MADRAS FISHERIES DEPARTMENT.

A NEW PROTOZOAN CAUSE OF WIDESPREAD MORTALITY AMONG MARINE FISHES

BY

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Widespread fish mortality is a well known phenomenon on the Malabar and South Kanara coasts; its recurrence yearly along certain stretches of the coast line is regular, though its intensity varies within wide limits. In certain seasons it is local in occurrence and affects only a few species close inshore; at others, by no means of annual or regular occurrence, many and diverse kinds are involved, and it may affect large shoals both close in and at several miles distance from the land.

Until the present, I believe no detailed investigation of this phenomenon has been attempted; neither has any satisfactory explanation been given, although various hypotheses have been advanced. My attention has been given to the subject intermittently for several years past, but till last year I was never able to spare the time necessary for a continuous investigation at a period coincident with the occurrence of the phenomenon.

Before detailing my own observations and the conclusions arrived at, I may note that all Malabar fishermen whom I have questioned agree in saying that every year after the passing of the rainy season and the subsidence of the south-west monsoon, if there be a continuance of fine weather for a week or ten days, with plenty of sunshine, and a weak coastal current, the water inshore becomes turbid and discoloured, brownish or reddish in tint; that this water has such poisonous effects upon fish that large numbers become affected and eventually die. The first effect of the poison is to make the fish sluggish and at this stage, as I have myself seen, boys and men crowd to the shore and make great hauls of the dying fish. Fishermen further state that if favourable conditions continue, the colour of this foul water changes and becomes distinctly redder, and emits a stench so strong as to be

* A paper read before the Zoological section of the Indian Science Congress held at Bangalore, January 1917.

almost unbearable; when this occurs they state that the poisonous influence increases and fishes of kinds not affected during the first onset of the poison, die and are cast ashore. They agree fairly generally in stating that sardines are seldom affected in any quantity, but some men have told me that on two or three occasions, separated by long intervals, they have seen widespread sardine mortality from this cause; in these cases the sea was covered for miles with dead and dying sardines in enormous multitudes.

The men's explanation of the cause of this foul and poisonous water, which they term indifferently *Karanir* (shore-water) and *Sen-nir* (red-water) in North Malabar, and *Karanir*, *Sennir* and *Kedunir* (bad-water) at Calicut, is simple and unvarying. One man's statement as taken down at the time is characteristic of all; according to him, *Kedunir* is the product of freshwater brought down by rivers; it runs into the sea and as it will not mix with sea-water, it stagnates in the heat of the sun, and gradually becomes stinking and of a red (*sic*) colour, something like brandy or tea without milk. Like brandy, too, it intoxicates all fish that drink it and after a time they die. All fish that enter the *Kedunir* first become stupefied and then die; if the *Kedunir* beats upon rocks the fish and crabs that live there will also die. Even big bamin (*Polynemus* spp.) and Kora (*Sciaena* spp.) have been affected, but those that usually die are small fish such as young kora (jew-fish), manthal (soles), malan (mullet) and etta (catfishes), also crabs. Sardines die during certain seasons but generally they are careful to avoid coming into this *Kedunir*. From this belief that the latter is consequent upon the mingling of river with salt water, is due the name sometimes applied of *Irunir* or "double water."

Among Europeans various hypotheses have been current, based, so far as I know, upon no solid ground of serious investigation—mere guesses in fact. Among the more plausible of these may be mentioned (*a*) suffocation by excessive mud in suspension in the water, and (*b*) the emission into the sea by rivers of large volumes of putrid water derived from the pits wherein coconut husks are soaked for long periods preparatory to the extraction of fibre, and also by the emptying or overflowing of rice fields in which vegetable matter is allowed to putrefy for manure.[1]

My investigation disproves all these theories. That of the fishermen is easily negatived, for in every case (and they were

[1] Day, F. "Land of the Perumauls," p. 417.

