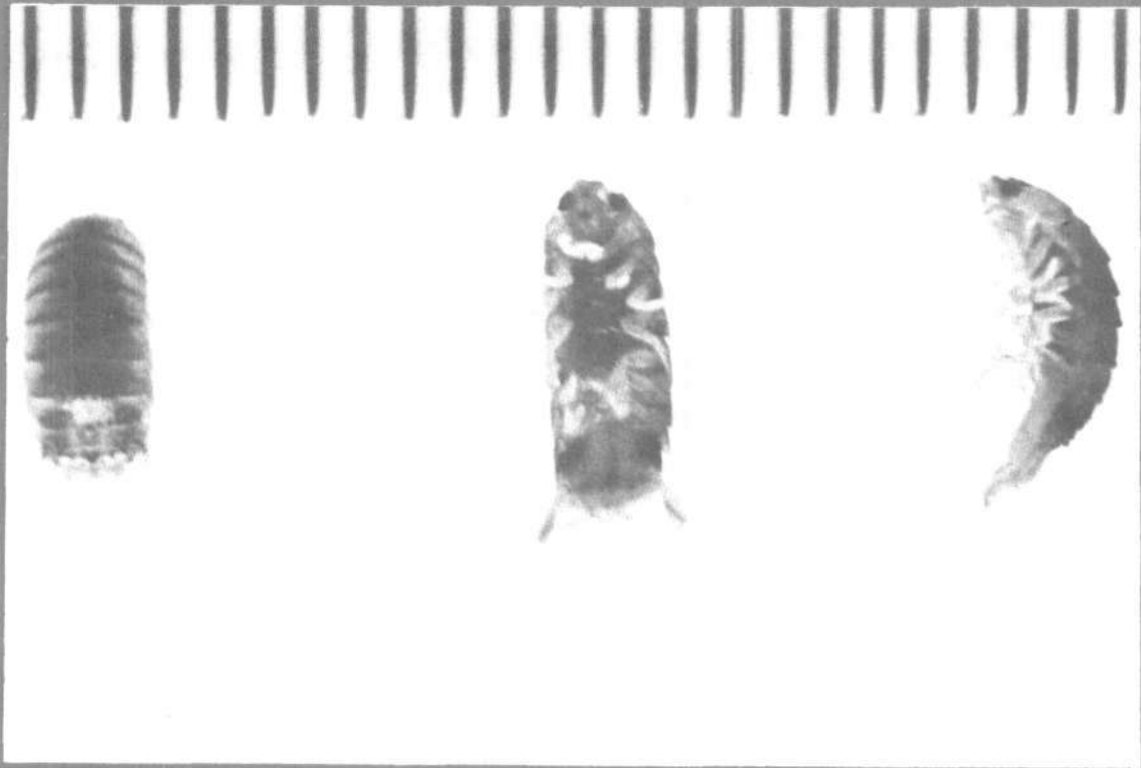
ISSN 0254-380 X

समुद्री मात्स्यिकी सूचना सेवा
MARINE FISHERIES INFORMATION SERVICE

No. 131 AUGUST 1994



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केन्द्रीय समुद्री मात्स्यिकी अनुसंधान संस्थान कोचिन, भारत CENTRAL MARINE FISHERIES RESEARCH INSTITUTE COCHIN, INDIA

भारतीय कृषि अनुसंधान परिषद
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

STUDIES ON THE INFESTATION OF AN ISOPOD CRUSTACEAN, *CIROLANA FLUVIATILIS* IN SOME PARTS OF THE COCHIN BACKWATERS, KERALA

K.J. Mathew, G.S.D. Selvaraj, T.S. Naomi, Molly Varghese, N. Sridhar, Manpal Sridhar, Geetha Antony, K.S. Leela Bhai, R. Anilkumar and K. Solomon

Central Marine Fisheries Research Institute, Cochin - 682 014

In July 1994 reports appeared in the media about the large scale occurrence of a tiny 'ant-like fish killer' in the Kumbalangi-Perumpadappu area of the Cochin backwaters causing threat to the aquatic living resources.

The CMFRI initiated an investigation on the problems and the following report presents the results of the study.

The Cochin backwaters and the Kumbalangi-water enclosure

The northern part of the Vembanad Lake forms the Cochin backwaters which open into the Arabian Sea at the Cochin barmouth (Fig.1). Although several islands situated in the northern part of the lake divide and sub-divide the lake system at several places, there is reasonable tidal flush which replaces the water to a great extent diurnally. At the Kumbalangi - Perumpadappu area, the backwater is in an enclosed condition with a rather narrow opening into the main lake (Fig.1). This narrow opening which is about 300 m wide is partly blocked for the last four years by the earthern bunds (about 65 m long on each side) (Fig.2) laid on either side of the opening at Perumpadappu and Kumbalangi. These earthern bunds act as approach roads to the bridge that is being constructed. These bunds have restricted the free in and out flow of the tidal water to a great extent thus making the water in the enclosed area to a near stagnation condition. The bridge under construction is to have nine pillars which will further restrict the tidal flow. The isopod menace according to the local people has started since the construction of the bunds.

