stoves for cooking.

Fishermen and their families eat simple meals. They obtain water from public taps and wells and family members carry it home in plastic buckets or pots. Families spend about half their incomes on food. The principal foods are rice and fish (Sathiadhas et al., 2004). Children eat rice 3 times a day along with some boiled or fried fish or black clams. Adults, especially women, eat food twice a day. Medical doctors have urged people to eat the meat of the black clams for the nutrition it provides. Rice, fish, and other foods are purchased on a daily basis, mostly on credit from nearby shops in small quantities. Some fishermen grow vegetables, such as beans, okra, eggplant, and yams, in their yards. Among fruits, they eat limited quantities of locally-grown mangoes, banana, and papaya. The money needed during the festival season is saved by cutting down on food expenses in the preceding 3–4 months. Some fishermen have goats and chickens. They add goat milk to their tea and sell the remainder to neighbors for about Rs.14 (US$0.30)/liter. The families with chickens give their children 3–4 eggs/week to eat, and they sell the remainder to local shops. Women keep the income from such sales for emergency expenses.

Figure 4.—House of a Vembanad Lake black clam fisherman.

Illnesses are treated at home or in a local primary health center. When mildly sick, fishermen consume herbal tea or they inhale steam from waters containing the leaves of some locally available medicinal plants such as 'tulsi' (*Ocimum sanctum*), basil, and eucalyptus along with dried ginger and pepper. They sometimes purchase analgesic medicines from local medical stores without a doctor's prescription but after consulting the pharmacists. They rarely visit hospitals because they cannot afford the expenses, but they appear to be healthy and have especially good teeth. They use toothpaste or charred rice bran when brushing their teeth.

Fishermen spend much of their free time resting and socializing with their relatives and neighbors. The villagers are used to being consistently among a group of people from the time they are infants and then through their entire lives. While family matters are prominent in the discussions with women, men are interested in political issues and playing cards.

Marriages are arranged by parents and relatives. Couples are aware of family planning, learned mainly from government-aided primary health centers. Couples now usually have 2–3 children; whereas several children per couple were standard in previous generations. Babies are born in primary health centers with the aid of a government doctor assisted by nurses.

Black Clam Fishery

The clam fishermen are organized into professional societies. There are eight black clam societies distributed around the lake in the Kottayam and Alappuzha districts. Fishing rights and licenses for harvesting in the lake are issued by the State Department of Mining and Geology. They in turn issue licenses for harvesting to their members. The total harvesting area leased out to the societies comprises about 4,582

acres (7.2 sq mi) (Laxmilatha and Appukuttan, 2002).

The societies handle the sales of the clam shells. They were formed in the late 1940's and early 1950's, so the clam shells could be sold in an organized manner. The societies purchase the clam shells from the fishermen at a rate of Rs.600–700 (US$13–15)/ton. Out of this, the societies pay Rs.25 (US$0.55)/t as a royalty to the State Mining and Geology Department. The society also takes 6 rupees (US$0.13) and sets it aside for every 30 rupees (US$0.66) they pay to the fishermen. The money is used for the benefit of the fishermen: 1 rupee is for time lost during the monsoon, 1 rupee pays for the national festival, 2 rupees for the regional festival, and 2 rupees are for emergencies, such as financial trouble of the fishermen.

Most of the society members, at least 70%, harvest clams on a typical day. The financial maintenance of each society is supported by the sale of the shells. Societies are not involved with sales of the clam meat. They are run by a president, who is elected by the fishermen every 5 years, and a secretary. The president is a full-time clammer. His position is honorary and he does not receive a salary. Presidents and secretaries handle finances and keep records (Fig. 5).

A typical fisherman began harvesting when he was about 18 years old and continues most of his working life. He had been in school until about 15 years old and from 16–17 helped his mother and father process the clams. He began going with his father, who showed him how to harvest the clams for a few months and then he went by himself. He is able to harvest through life until the age of about 60 years.

There are no government regulations[2] for the fishery, except that juvenile clams should not be taken. This is only lightly enforced, and there are no shellfish officers. The black clam areas were once open to all fishermen, but gradually local groups have been trying to keep other fishermen out of their harvesting areas, and the fishery in the lake is becoming more compartmentalized.