many) where *Karanir* and *Kedunir* were indicated to me, the specific gravity of such water was found to be fully as high as that of ordinary sea-water in the vicinity. The density of the water in which the dying fish were found on several occasions was also that of normal sea-water. As to mud being a cause, that was early seen to be out of court as no mud was in suspension in any *Kedunir* pointed out by fishermen nor in that in which fish were found dead and dying. On the contrary this mortality takes place not in rough weather when mud banks are disturbed, but in calm sunny weather when the sea is usually free from sediment. The fish most commonly found dying at the beginning of the phenomenon are bottom fish such as soles and cat-fish, and these I have found by direct experiment can live and thrive in water in which such mud is kept artificially in suspension. There remains the theory of foul water from rivers; this is negatived (*a*) by the lack of foul odour in the water when it first occurs, (*b*) by its density being that of nearly normal sea-water, (*c*) by the absence of vegetable debris in suspension in the water called *Kedunir* or *Sennir*, and lastly, (*d*) by the fact that it is as frequent in bays into which no great river empties as in those where one does.

After this short review of facts and theories, I shall now state my own observations and conclusions.

My first experience of poison water was in November 1908 when on a fishery cruise along the west coast of the Madras Presidency. On that occasion I was so fortunate as to witness one of those specially widespread cases of mortality which affect whole shoals of fish and cover comparatively great areas, but which are said by fishermen to be infrequent and not of annual occurrence.

In this instance great stretches of water off the Mangalore coast were thick with dead sardines in various stages of putrefaction. The area affected was over fifteen miles in length and lay generally from one to two miles off shore. No organisms except bacteria were present in quantity in the water. The stench was intolerable. Details are recorded in Fisheries Bulletin No. 4.[2]

The next occasion when I met with poison water was on 8th November 1912, when my attention was drawn to a dirty and malodorous condition of the water lapping the beach at Calicut. The colour of the water was distinctly brownish, a clear yellowish

[2] Hornell, J. "Report on the Results of a Fishery Cruise along the Malabar Coast," *Madras Fisheries Bulletin*, No. 4, p. 101 : Madras, 1910.

brown not unlike brandy but with a suggestion of olive in it. This the fishermen told me was *Kedunir*, a water that would kill fishes if it were thicker as it would become if calm weather and a hot sun were to continue two or three days longer. I saw no fishes or crabs dead then but as I was busy with canning experiments at the time I had no opportunity to search carefully. I did however examine the water microscopically and to my surprise found it to be full of myriads of brownish yellow Euglenids to the virtual exclusion of all other organisms. The Euglenids were filled with very granular protoplasm, had a large colourless nucleus, and contained many minute dirty yellow chloroplasts and usually several fairly large oil globules. Unlike the typical Euglenid of fresh water, this species had no red eye-spot. A long flagellum emerged from a well marked pit at the blunt end of the body. The most remarkable feature of the organism was seen, however, after the water had stood for half an hour. By that time, many of the Euglenids had sunk to the bottom of the vessel and were seen to have become embedded and semi-quiescent in a delicate colourless jelly of relatively enormous bulk, obvious to the naked eye as it formed a distinct dirty brownish yellow layer at the bottom equal to fully one-twelfth the volume of water present. In those individuals which had not settled to the bottom, a well defined firm cuticle could be observed, but in those in the jelly no sign of this was seen ; the surface of the body was rough and almost wart-like through the protuberance of granules of the body substance. Hence it is clear that the jelly-like matrix in which the Euglenids were embedded had been formed at the expense of the cuticular layer.

At this stage the matter remained till September 1916 when I was able to visit the Malabar coast with more favourable opportunities for the study of this problem.

In the beginning I made Cannanore my headquarters. To my disappointment I was told on arrival that an occurrence of fish mortality had already taken place and had passed away. As nearly as I could fix the date it had occurred during the last week of August. According to my informants, there had then been a week's break in the monsoon with calm sea and a sunny sky. *Karanir* had appeared after a few days and coincident with it, many crabs and soles had died. Rain and strong wind set in again shortly after and the mortality ceased. For several days after my arrival no

sign of *Kedunir* appeared, but on 20th September I sighted several bright red patches moving northward at about half a mile from the shore. Procuring a boat, the patches were found after a long search, a mile off shore and samples obtained. The water of the patch was found to be 1023 S.G. at 80° F., that of normally coloured sea-water close by being identical. On examining the samples, the organisms colouring them were found to consist of a nearly pure gathering of *Noctiluca*; in the containing jar they kept close to the surface and there formed a dense layer nearly a quarter of an inch thick, coloured a distinct pink. Fishermen called it *Punkara* or "flower water" and asserted that it was a sign of the early reappearance of poison water (*Sennir*, *Karanir*, or *Kedunir*). While alive this scum of *Noctiluca* gave out a strong and unpleasant odour; with death, the smell decreased markedly.