The 'Arippan'

The organism causing disturbance to the fishes and prawns is an isopod identified as *Cirolana fluviatilis* which belongs to the class Crustacea, order Isopoda and family Cirolanidae. It is called as 'Arippan' in Malayalam, the local language.

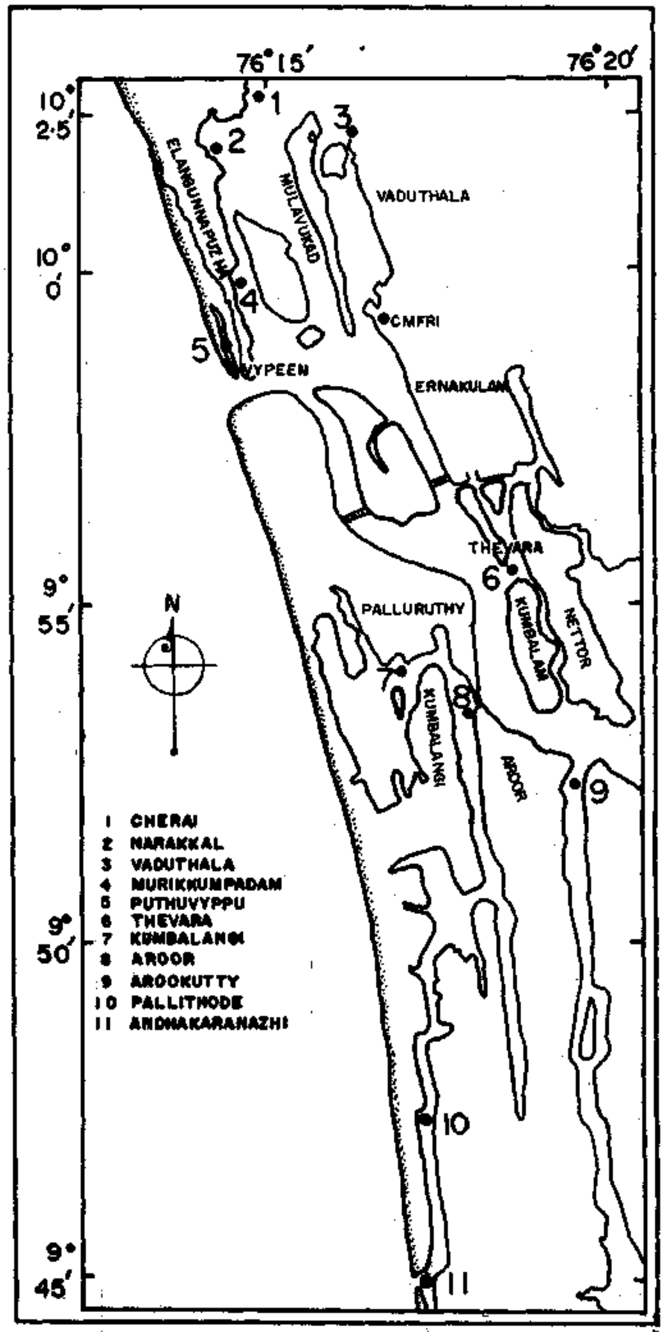

Fig. 1. Map of Cochin backwaters showing the isopod infested area and the sampling stations.

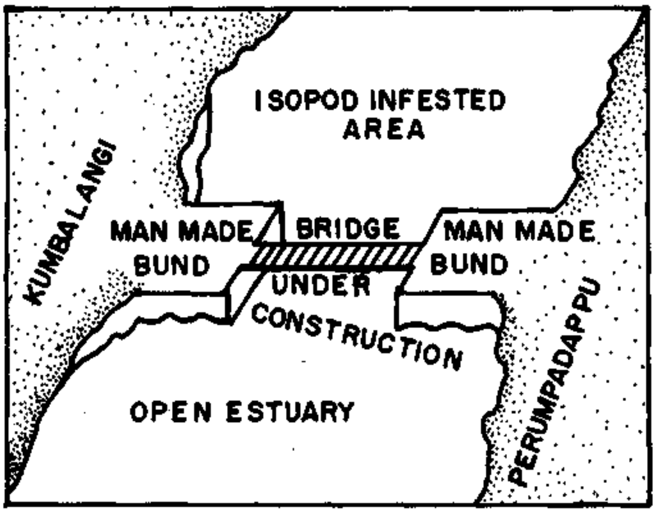

Fig. 2. Diagrammatic representation of the disposition of the earthern bunds which partially block the tidal flow into and out of the Kumbalangi water enclosure.

Fig. 4. A collection of *C.fluviatilis* kept ready for ling experiment.