In one village, Udayamperoor, local women perform all the activities from harvesting, processing, and selling to consumers. Under State government authority, male fishermen gather juvenile clams from deeper waters and transplant them to shallow zones along the shores, where the women can wade at low tide and harvest them by hand. The State government has given each village Rs.15,000 (US$335) to do this. Over 3–4 days, nearly all the fishermen in the local area collect and stock the seed. They have been doing this every 3 years for at least the past 10 years. The women harvesters have agreed among themselves that each one will harvest no more than a certain quantity of market-sized clams each day. They also do not allow women from other villages into their harvesting areas (Laxmilatha and Appukuttan, 2002; Sathiadhas et al., 2004).

The black clam fishery does not show signs of over-exploitation of the clams. The long-term effects of the Thaneermukkom Bund and industrial pollution may lead gradually to some decline in their abundances.

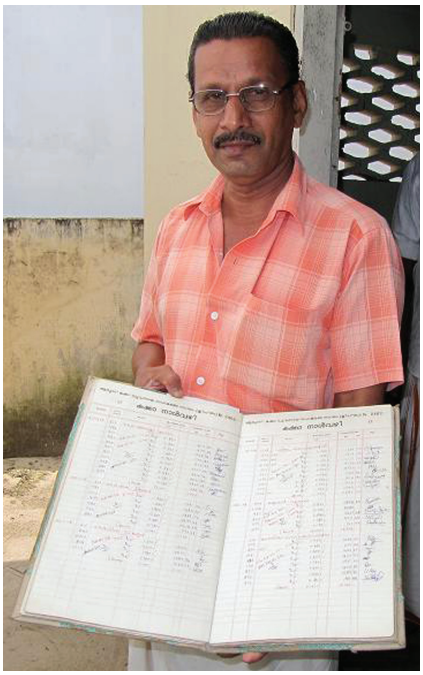

Figure 5.—The president of a fishermen's society with his ledger of fishermen and sales of black clam shells.

Fishing Methods

Harvesting of the black clams continues throughout the year (Kripa et al., 2004). Each fisherman harvests black clams about 20 days a month. Sundays are an off-day, fishermen cannot harvest in stormy days during the June to July monsoon months, and some days are taken to rest. The principal harvesting method is by diving under water and collecting the clams by hand. The water is about 2.1–2.7 m (7–9 ft) deep. The fishermen usually travel to harvesting sites by paddling their canoes that are constructed of planks with corked seams and about 8 m (26 ft) long. Most fishermen own their canoes, while others rent them at a rate of about Rs.20 (US$0.44)/day. Their harvesting gear also consists of a bamboo pole, about 15 ft long, and one of two types of cylindrical baskets ("koodu"). The more common type is about 16 cm (6 in) high and 45 cm (18 in) in diameter; the other is higher and narrower (Fig. 6). Baskets are made of strips of bamboo. The strips are 5–6 mm (0.22 in) wide and the space between them is 2 cm (0.8 in). The baskets are constructed by the fishermen and last about 2 years.

The harvesting sites with abundant clams vary somewhat among years according to spat settlement (Laxmilatha and Appukuttan, 2002; Ravindran et al., 2006). Fishermen harvest in a different site almost every day, and it often takes them about 1.5 hr to paddle each way. At about 5 a.m., after a breakfast that usually consists of a cooked dish of wheat flour and rice and maybe some rice soup, they leave home with a container holding 2–3 l of drinking water.

Fishermen can also get to harvesting sites by having their society hire a motor boat to tow them usually in groups of 15–25 canoes (Fig. 7) (Laxmililatha and Alloycious, 2001). These sites will have a large abundance of clams and they are at the farthest distances from home. Fishermen have to pay for this

[2]The state government of Kerala has notified during July 2010, the Kerala Inland Fisheries Bill, which calls for separate licensing for any type of fishing activity in its inland waters.

service. The charge for each fisherman is Rs.20 (US$0.44) for the towing and Rs.20 (US$0.44) extra if they need to rent their canoe. The fishermen leave for the harvesting area at about the usual time, and they can harvest up until noon (Laxmilatha and Appukuttan, 2002). The captain of the motor boat sounds a horn and they all quit harvesting. Fishermen usually harvest in a group, so if one is injured or sick, he can be assisted by the others. In practice, they alternate between paddling and being towed every few days. A comparison of the total time paddling each year and the time being towed shows they paddle for 8 months and are towed for 4 months in a year.