For some days thereafter heavy rain and overcast skies prevailed and no sign of poison water appeared, then a transient interval of fine weather supervened, and on 25th September news was brought to me that *Karanir* had appeared and that dead crabs and fish were coming ashore. Sure enough I found the beach south of Cannanore littered with dead crabs (chiefly *Neptunus pelagicus*) but the *Karanir* had disappeared with a sudden change of weather. The specific gravity of the shore-water when examined was found to be 1023 at 85° F. and contained a considerable number of greenish *Peridinians* of two species (*Gymnodinium* spp.) and a smaller number of brownish *Euglenids*. The former I thought might possibly be the cause of the poison water, as "red-water" containing hordes of a brownish Peridinian (*Gonyaulax polygramma*) is known to cause widespread mortality in Japan among fishes and molluscs, and as I had seen Peridinian red-water at Tuticorin causing limited mortality. The fishermen, however, asserted that the true *Karanir* had disappeared and subsequent events showed that Peridinians are not (at least usually) the cause of fish mortality on the Malabar coast.

A few days later we had another spell of fine sunny weather and on 2nd October *Kedunir* was again reported, and this time I was able to watch the whole sequence of events from the commencement. As soon as I saw the water lapping on the beach I recognized the olive-brown water I had seen in 1912 at Calicut; examination showed it to be swarming with the same brownish yellow Euglenid to the exclusion of all else except a

comparatively few green Peridinians and a very few Diatoms. Dead crabs (chiefly *Neptunus pelagicus*, with a few *Thalamita*, *Scylla*, *Neptunus sanguinolentus* and *Matuta*) were abundant in the wash of the tide and along tide-mark and crowds of men and boys were busily engaged in netting and spearing crabs and fish in the shallows. The fish were chiefly soles *(Plagusia bilineata)* and small jewfishes *(Sciaenids)*, together with smaller numbers of catfishes, *nonthal (Sillago)* and *Koruppan (Platycephalus)*. Several fairly large shore seines were being operated and these made great captures. Two *peruvalas*, each used from two canoes nearer the rocks at the south end of the bay, made even greater hauls and in these were to be seen larger jewfishes and numerous large crawfishes *(Panulirus)* and many *Neptunus*; the catches, however, consisted principally of soles and I was told that several of these large nets had been torn the night before because of the immense weight of soles captured. All the live fish seen were evidently in a state of exhaustion, varying in degree from a slight lack of ordinary vigour to one of marked stupefaction or coma. In the latter the gills had the appearance characteristic of asphyxiation and in the case of the crabs, the stomach and intestine were empty. Over the whole area affected, the water was olive-brown, the sea being calm with no apparent current within the bay. The mortality continued during the next three days, the affected area moving slowly northwards along the shore in response apparently to an eddy-drift within the bay. With this continuance of the poisonous condition, an extension of the mortality became apparent. On the first day a few *Hippa* were seen thrown up but upon the third day, thousands of dead of the two species found here, together with a few of the rarer *Albunea*, accumulated on the level beach adjacent to the Old Town. The great majority were dead, but a few were seen feebly and unsuccessfully trying to burrow. Littoral molluscs were also greatly affected; *Donax cuneata* was thrown up dead in quantity near the mosque, and still larger numbers were seen washing to and fro on the bottom. A small *Pholas* and some *Mytilids* were also seen dead in considerable quantity, together with occasional dead individuals of *Donax scortum*, a large *Mactra* and other bivalves.

Along with the stranded *Hippa* were found over a dozen individuals of the fine Alcyonarian, *Cavernularia obesa*, still alive but evidently in an advanced stage of asphyxiation, as the polyps

were all in a state of expansion and did not retract or respond readily upon irritation.