This isopod (Figs. 3 & 4) is commonly found in the Cochin backwaters. They have also been reported from the Chilka Lake in Orissa and from Madras and Mandapam in Tamil Nadu. A diagrammatic figure of the animal along with its diagnostic body parts is given in Fig. 5a-h. The isopod attains a maximum length of 9.3 mm as observed during the present studies. Body somewhat dorso-ventrally compressed with a convex dorsal side and has an oblong ovate shape.

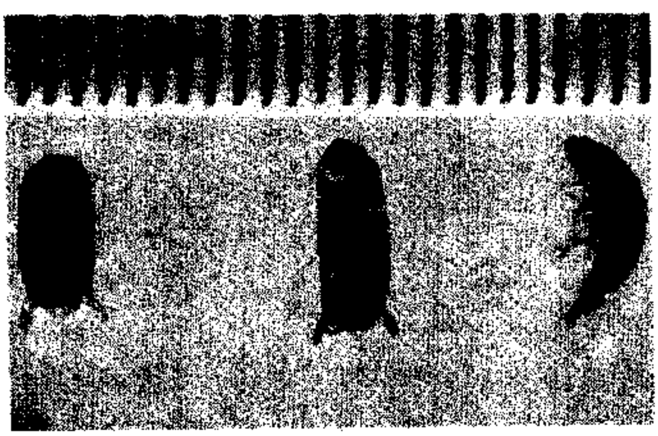

Fig. 3. Dorsal, ventral and lateral views of *C.fluviatilis* (scale in mm).

Materials for the study

Hundreds of live specimens of *C.fluviatilis* were collected on 14.7.'94 from the Kumbalangi area where the infestation is said to be the maximum. The specimens could be collected easily from the baits (flesh of prawns or fish) attached to the crab nets in operation. (It is common experience of the fisherfolk that baits for catching crabs from the infested area if put for longer time are fully eaten away by the isopod. The time taken for devouring depends on the number of isopods which attack the prey). Since mud is the normal habitat of these animals, mud samples were collected using a Van-Veen grab to study their population density, the associated organisms and to analyse the sediment for its various physical and chemical properties. Water samples were also collected from the area for measuring temperature, salinity and dissolved oxygen. In addition, samples were collected from other parts of the Cochin backwaters for the purpose of a comparative study (Fig.1).

Hydrology

The hydrological features of the investigated places are given in Table 1. The water temperature ranged between 24.8°C and 27.8°C, while the salinity had a range between 2.0‰ and

TABLE 1. *Hydrological features observed at different stations covered during the survey*

Station No.	Stations	Temperature (°C)	Salinity (‰)	Dissolved O_2 (ml/l)
1	Cherai	24.8	2.0	1.060
2	Narakkal	26.0	3.0	1.641
3	Vaduthala	25.3	2.0	3.180
4	Murukkumpadam	26.0	3.0	2.524
5	Puthuvyppu	26.0	3.0	4.190
6	Thevara	26.5	3.0	3.029
7	Kumbalangi	27.8	3.0	4.089
8	Aroor	27.6	4.0	2.473
9	Arookutty	27.8	2.0	3.988
10	Pallithodu	27.5	4.5	5.225
11	Anthakaranazhi	26.7	10.5	3.282