Figure 6.—The two types of baskets that Vembanad Lake fishermen use to hold their black clams while they gather them by hand from the lake bottom. The larger basket is the one more commonly used. The spacing in the bottoms and walls allows fine sand and mud and also the juvenile clams to fall from the baskets.

Figure 7.—After being towed to a site by a motorboat (foreground), the fishermen are looking for places to set their poles and begin harvesting black clams.

Upon reaching a harvesting site, they push their pole 30 cm (12 in) into the bottom, tie their canoe to it, and slide into the water with their basket tied to their waste. To get to the bottom quickly, they grasp the pole, push themselves up chest high in the water and then go to the bottom feet first (Fig. 8 a, b). Their eyes are closed because they sting if left open. They fix their feet against the pole, stretch out their bodies with extended arms and fingers along the bottom, collect the dense quantities of clams lying just below the sediment surface with their fingers, scoop them to the pole, remove the basket from their waist, and pile the clams into it. The fishermen work quickly while underwater and can remain there for 20–40 sec each dive. They come up the pole to the surface, catch their breath, and descend to the bottom again. They stretch out again in another direction to bring more clams to their baskets. After about 10 (range, 7–12) such dives, they have gathered enough clams to partially fill their basket. With one hand beneath the middle of the basket and the other on the pole, they bring the basket and the clams to the surface. While holding the pole with their feet and legs, they shake the basket vigorously to wash out any sediments and seed clams, and then empty the clams into the canoe. The fishermen then descend again to begin refilling their baskets. If the clams are not abundant in the first location, the fishermen have to pull up their poles and place them in another location nearby.

In one harvesting location, the fishermen-divers do not use their fingers to gather the clams. Instead, they use an iron frame with a net (Fig. 9). They gather the clams in the net by dragging

Figure 8a.—A fisherman driving his pole into the fine sand-mud bottom. He will next remove his outer clothing, and enter the water, 2.1 to 2.9 m (7 to 9 ft) deep. He will gather the clams within his body and arms' length in a complete circle around the stake.

Figure 8b.—A fisherman ready to descend to the bottom and gather black clams.

the frame through the bottom surface. The clams are emptied into the canoe.

Another harvesting method is using a hand rake with a pole attached ("kolli" or "varandi") while standing in the canoe (Fig. 10 a, b). The pole is one inch in diameter and made of wood or iron. It lasts for 4–6 months. A new pole costs Rs.500–600 (US$11–13). If the fisherman becomes tired raking, he can switch to diving. The net used with a rake eventually wears out and needs to be changed about once a month; a new one costs Rs.500 (US$11.00). Diving is easier work than raking, but raking gathers more clams per unit of time. Divers have shown that a rake obtains nearly all the clams in a trench and also that new generations of clams will set in the raked trenches.

After about 4–5 hr of harvesting, the fishermen have collected 300–400 kg (3–5 bushels) of black clams. They paddle back home and berth their canoe at a landing quay near their house by about 2 p.m. The quays are about 2 m (6–8 ft) wide and are stone-lined depressions in the shoreline where persons

Figure 9.—This is how some fisherman-divers hold their rectangular scoop with net attached before they push it into the bottom and drag it to gather black clams. This type of collector is not used by most fishermen.

can stand in water knee-to-thigh deep on a solid foundation (Fig. 11a). Upon arrival, they and their wives rinse the clams again to wash out any remaining mud, and then they carry the clams in baskets or a wagon to the processing site in their yards (Fig. 11b).

Processing Live Clams

Processing of the clams is usually done in the fishermen's yards at home on the same afternoon. The fishermen often separate the seed clams and stock them on the bottom in front of their homes for further growth, a practice termed relaying or semi-culture. This is done a few months before the monsoon season (Kripa et al., 2004).

The clams to be processed are put in large aluminum tubs with some water obtained from the edge of the shore. The clams are boiled for about 45 minutes with a fire fueled by wood and dry coconut leaves. The wood is purchased from people who collect it and sell it for about Rs.500 (US$11.00)/load. This quantity of wood will last about a month. The cost is about Rs. 20 (US$0.44)/day. Wives, children, and grandmothers may help with the fire (Fig. 12). While being cooked, the clam meats become loose from their shells. The cooked clams, about one pailful at a time, are lifted onto a sieve hung between trees.