Wherever rocks are found within the bay, it was notable that many small hermit crabs were found washed up dead and dying in the vicinity. It was most significant that the majority of these had no sheltering shell. They had obviously become so enfeebled and stupefied as to be unable to retain a grip on the columella of their house and had slipped out and been carried ashore. The few still within shells, *Trochus* and *Turbo* chiefly, were either dead or could be pulled out without resistance. This instance, together with that offered by the dying off of *Hippa*, *Donax* and *Cavernularia*, appears to furnish the clearest evidence of the correlation of this mortality with the presence of the Euglenid-infected water, as all these are not vagrant forms such as the swimming crabs and fishes generally; the latter might conceivably have been poisoned elsewhere and have drifted ashore into the Euglenid water, but such a possibility is impossible in the case of *Cavernularia*, Hermit-crabs, *Hippa* and burrowing Molluscs.

On the fourth dav the mortality had decreased markedly; men no longer found it profitable to net the inshore water and the number of Euglenids had sensibly decreased. This change coincided with an alteration in the weather; the wind had freshened and it was clear that the poisonous water was being dispersed by the roughness of the sea and the stronger inshore current. The next day conditions had become practically normal. Later in the month (9th October) similar Euglenid-infected water was seen at Calicut accompanied by mortality amongst soles and *Hippa*; the extent of the trouble was however insignificant and it appears that the open character of the coast, with the absence of any embayment, is an adverse and limiting condition against severe concentration of poison water along the shore in this particular locality.

In the bays in the neighbourhood of Quilandi and Tikkotti, a few miles north of Calicut, more favourable physical conditions prevail and from 9th to 16th October the presence of Euglenid water and concurrent fish and crab mortality were noted, less severe but otherwise similar in character to that which occurred at Cannanore earlier in the month.

The specific gravity of the olive-brown affected water on 2nd and 3rd October when the mortality was most intense was 1026 at 81° F.; water taken on October 3rd a quarter of mile from the shore, which

contained comparatively few Euglenids, was slightly higher, being 1026·5 at the same temperature. On 5th October when the water in the bay had begun to clear, a distinct rise in the specific gravity of the inshore-water was noticed, being 1026·5. Off shore-water was undoubtedly coming in and driving out the foul water, for coincident with the rise in density, the number of Euglenids were now comparatively few, their place being taken by several species of diatoms common to ordinary sea-water on this coast.

The Euglenid-infected water noted at Calicut and Quilandi from 9th to 16th October, ranged in density from 1025 to 1026·5 at 82° F. The Euglenids appear to flourish equally at the higher as at the lower density.

On the evening of 16th October a break of weather occurred, the fine sunny conditions of the preceding week giving place to heavy rain and cloudy sky. On 17th October sea-water from near the shore showed an almost entire disappearance of Euglenids and a fall in density to 1024·5 at 80° F. No further swarms of Euglenids were noted during the remainder of the month which was characterised by a continuance of rainy weather.

There can now be no question that the prodigious multiplication of Euglenids in shallow water on the Malabar coast causes extensive recurrent local mortality amongst the inshore fauna; whether other organisms also cause mortality and the precise way in which stupefaction and death are brought about remain uncertain.

With regard to the former question, it is to be noted that never before has fish mortality been attributed to the superabundance of flagellate infusorians such as the *Euglena* above described; all other observations point either to the group of Peridiniales or Dinoflagellata or to the cysto-flagellate *Noctiluca* as being the organisms involved in those cases where fish mortality has been traced to the occurrence of the phenomenon termed "Red-water" in other parts of the world. The phenomenon is by no means unique. Nishikawa has recorded interesting cases from Japan [3] while Gilchrist has recorded others from South Africa.[4]

Nishikawa records that in September 1900, "streaks and patches of brownish yellow water emitting an unpleasant odour

[3] Nishikawa, T. "Gonyaulax and the discoloured water in the Bay of Agu," *Annotationes Zoologicæ Japonenses*, Vol. IV, part 1, pp. 31–34, Tokio, 1901.