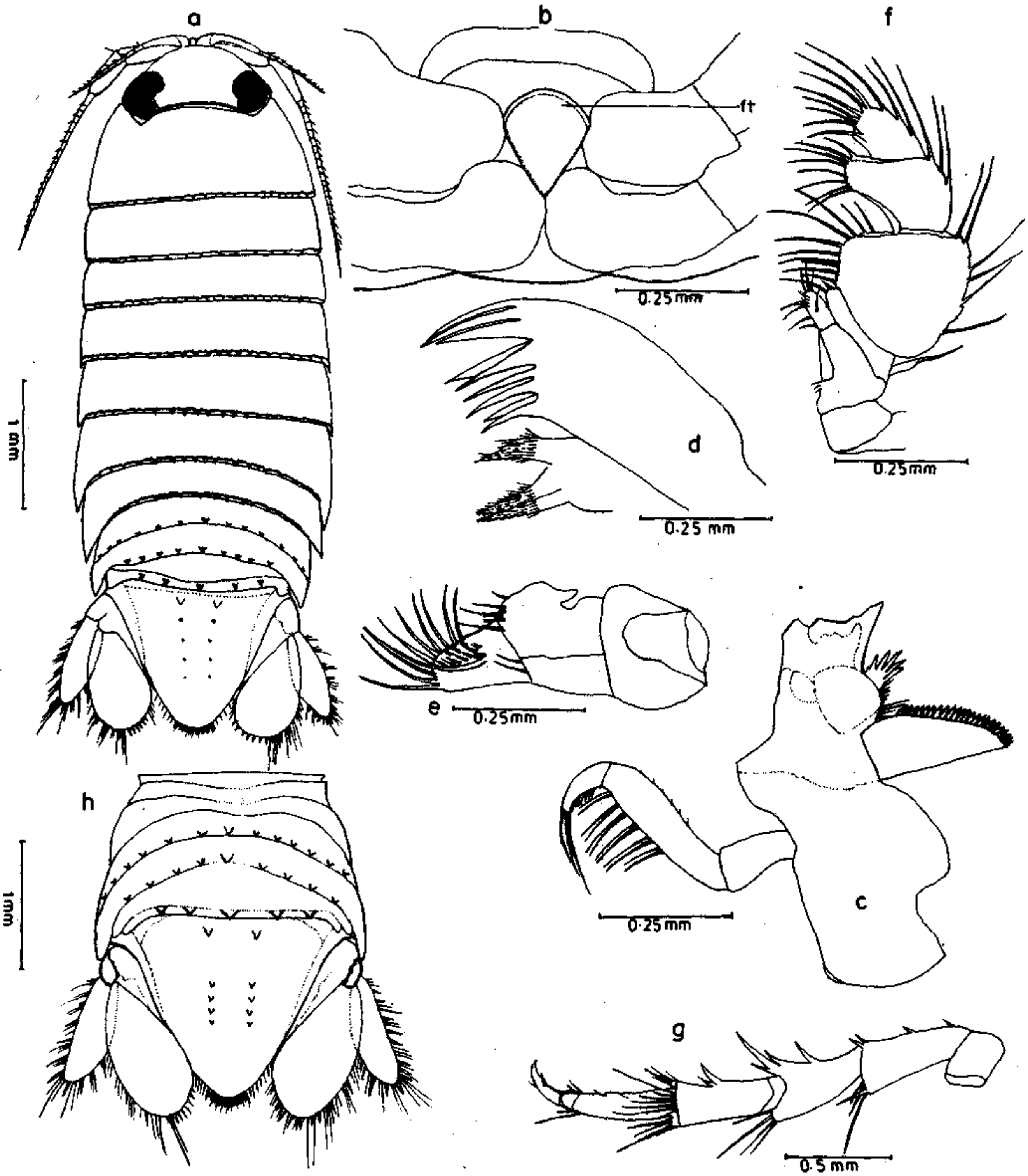

Fig. 5. The diagnostic features of *C. fluviatilis*. a. dorsal view, b. ventral view of head showing the frontal lamina (f.1.), c. mandible, d. first maxilla, e. second maxilla, f. maxillipede, g. seventh peraeopod, h. dorsal view of pleon, telson and uropods.

10.5‰. The dissolved oxygen ranged from 1.060 ml/l to 5.225 ml/l.

The mean water temperature in the Kumbalangi waters (infested area) was 27.8°C which was the highest when compared to the other places during July and salinity registered a value of 3.0‰ and the dissolved oxygen content was 4.089 ml/l.

Low oxygen values of slightly more than 1 ml/l were obtained for stations 1 & 2 (Fig.1) which were north of the Cochin bar mouth. However, these were areas where rich population of *C.fluviatilis* and other associated fauna were obtained from the heaps of bottom mud.

The three year average monthly temperature and salinity for the Cochin backwaters as studied by Cherian (*Bull. Dept. Mar. Sci. Univ. Cochin*, 1978, **9**: 1-14) are given in Fig. 6. The temperature varied from 27.77°C in July to 31.87°C in April thus showing an annual difference of 4.1°C only. On the other hand the salinity ranged over a wide scale, with the lowest value of 0.77‰ in July and the highest of 33.33‰ in April. Thus it is seen that while the highest values for both temperature and salinity were in April, the lowest values of both the parameters was in July. *C.fluviatilis* being highly tolerant to wide range of salinity (results of salinity tolerance test are given elsewhere), the Cochin backwaters with all its seasonal variations in salinity is still a favourable habitat for this isopod.

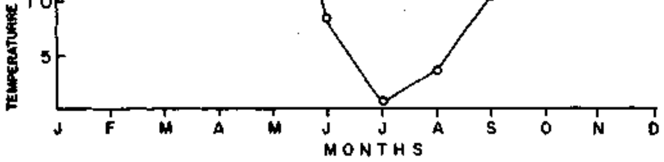

Fig. 6. Monthly mean values of temperature and salinity for the Cochin backwaters (source : Cherian 1978. *Bull. Dept. Mar. Sci.*, **9** : 1-14).

Sediment analysis

The bottom sediments collected from the isopod infested area and elsewhere in the estuary were analysed for some important parameters and the results are given in Table 2.