Figure 10a.—Fisherman holding a hand rake used from a canoe to harvest black clams. Its teeth are 7.5 cm (3 in) long; there are 70 teeth; its nylon mesh netting has holes 1.5 cm (0.5 in) wide; the pole is 5 m (16 ft) long; weight hand rake is 6.8–9 kg (15–20 lbs). A complete new rake costs about Rs.1, 000 (US$22).

Figure 10b.—Close-up of hand rake for harvesting black clams showing some of its teeth and net to hold the clams.

The mesh size of the sieve is chosen to hold the shells but it allows the meats to fall through to the ground (Fig. 13). Some other fishermen use large bowls with holes of appropriate size instead to shake out the meats (Fig. 14). A plastic sheet has been stretched out beneath the sieve to collect the meats as the fishermen alone or with his wife shake the sieve back and forth for a few minutes. Afterward, the shells are tossed onto a pile next to the sieve. Then one pailful after another is lifted onto the sieve and shaken. Usually 2–3 tubfuls are needed to process the entire harvest. All the clams are cooked and sieved by about 5 p.m. The meats then are taken to the quay at the shore, washed in another sieved plastic bowl and then poured into an aluminum tub (Fig. 15). The ratio of meat to shell weight is 1 to 10; the wet meat percentage varies from 9 to 14% (Laxmilatha and Appukuttan, 2002). Each fisherman and his family produce about 14 kg (30 lbs) of meat and 130–140 kg (300–325 lbs) of shells on his best harvesting days. They produce less on the days when the weather is stormy or when the fisherman feels tired or weak. They attempt to harvest and process the clams six days a week.

Marketing Black Clam Meats

Fishermen's wives usually sell the meat. Most is sold in the local village door-to-door, where it is included as an important component in their evening meal for its high nutritional value. The households are close together, 50 to 100 m apart. The meat is held in an aluminum tub that is carried on her head (Fig. 16). She uses a weighing balance or container of a specific size to measure the quantity of meat. A typical purchase for a customer (who takes it in a bowl) weighs 0.5 or 1.0 kg and it sells for Rs.15 or 30 (US$0.33 or 0.66). She sells to 30–40 houses within 3 hr and is finished by dusk, at about 8 p.m. One wife began processing clams and selling the meats when she was 20 years old. She continued doing it for 50 years until she was 70 years old.

A minority of the wives process the clams the day after their husbands harvest them. They rise from their sleep at 2 a.m. and begin cooking the clams by 3 a.m. They go to the market by bus at 7 a.m., carrying the clams on their heads. At busy locations, they stand at a bench with the clam meat in a vessel covered with banana leaves. The market charges them Rs.2 (US$0.044)/kg for using the space. A typical person purchases a kg (about 2 lbs). The wives use old newspapers, folded into a cone to hold the portions of meat. Sundays and holidays are the busiest sales days, and she can sell all the clams within 1–2 hr. The

wives arrive back home at about 10:30 a.m. Agents sometimes collect the meats directly from the fishing villages and sell them to retail food markets and large restaurants. The larger the meats the higher the price. The price of clam meat has remained stagnant for several years (Kripa et al., 2004). A kilogram of large meats brings about Rs.40 (US$0.88). During the past decade, the meats of the juvenile clams sometimes are sold to be used as an ingredient in the manufacture of food pellets used by shrimp farms and they are also fed to ducks. Fishermen receive Rs.5–10 (US$0.11–0.22)/kg for the juvenile clam meats.

The fishermen families usually keep some of the cooked clam meat to eat themselves as a means of saving money. Their staple foods are rice, fish usually caught in the lake, and tapioca with clams. Most fishermen families eat clam meats 1–2 times a day, 5–7 days a week. The meat is fried in oil obtained from mature coconuts. They also prepare dishes with the clam meat by adding tapioca, coconut, and green chilies. They commonly marinate the clam meat in a mixture of spices (red chili, pepper, and turmeric).

Marketing Black Clam Shells

The black clam shells are in high demand because the occurrence of limestone is scarce. The black clam shells are sold for Rs.800–Rs.1, 000(US$17.75–$22)/t. Out of this, the fishermen receive Rs.600–700 (US$13.30–15.50) (Laxmilatha and Appukuttan, 2002). The shell is used by industries that make cement, calcium carbide, and lime (for use on rice farms). The quantity of shells that go to the factories exceeds the quantity that goes for the manufacture of lime by about four times. The societies collect the shells from the fishermen's yards on a rotational basis, so every fisherman gets to sell his shells.