[4] Gilchrist, J.D.F. "An enquiry into fluctuations in fish supply on the South African coast," *Marine Biological Reports* (Union of South Africa), No. 2, Cape Town, 1914.

were observed by fishermen in the Bay of Agu . . . As this 'red tide' (*sic*) is said to have been in former times highly destructive to the beds of the pearl oysters which form one of the principal productions of the Bay, great alarm was felt for the molluscs. Fortunately on 28th of the month, a heavy storm arose and cleared the waters of the bay so that very little damage was actually done." When Nishikawa went to Agu to investigate, the discolouration of the water had almost disappeared and in consequence his enquiry was incomplete. He was able to show however that the discoloured water was due to the presence of a superabundance of a Peridinian, *Gonyaulax polygramma* Stein, so numerous that he estimated the Peridinian population of a drop of this water at from 800 to 3,000 at the densest area. Nishikawa remarks that "usually the appearance of discoloured water is accompanied by a great mortality of fishes, molluscs, and shrimps. According to the observation of a pearl-oyster culturist, in the latter part of August 1899, large streaks and patches of yellowish-red water floated about with the tide in the Bay of Toba. Fishes which were kept in baskets floating on the surface of the sea were damaged by them. Fishermen easily caught the littoral fishes by spearing, for the fishes had become very sluggish in the discoloured water. Even Haliotis seemed to suffer."

Owing to the incompleteness of his observations Nishikawa was uncertain whether the presence of the peridinians *per se* was the immediate cause of the mortality. He noted as significant that other forms of plankton abundant in neighbouring uncontaminated water were practically absent from the discoloured water, a fact similar to that which I noticed in the euglenid water off Malabar. He inferred that water fitted for the propagation of peridinians and unsuitable for the existence of the usual plankton is probably also unsuitable for other fish life, or else the dead bodies of enormous numbers of peridinians sinking to the bottom and putrefying there, may eventually become injurious to other organisms.

Mr. Nishikawa, whom I had the pleasure of meeting when in Japan in 1907, informed me further that when "red water" runs into a bay fishes float to the surface stupefied. He added that in Omura Bay, near Nagasaki, the farmers of the district welcome the appearance of this poison water as they can then catch quantities of fish with ease.

He mentioned that truly red or pink water is also found in Japan, also yellow water. The former is due to a superabundance

of *Noctiluca*, the latter to myriads of diatoms, chiefly *Rhizosoma*; he held that neither exercise harmful effects upon fish life even when in vast superabundance.

This latter opinion is directly opposed by Gilchrist who states that [5] :—

"Red water is a phenomenon observed not infrequently in South African seas. It consists of masses of red-coloured water sometimes a mile or two in extent, at other times occurring only in small patches. In False Bay it may be seen usually several times during the summer months, and presents a very remarkable appearance, being frequently of an almost blood-red colour. It consists of multitudes of *Noctiluca*, normally present in sea water nearly everywhere. At certain times, however, they increase enormously in numbers, when they can be seen to consist of minute egg-like bodies, which in mass present the conspicuous red colour referred to. Such crowding together of these minute organisms appears to pollute the water, for when examined microscopically most were found to be dead . . . It has been observed that fish seem to avoid the red water and fishermen do not care to fish in its vicinity. It is said that mullet caught in it, decay very quickly, becoming quite decomposed if left ungutted overnight. One or two instances are known in which fish and other marine animals have been killed apparently by such polluting of the water. I am indebted to an old resident in Saldanha Bay for some particulars of such an occurrence at that place. He stated that on one occasion, the only one in his experience, about the year 1907, the bay, which is almost landlocked, became filled with red water, known locally as 'flower water.' At the time there had been a north-west wind for some days previously. The fish in the bay were seen floating belly upwards in a disabled condition. Some of them were cast on shore in quantities at the end of the bay, in such numbers that they were 'taken away in cartloads.' Even the shell-fish, such as Mussels (*Donax serra* probably), Klip-koes (*Haliotis*) were killed off in large numbers, apparently on account of the presence of large quantities of decaying organic matter."

Gilchrist is also of opinion[6] that when diatoms occur in vast swarms, under certain circumstances they may decay and cause the death of fishes by suffocation.

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[5] *Loc. cit.*, p. 17.