TABLE 2. *Properties of sediments collected from Cochin backwaters*

Station No.	Stations	pH	Organic Carbon (%)	Salinity (ppt)
1	Cherai	7.40	1.53	1.02
2	Narakkal	7.55	0.93	2.55
3	Vaduthala	7.49	0.23	0.26
4	Murukkumpadam	7.57	2.51	3.83
5	Puthuvyppu	7.69	3.32	1.92
6	Thevara	7.59	2.91	4.08
7	Kumbalangi	6.72	3.22	3.06
8	Aroor	7.88	1.58	.2.30
9	Arookutty	7.87	0.00	0.26
10	Pallithodu	7.51	0.00	1.53
11	Anthakaranazhi	7.44	1.80	8.17

While the pH of the sample collected from Kumbalangi, the isopod infested area, was slightly acidic (6.72) all other samples were alkaline. The organic carbon yielded high value of 3.22% at Kumbalangi while it was much less in other areas except at Puthuvyppu where it was 3.32%. At some places where the bottom sediments were either of pure sand or of dredged mud, no organic carbon was detected. The salinity of the mud showed a range between 0.26 and 4.08 ppt. The interstitial salinity value for Kumbalangi area was 3.06 ppt which was quite normal for the area during the southwest monsoon season. It is observed from the present study that the isopods flourished in conditions of low pH and high organic matter.

Habits and behaviour

These isopods, benthic in habit, live on and inside the bottom sediments in the shallow waters. However, for foraging purpose they may even swim freely in water with the help of their fan shaped abdominal appendages. The presence of the food is easily sensed by the animals even from a distance and they are quickly drawn to the food materials.

C.fluviatilis feeds on live or dead organisms especially wood borers, foulers, polychaetes and nematodes. They are also found to feed on weak or dead prawns and fishes, fish baits, fish and crustaceans trapped in nets and even dead human bodies floating in water. They attack en masse and eat away the prey in no time. The mouth parts of the isopod are well equipped for a predatory carnivorous life (Fig. 3).

In the laboratory the isopods were fed with prawn flesh. As soon as the bit of prey was dropped into the water, these isopods were found swimming fast towards the food from a distance. When live prawns were put in a trough containing a few hundreds of these isopods, they were soon attacked and immobilised. To start with, the attack was on the eye and the eyestalk and also on the ventral side of the thorax and abdomen (Fig.7). As soon as the isopods started nipping the live prawns they were found to make violent jerking movements to ward off the pests. However, the prawns could evade the isopods for a short while only and as they became stressed and weak they had to submit themselves to the attackers and thereafter it was an attack en masse. The isopods devoured the soft prawn body from all possible directions (Fig. 8-11) and soon they penetrated into the body eating up the flesh in an astonishingly faster rate. What left in the end was the chitinous exoskeleton devoid of a speck of flesh (Fig. 12).

Fig. 7. A live prawn under attack. At first the attack is on eyes, at joints of body segments and on the ventral side.

The live fishes were not found easily attacked by *C.fluviatilis* because of their swimming mode of life and fast movements. But once the fish was dead or in a weak condition, the isopods spared no time to collectively attack it and in the end clean bones and scales alone remained.

In the laboratory the specimens were found migrating above the water mark of the containers when the water was highly polluted with putrified animal matter. In order to find out their ability

Fig. 8. The attack intensifies as the prawn resists.

Fig. 9. After death of the prawn the isopods enter the body through all possible ways.

Fig. 10. Now most of the pests are inside the shell. A fish under attack is seen on top.

to survive outside water, a few specimens were kept out of water in wet as well as dry condition. The specimens kept in just-taken-out of water condition survived for 2-3 hrs without again immersing in water. On the other hand those kept after drying with blotting paper survived for

Fig. 11. What remain at the end are the clean shells and bones.

1-2 hrs only. This study indicates that these isopods need moisture on their body for survival, and they can live for longer even with a tiny droplet of water held between their appendages.

Habitat and assoicated fauna

The *C.fluviatilis* lives on or inside the mud where the water current is nil or moderate. According to the local folk, these isopods are capable of making mud heaps below the water with interspaces resembling ant-hills which may even protrude out of water in shallow areas during low tide. Mud samples collected from the infested area confirmed the tubicular nature of the surface mud to a depth of 8-10 cm and the tubular spaces are formed chiefly of these isopods and benthic amphipods such as *Corophium triaenonyx* and others.

A number of sediment samples from the infested and other areas were collected by using a Van - Veen grab and quantitative analyses were made for the organisms contained in the samples. Tubular mud formations were observed at Kumbalangi, Puthuvyppu and Narakkal areas where animals like isopods and amphipods were abundant. Therefore the tube forming habit could be attributed to these animals. Of these the amphipods are well known for their tube making habit. Incidently their population density was found to be several times more than the isopod (Table 3). Polychaetes were found only in smaller numbers and hence their role in the tube making process may not be significant. The association of these isopods with the tube dwelling benthic amphipods is not clearly understood.

Live isopods along with mud were kept in the laboratory for studying their tube making behaviour, if any. It was found that they have a tendency to bury into the mud and live there. Also they were found to make canalicular spaces inside the mud in the act of which the mud was seen pushed up. This finding gives positive evidence to the heap forming habit of isopods also. Therefore while one recognizes the role of isopods in the formation of tubicular mud, the role of amphipods should also be recognised.