Orders from companies for the shells arrive at the societies every 2–3 days. One of the societies with 562 members handles about 500 t a month. When an order for shells is received, the society rents a large canoe (6 m long and 3 m wide) that is paddled by its 4-man crew of laborers by water to the fishermen's homes. The crewmen carry the shells from the yards on their heads in aluminum tubs or bamboo crates and dump them into the canoe. The quantities are measured by using a box in the canoe that holds 20 kg. The boat collects about one ton of shells from each of 12 fishermen's yards in a day. The collections from all fishermen yards take about 3 hr. The crew returns to the society shell depot, a wide yard on the shore, with the load and piles it. A truck from a company in neighbouring Tamil Nadu state collects the shells and brings them to its plant for processing. Each crew collects shells 6 times a month, so it collects 72 tons a month. The factories that purchase the

Figure 11a.—A fisherman and his wife are at a quay near their house and yard. They are removing their black clams from their canoe, washing and putting them into a cart to take them to the processing site in their yard.

Figure 11b.—A fisherman has just arrived from harvesting and his wife is carrying them to the processing site in their yard.

shells pay for collecting and transporting them.

The secretary of the society maintains a record of the quantity collected from each fisherman. The fishermen receive a fixed price of Rs.1,350–1,500 (US$30–33)/t for their shells. The society pays the fishermen each month whenever the fisherman requests it in a lump sum. During 2008–09, a total of 46,192 t of black clam shells worth Rs.57 million (US$1.21 million) were sold through the Kerala societies. The demand for black and white clam shells is stronger than the supply.

Four societies also handle the white (mined) clam shells. In one of the societies, the Vaikom Black Clam Industrial Co-operative Society, 400 members collect live clam shells while 50 members collect white clam shells.

Figure 12.—A grandmother is feeding dried palm leaves into a fire that is cooking part of the day's catch of black clams.

Figure 13.—A fisherman shaking the meats from the shells of cooked black clams he harvested earlier in the day while his wife watches. The meats fall onto a plastic sheet and the shells are tossed onto the pile to the right of the fishermen.

White Clam Harvesting

Large scale dredging for the white clam shells is practiced in Vaikom and Allappuzha. The subsoil deposit of white clams in the lake is estimated at about 4.5 million tons. The shells are taken at a rate of 41,000 to 69,000t/yr. The taking of the shell deposits is controlled by the government. Dredges are used where waters are about 3 m (8–9 ft) deep. One of the largest shell-dredging companies, Travancore Cements Limited Co. (TCL), uses a cutter suction dredger with a pumping capacity of 2,500 gal/min (Fig. 17). The volume of shell it brings up varies from 5 to 10% of the dredged material: water and solids. A filtering unit separates the shell from sand-clay and water (Ravindran et al., 2006).

The wash debris slides back into the dredged track, thus leveling it to an extent. Sand and other heavier particles settle immediately in the track. The trench gets deepened only to the volume of lime shell removed. Particles less than 100 microns, however, are carried with the water current. Depending on the current magnitude, particles finer than 100 microns settle slowly while the particles less than 2 microns do not really settle under natural conditions and cause mild water turbidity. The physical effect of the dredging on the quality of the adjoining water is minor and is limited to the immediate vicinity. The clam shell is transferred to a barge, taken to a shore site, and then by truck to the factory. The government limits the operation of the TCL dredger to 50 acres of bottom area/year (Ravindran et al., 2006).

During the operations, the dredging of bottom material also removes the benthic animals living on and in the sediment in the excavation site. Only the finfish can avoid the dredging site (Ravindran et al., 2006).

The white clam shells are also harvested by individual fishermen, who use hand rakes from their canoes. Each fisherman collects 250–300 kg of white clam shells/day (Ravindran et al., 2006).

Figure 14.—This fisherman's wife separates the meats from the shells of black clams by shaking a basket with holes of appropriate sizes.

Figure 15.—Before the black clam meats are sold they are rinsed of mud and any small shells are removed by hand at a quay.

Figure 16.—This woman is about to walk to various homes in her village selling the day's harvest of black clam meats, about 14 kg (30 lbs), on a rainy day.

Figure 17.—A barge mining white clam shells, *Villorita cyprinoides*, from beneath sediments in Vembanad Lake.