[6] *Loc. cit.*, p. 19.

Prior to my Malabar experience last year, my attention had been drawn to this subject by a small occurrence of bright red water at Tuticorin. In this case the colour was due to the presence of immense quantities of a bright pink peridinian of very minute size. A few small fish were seen dead where this water settled, but the swarm passed away quickly and was of too small extent to cause serious harm. This bright red water (not the brownish-yellow of the Japanese "red-water") emitted an intolerable stench, a blend seemingly of sulphuretted hydrogen with the smell of decomposing fish oil. Accompanying this red water was a dense scum of a sage green tint due to the presence of vast quantities of an extremely large species of a green *Paramoecium*, which appeared to be preying upon the peridinians.

From this experience and remembrance of Mr. Nishikawa's Japanese observations, I began the Malabar investigation on the hypothesis that the cause of fish mortality was to be sought in an undue abundance of some peridinian. As my first samples of water taken at Cannanore, from a place where discoloured water with accompanying fish mortality had been seen a fortnight previously, contained considerable numbers of two species of yellowish green Peridinians (*Gymnodinium* spp.), my belief was strengthened but, as above detailed, I had to abandon this in face of the repeated conjunction of euglenid-infested water with widespread mortality of fishes, crustaceans and molluscs within the same area.

The immediate cause of death in the case of fishes, crabs and shell-fish caught in the foul water seen periodically on the Malabar coast is undoubtedly some form of suffocation in the wide sense of a poisoning of the blood of the animals concerned by some asphyxiant present in the surrounding medium—the water of the sea. The symptoms are distinctively those of this form of death—the gills dark and livid and movements sluggish. Especially marked was the comatose condition of affected crustaceans. Exactly how the asphyxiation is brought about is uncertain; it may either be by exhaustion of oxygen in the sea water or by poisoning due to the excretion of waste products on the part of the euglenids or it may be semi-mechanical in cases where bottom-loving animals have come within an area where vast masses of the euglenids have settled to the bottom and have there passed into the jelly-forming resting stage. The first suggestion is the least likely, as the euglenids are possessed of chloroplasts and are more

likely to set free oxygen in quantity than to absorb it. On the other hand poisoning of the water by the excretions of myriads of individuals and by the decomposition products liberated through the death of the short-lived generations of these organisms is sufficient cause for much of the mortality noted; the third, or mechanical factor, has, I believe, particularly harmful influence upon burrowing and sedentary organisms, as these are unable to escape its blanketing effects.

Fishermen aver that the phase of mortality which I witnessed last year is by no means the climax; they hold that with a continuation of favourable weather—calm seas and an abundance of sunshine—the trouble increases, being characterized by a thickening of the water and emission of an intolerable stench, entailing an extension of widespread death among larger fishes and occasionally among shoals of sardines. As I have not had an opportunity to watch this further progress and enhancement of the trouble, I cannot say definitely how it is caused. I have, however, seen the ultimate result of such an extended death in the case of sardine shoals as already mentioned.[7] I am inclined to the opinion that these more extensive instances of mortality owe their origin primarily to the same cause as induces the more limited and localized cases described above, that is, to the superabundant multiplication of immense swarms of euglenids. The extension of the area covered and the increase in the numbers of fish involved may be explained by (*a*) simple increase in the extent of the euglenid swarms, reinforced by (*b*) a progressive intensification of the evil influence due to the putrefaction of ever-increasing quantities of dead fish. Many of the patches of putrefying sardines seen in November 1908 off Mangalore (*loc. cit.*) were reduced to mere frothy ochreous yellow bacterial scums. These patches were often as much as half a mile in length by half that in width. The atmosphere was horribly contaminated by an intolerable stench of oily decomposition; the water contamination must have been intense. Healthy fish wandering into these areas of decomposition quickly became affected, rushing hither and thither aimlessly and in evident distress, coming gasping to the surface and finally turning on their sides and dying. With each accession of material to the putrefying mass, the area of contamination continues to

[7] Hornell, J., *Madras Fisheries Buleltin*, No. 4, pp. 101–105.

increase gradually till rough weather supervenes when the mass becomes broken up and scattered and thus ceases to be a focus of death.