A study of the benthic communities found in association with *C.fluviatilis* in the Kumbalangi and other areas has given some significant results. A variety of animals representing about 17 major groups formed the benthic fauna. The numerical density of the animals/m^2 is presented in Table 3.

Out of the 12 stations sampled in the Cochin backwaters, only 4 stations recorded the isopod. The maximum density of 1,82,400/m^2 was found at Narakkal canal. In Kumbalangi the animals were present at a rate of 1,19,850/m^2. The isopod was obtained in some numbers from Puthuvyppu and Cherai. One interesting feature observed was the presence of large population of amphipods along with the isopods. Their number went to the extent of 4,54,65,600/m^2 at Narakkal. Nematodes, polychaetes and bivalves were the other major benthic animals encountered.

An analysis of the data on benthic animals revealed that eventhough *C.fluviatilis* is a common isopod of the Cochin backwaters, its population is restricted to isolated pockets where probably the environmental conditions are congenial for its growth and multiplication. Wherever present it tried to establish by fast multiplication and probably this would have given it the diamensions of a menace.

Salinity tolerance

A laboratory experiment was carried out to understand the survival rate of the isopod in different salinities. Equal number of unacclimated *C.fluviatilis* of almost the same sizes was kept in equal quantity of liquid medium for 15 days without feeding and aeration. The specimens were kept in fresh water and in water of salinities of 3, 6, 12, 17, 23, 30, 35, 40, 45 and 50 ppt. The percentage of survival on each day of experiment is given in Table 4.

The experiment showed that these isopods can very well survive from fresh water to 40 ppt. of salinity beyond which the survival rate was

Table 3. *Numerical abundance of benthic organisms in the Cochin backwaters (No./m²)*

Sl. No.	Benthic groups	Stations										
		1	2	3	4	5	6	7	8	9	10	11
1.	Foraminifers	—	—	240000	4800	—	—	—	—	—	877980	808350
2.	Nemertines	1200	9600	—	—	—	—	—	—	—	1275	7200
3.	Nematodes	1200	2822400	—	14400	3115570	—	2400	—	750	30825	411525
4.	Polychaetes	15600	19200	1200	—	18750	1500	18450	6600	600	3600	19875
5.	Ostracods	—	—	—	—	—	—	—	—	—	—	—
6.	Copepods	1200	336000	—	4200	17100	150	24000	300	300	2850	1900
7.	Barnacle larvae	—	—	—	—	—	—	—	—	—	600	—
8.	Amphipods	33600	45465600	13800	—	509925	150	2243550	300	—	150	16500
9.	Isopods *(Cirolana fluviatilis)*	1200	182400	—	—	38550	—	119850	—	—	—	—
10.	Decapods	—	9600	—	—	4800	—	—	—	—	—	—
11.	Penaeid larvae	—	—	—	—	75	—	—	—	—	—	—
12.	Tanaidacea	—	273600	—	—	43575	300	4800	—	—	—	75
13.	Diptera	—	—	—	—	—	—	—	—	—	—	375
14.	Bivalves	26400	6115200	2400	38400	39300	150	5400	—	3900	97575	198300
15.	Gastropods	2400	—	—	12000	—	—	—	—	1050	11300	5775
16.	Fish larvae	—	—	—	—	75	—	—	—	—	—	600

Station names are given in Fig. 1.

TABLE 4. *Percentage survival of* C.fluviatilis *in different salinities*

Days	Salinity level (ppt)										
	0	3	6	12	17	23	30	35	40	45	50
1	100	100	100	100	100	100	100	100	100	50	0
2-5	100	100	90	100	100	100	90	100	100	30	0
6-8	90	100	90	100	100	100	90	100	90	30	0
9-10	90	100	90	100	100	100	80	100	90	20	0
11-12	90	100	90	100	100	100	80	100	90	10	0
13-14	90	100	90	100	80	100	70	100	90	10	0
15-16	90	100	90	90	70	100	70	100	90	10	0

poor. In 45 ppt, 50% mortality was observed on the first day itself. In 50 ppt and above salinities the animals died within a few hours. The results show that this isopod is a very sturdy organism having wide ranging capacity for salinity tolerance which indicates that they can survive for several days in adverse conditions even without food.

Tolerance to pH

The preference of *C.fluviatilis* to low pH as found during the present study necessitated to test their tolerance to wide ranging pH. An experiment was conducted by keeping equal number of animals in equal quantity of distilled water with manipulated pH varying from 4.04-9.04. The survival of isopods was monitored for 7 days at definite time intervals. The results obtained are given in Table 5.