There are 8 times more black clams collected than white clam shells in Vembanad Lake. The white shells bring a higher price than the black shells. The white clam shells are used to make white cement and some go to poultry farms for hardening egg shells.

Black Clam Fishery in Ashtamudi Lake

The black clams are harvested in relatively minor estuaries also, such as Ashtamudi Lake in Kerala (Fig. 18). Ashtamudi Lake lies 145 km (80 mi) south of Vembanad Lake and has an area of 12.4 sq mi. The lake is permanently open to the Arabian Sea and the Kallada River runs into the lake, giving it an estuarine environment. Its black clam fishery was described by Appukuttan et al. in 1988. The black clam beds extended over about 125 acres, though the clam distribution was patchy in many places. At least 150 people including 20–25 women harvested the black clams. From 75 to 90 canoes were used every day. The clams were gathered by hand-picking or with a rectangular metal frame attached to

a net bag. The frame is dragged on the bottom to gather the clams. The clams are emptied into canoes or submerged baskets. One person with a canoe got about 225 lbs of clams/day. The meat was sold to local households and in nearby markets. Women harvested the clams in wading waters. About 100 additional women, who worked in nearby cashew factories, harvested the clams when there was no work in the factories. There was a good demand for the clam shells. Annual production from the lake was estimated at about 5,000 to 6,000 t of black clams.

Declining Trend in Young Fishermen

It can be inferred that far fewer fishermen will be available to harvest the clams in 20 to 30 years from now, because the younger fishermen comprise a small percentage of clam fishermen and few teenagers wish to earn their livelihoods diving for black clams (Fig. 19). If this takes place, more efficient harvesting methods will need to be developed to provide consumers with this clam meat and the shells.

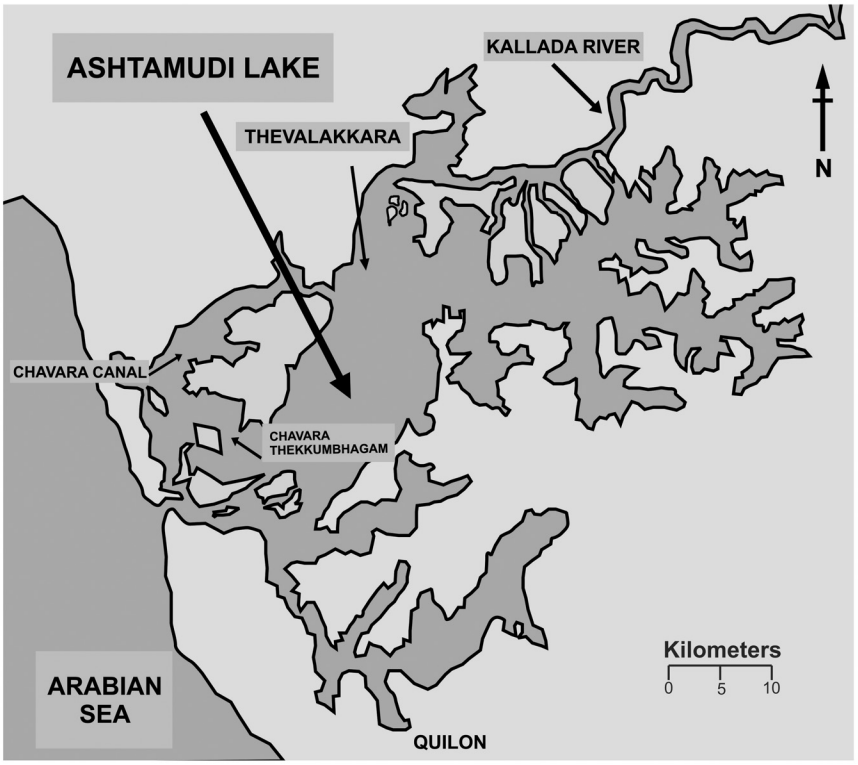

Figure 18.—Ashtamudi Lake showing the black clam harvesting areas.

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Figure 19.—Most boys nowadays do not wish to follow the work of their fathers who became fishermen for black clams.

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Above: Fisherman holds a black clam that he harvested. Right: Fisherman scooping water from his canoe upon reaching a dock at the end of the day. Basket for holding the clams he harvested from Vembanad Lake and parts of his diving pole, paddle, and black clam harvest are visible in the foreground.