So far as my observations go, they favour the view held by Mr. Nishikawa already referred to, that *Noctiluca* is not an active agent in causing fish mortality. I have seen it in great profusion colouring considerable areas bright pinkish red both off Cannanore and in Palk Bay and in neither locality did I find any associated with fish mortality nor would any of the fishermen accuse it of evil influence ; they agreed in declaring it to be innocuous. At Cannanore it is called Punkara (" flower-water "), while at Tirupalakudi it is known as Valkarai (" stain-streaked water ").

On several occasions both at Cannanore and at Calicut, there were great numbers of *Noctiluca* present, especially near the surface ; in one instance only did I find it reproducing actively by sporulation and it is noteworthy that in this instance the individuals were ingesting the accompanying euglenids in great numbers.

The masses of jelly-cased resting euglenids which accumulate on the bottom form an important food source of the oil sardine *(C. longiceps)* and hence possess an important economic value as an offset to the mortality they occasionally entail among fishes.

I should mention that unlike *Noctiluca* and Peridinians generally, these euglenids do not emit any appreciable bad odour while alive.

Incidentally this enquiry furnished a satisfactory explanation of a curious incident in the siege of Cannanore in 1507 that has long puzzled historians. In the year named, the Portuguese, not long arrived in India, were besieged in the fort of San Angelo by the Kolattiri Raja and the Zamorin of Calicut with an army of 60,000 Nayars. After a lengthy siege the garrison were reduced to the greatest straits and lived on lizards, rats, cats and other animals. " On the 15th August, however, a miraculous event occurred, seemingly in answer to the prayers of the besieged to the Queen of Heaven, whose feast day it chanced to be, for the sea sent forth shoals of crabs and prawns, and the garrison again lived in plenty." So says Logan in his " Manual of Malabar,"[8] an explanation which is undoubtedly correct, in spite of the fact

[8] Logan, W., *Malabar*, 2nd edition, page 316, Madras, 1906.

that the date given is earlier than that at which dead fish and crabs usually appear. This apparent discrepancy vanishes when we remember that the date given is old style: to bring it into agreement with the present calendar ten days must be added, thus bringing the date to 15th August; last year abnormally fine weather prevailed during the last week of August, with the result that kedunir and dead fish and crabs were noticed at Cannanore during that week, thereby reproducing almost to the day the phenomenon of 1507.

Addendum.

The above account was written in November 1916 immediately after my return from Cannanore in October. I brought away a small bottle containing a quantity of euglenid jelly with a view to ascertain the odour it would give out when dead and undergoing decomposition. The jelly has refused however to decompose. The bottle has stood upon my desk from October till now (17th March 1917), and under the microscope the jelly shows almost precisely the same appearance it did when first the free-swimming euglenids passed into this resting condition. The one difference I note is that the chloroplasts are now distinctly more green than when the jelly-stage was entered upon; the colour then was a distinct olive brown in the mass, now it is a dark olive green. The gelatinous matrix seems also somewhat reduced. I propose devoting attention during its next seasonal appearance to a further elucidation of its life-history.

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T. Fisher Unwin (Ltd.), 1, Adelphi Terrace, London, W.C.
Grindlay & Co., 54, Parliament Street, London, S.W.
Kegan Paul, Trench, Trübner & Co. (Ltd.), 68—74, Carter Lane, London, E.C. and 25, Museum Street, London, W.C.
Henry S. King & Co., 65, Cornhill, London, E.C.
P. S. King & Son, 2 and 4, Great Smith Street, Westminster, London, S.W.
Luzac & Co., 46, Great Russell Street, London, W.C.
B. Quaritch, 11, Grafton Street, New Bond Street, London, W.
W. Thacker & Co., 2, Creed Lane, London, E.C.
Oliver and Boyd, Tweeddale Court, Edinburgh.
E. Ponsonby (Ltd.), 116, Grafton Street, Dublin.
W. Wesley & Son, 28, Essex Street, Strand, London.

ON THE CONTINENT.

Ernest Leroux, 28, Rue Bonaparte, Paris.
Martinus Nijhoff, The Hague, Holland.