TABLE 5. *Percentage of survival of* C.fluviatilis *in varying pH levels*

Days	pH level					
	4.04	4.90	5.92	6.86	8.05	9.04
1	0	100	100	100	100	100
2	0	70	100	70	100	100
3	0	30	90	50	100	90
4	0	20	90	50	90	80
5	0	10	90	50	80	80
6	0	10	90	50	60	60
7	0	10	90	40	40	50

The maximum survival was found at a pH of 5.92. Better survival was found also in higher pH of upto 9.04. Eventhough an acidic medium was preferred by the isopods, a pH level below 5.92 was found detrimental to them.

Oxygen consumption

In order to understand the capacity of *C.fluviatilis* to survive under decreasing oxygen level in the medium, two sets of experiments were conducted on their oxygen consumption under two different conditions. In the first experiment varying number of specimens of average 6 mm length were kept in separate dark bottles (closed) having the same quantity of water (125 ml) for a period of three hours, and the oxygen consumed during the experiment was measured. The results obtained are given in Table 6.

It was found that as the number of animals increased the rate of oxygen consumption per individual reduced which was a direct evidence of reduced metabolism under low level of dissolved oxygen. It is interesting to note that eventhough the dissolved oxygen level came down to the level of 0.126 ml/l at the end of the 3 hours experiment, the isopods were active which shows their ability to live under very low level of dissolved oxygen.

In the second experiment, same number of animals (25 Nos. each of average 8 mm length) were kept in five dark bottles (125 ml) from 1 to 4 hrs and the quantity of oxygen consumed was determined using blanks at different time intervals. The results obtained are given in Table 7.

In this experiment it was seen that the rate of oxygen consumption remained more or less same irrespective of the duration of the experiment. This is mainly because there was sufficient dissolved oxygen until the termination of the experiment for the isopods to live on. The two experiments show that these isopods can adjust and survive even under acute shortage of dissolved oxygen. The experiments also indicate that the oxygen consumption increases with increase in size of the isopods.

Eggs and hatchlings

The eggs are laid into a brood pouch of chitinous plates formed ventrally below the thoracic region in between the legs. Large number of females carrying eggs in their brood pouch were present in the samples. The egg develops and hatches out as a miniature adult. A female of 7.8 mm total length was found to carry 34 eggs inside the brood pouch. The diameter of the eggs ranged between 0.8 and 1.0 mm with the average size at 0.86 mm. Another female of 7.7 mm in total length was found to carry 21 young ones having a mean length of 1.5 mm. Eventhough the young ones were fully formed with distinct eyes and appendages, part of the yolk present in them was yet to be absorbed.

Biochemical and enzymatic studies

A few experiments were carried out on the

TABLE 6. *Rate of dissolved oxygen consumption by* C.fluviatilis *under different population density*

No. of specimens in dark bottles	Duration of expt. (hrs)	Diss.O_2 at end of expt. (ml/l)	Qty. of O_2 consumed in 3 hrs (ml/l)	O_2 consumption per hour (ml/l)	O_2 consumption per individual per hour (ml/l)
10	3	2.044	1.237	0.412	0.041
25	3	1.165	1.666	0.555	0.022
50	3	0.404	3.487	1.162	0.023
75	3	0.278	3.607	1.202	0.016
100	3	0.126	3.750	1.250	0.013

TABLE 7. *Rate of dissolved oxygen consumption by* C.fluviatilis *at varying length of time*

No. of specimens in dark bottles	Duration of expt. (hrs.)	Diss. O_2 at end of expt. (ml/l)	Qty. of O_2 consumed (ml/l)	O_2 consumption per hour (ml/l)	O_2 consumption per individual per hour (ml/l)
25	1	3.256	0.959	0.959	0.038
25	1.5	2.423	1.742	1.161	0.046
25	2	2.322	1.817	0.909	0.036
25	3	1.237	2.828	0.943	0.038
25	4	0.505	3.533	0.883	0.035

isopod to ascertain its biochemical composition and enzymatic profile so as to find out the possible correlation to its voracious feeding and also the metabolic activities.

Biochemical constituents: These were estimated for fresh as well as dried specimens. The various biochemical constituents estimated are given in Table 8. All the values given are averages of two or more estimates and are expressed as percentages of unit weight.

TABLE 8. *Biochemical constituents estimated in* C.fluviatilis *(average values)*

Parameters	Wet weight basis	Dry weight basis
Average weight (g)	0.020	0.013
Average length (mm)	7.000	—
Water content (%)	68.600	—
Dry matter (%)	—	31.400
Protein (%)	8.000	36.300
Lipid (%)	3.890	5.320
Carbohydrate (%)	0.237	0.386
Ash (%)	—	30.600
Fibre (%)	—	0.000
Non-protein nitrogen (%)	—	8.920
Chitin (%)	—	7.620
Phosphorous (%)	—	0.320
Calorific value (KJ)	—	1041.630

The water content in the samples averaged at 69% which is normal and agrees with the earlier finding. The protein content was quite high at 36%. The lipid content gave a value of 5.32% for the species.

The carbohydrate content was low at 0.39%. The ash content was high at 31% and this high value may be attributed to the chitinous exoskeleton of these animals which is composed mainly of minerals. Fibre was not detected. Non-protein content was observed to be around 8%. The isopod has a low phosphorous content of 0.32%. The calorific value as determined was 1042 cal/g.

Enzyme analysis: This was carried out to correlate the voracious feeding of *C.fluviatilis* to its metabolic activity. The isopods were fed with live prawns and fish meat. In addition, a set of starved animals were also included in the experiment since during starvation the digestive enzymes seemed to reach a low baseline value. The whole animals were assayed for trypsin, carboxypeptidase A, carboxypeptidase B, pepsin, acid protease and general protease activity. The total and specific activities of the enzymes are given in Table 9.

C.fluviatilis exhibited high activity of carboxypeptidase B and trypsin. Protease activity was also detected at pH 7.0 (general protease) and

TABLE 9. *Results of enzymatic studies conducted for* C.fluviatilis

Enzyme	Total activity		Specific activity	
	Fed	Starved	Fed	Starved
General protease[1]	114.00	88.00	11.670	12.100
Acid protease[1]	5.11	2.04	0.523	0.281
Carboxypeptidase A[2]	9.77	5.20	1.001	0.715
Carboxypeptidase B[2]	7.88	3.20	0.803	0.440
Trypsin[3]	1.46	0.70	0.150	0.138

1 = Total activity expressed as μM tyrosine produced/min/g wet tissue and specific activity as μM tyrosine produced/min/mg protein

2 = Total activity expressed as enzyme units/g wet tissue and specific activity as enzyme/mg protein

3 = Total activity expressed as μM nitroanilide produced/min/g wet tissue and specific activty as μM nitroanilide produced/min/mg protein

at pH 2.0 (acid protease). No peptic or chymotryptic activity was detected. The results indicate that this isopod is capable of effectively hydrolizing proteins utilizing endopeptidases and exopeptidases. All the enzyme activity decreased considerably in the starved animals but starvation has less effect on specific activities. In conclusion it may be stated that greater amounts of enzyme secretion for faster chemical digestion may be a possible cause for the voracious feeding habit of *C.fluviatilis* coupled with a high metabolic activity.

Remarks

The isopod *C.fluviatilis* is a commonly occurring organism in the Cochin backwaters and elsewhere. It is a voracious carnivore which if present in very large numbers can cause a threat to the living resources in the estuarine water area. It is true that a population explosion of this isopod has now taken place in the Kumbalangi - Perumpadappu area. It has created some problem to the local fisher-folk, in that the fish and prawns caught in their net are eaten up by this pest. The problem is more with the stake-net catches in which case the nets are lifted after a tidal period. This time is enough for the isopods to eat away the catches. Any kind of quick fishing using dip nets, cast nets or hooks and line are not usually affected by these isopods. However, the baits used in crab nets are not spared by them.

A large number of people of Kumbalangi-Perumpadappu area of the Cochin backwaters depend on this water body for their livelihood. The fish and prawn resources of the isopod infested area have been considerably reduced. It is understood that the catch from the area has been reduced by more than 80% and this could be due to several reasons associated with the isopod infestation such as direct attack, reduction in dissolved oxygen in bottom waters and reduction in other benthic biota in the ecosystem.

The reason for the unprecedented population explosion of this isopod in the Kumbalangi-Perumpadappu area is the recent changes taken place in the ecosystem there. The reduction in the tidal flushing into and out of this water enclosure because of the laying of the earthern bunds on either side of the already narrow water passage seems to be the main reason for the sudden change in the ecosystem. A lack of proper tidal flushing of the water of the area has led to stagnation of water and more sedimentation along the sides, resulting in a change in the benthic biota around this place. Soft bodied animals like polychaetes, nemertines and nematodes represented in this area are being eaten up by these isopods.

Eventhough the mother nature can always take care of, in her own way, any adverse condition arising out of temporary or permanent changes in the ecosystem, the present isopod infestation in the Kumbalangi-Perumpadappu area calls for some remedial measures. A two way solution to the problem may be suggested. The first is to remove by dredging or any other means the superficial layers of the mud in the affected area. However, this method may have its own drawbacks such as a total change in the environment the impact of which may not be predictable and the high cost involved in such operations. A recolonisation and subsequent outburst of isopod population also cannot be ruled out. The second alternative which is much more easier and safer is to restore the tidal flow to its original level. The recently laid earthern bunds mentioned earlier have restricted the tidal flow to a great extent.

We wish to thank Dr. P.V. Rao, Director for his valuable suggestions and for critically going through the manuscript. Our thanks are also due to Dr. M.S. Rajagopalan, Head, FEM Division and to Dr. Peer Mohammed, Head, P.N.P. Division for their support in this work.