A NOTE ON THE OCCURRENCE AND FEEDING HABITS OF *NOCTILUCA* AND THEIR EFFECTS ON THE PLANKTON COMMUNITY AND FISHERIES*

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Introduction

Noctiluca miliaris (Suriray) are widely distributed in the tropical and temperate seas and under favourable conditions they rapidly reproduce by binary fission resulting in the production of great masses of individuals particularly in the inshore waters. The countless numbers thus produced, by their accumulation, impart a reddish, pinkish or greenish (if the *Noctiluca* have the green flagellates in them) colour to the surface waters. There are several reports of such swarming from various parts of the world but except in a few instances the mere swarming of these does not seem to have caused any widespread mortality of the marine fauna.

Along the coasts of India *Noctiluca* are extremely common and some of the effects of their swarming on fishes and fisheries have been reported by Aiyar (1936), Bhimachar and George (1950) and Prasad (1953). The causes responsible for these great outbreaks are not fully known, but according to Brongersma-Sanders (1948) regions where there is rapid replacement of nutrients resulting in their high concentration and consequent phytoplankton production are the obvious places of great outbreaks of *Noctiluca* as these organisms are holozoic and feed on phytoplankton. Among these regions, she considers those of upwelling near the coast to be by far the most important. Prasad and Jayaraman (1954) made preliminary observations on certain changes in the plankton and hydrological conditions associated with the swarming of *Noctiluca* in the environs of Mandapam. These studies were continued by the present author to ascertain the conditions which favour swarming, the feeding habits of *Noctiluca* and their possible effects on the plankton community and fisheries.

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OCCURRENCE, FOOD AND FEEDING HABITS

The occurrence of *Noctiluca* in Palk Bay and the Gulf of Mannar during the years 1952–56 is shown in Table I. In all these years only the 'green *Noctiluca*' were present in this area and they were more abundant (except in 1954) in Palk Bay where, it is interesting to note, in 1952 a large population persisted for a considerable period of time. In general, the population of *Noctiluca* showed a decline from 1952 up to 1954, then it increased in 1955 and again decreased in 1956. Further, it will be seen from Table I that there are marked differences in the time of occurrence and magnitude of populations between the areas and also within the same area from year to year.

The factors which create conditions favourable for swarming are not fully understood but the present study has clearly revealed two conditions which are essential. Firstly, it has been observed locally that *Noctiluca* are able to multiply rapidly and form swarms only when calm conditions prevail in the area. Turbulent conditions seem to be not only unfavourable for their rapid growth and accumulation to form swarms but even large populations which are sometimes brought into turbulent areas do not seem to remain there for any length of time. Secondly, there is a definite indication that swarming is closely associated with diatom blooms which themselves, in this area, coincide with the calm conditions following turbulence and consequent replenishment of nutrient salts from the bottom. The available data suggest that if *Noctiluca* are present in an area where there is rich diatom population or if they are carried into such regions, they rapidly multiply and form swarms provided the sea is calm; the magnitude of the population depending upon the richness of the diatom population. If, on the other hand, the diatom population is low in the particular area swarms are not formed and even large populations brought into regions of low diatom production rapidly decrease in number. The diatom cycles and the periods of turbulence in Palk Bay and the Gulf of Mannar are different (see Prasad, 1958) and the observed differences in the occurrence, time of maxima and magnitude of population of *Noctiluca* between the two regions can be explained in terms of the two main factors mentioned above which seem to control to a very large extent the swarming. It should be pointed out here that although the hydrological conditions of the environment show certain changes during the actual swarming of *Noctiluca* (Prasad and Jayaraman, 1954) it has not been possible to detect any changes in the physico-chemical or biological conditions of the environment which precede and would thus forewarn these outbursts.

Noctiluca are known to be voracious feeders engulfing particulate food such as diatoms and other small organisms. Devanesan (1942) remarked

TABLE I

The distribution of Noctiluca *in Palk Bay (P) and the Gulf of Mannar (G). The numbers represent the monthly average numbers present in 1 c.c. of the standardized sample. Fractions are omitted*

Months	1952		1953		1954		1955		1956	
	P	G	P	G	P	G	P	G	P	G
January	..	..	61	..	*	482	..	2	..	106
February	..	..	357	22	49	314	*	748	..	..
March	19	41	116	7	1	2	..	..	..	1
April	866	140	172	4	37	..	..	124	926	..
May	1,125	..	3	..	37	..	*	37	17	..
June	1,209	..	1	..	..	1	1,961	..	..	..
July	1,846	911	..	..	89	2	811	..	..	33
August	364	..	111	..	..	..	469	1,135	..	10
September ..	1,000	..	90	..	..	..	502	..	..	..
October	1,186	688	1907	534	..	..	20	6	..	2
November ..	122	913	598	998	..	..	1	..	..	..
December	343	..	48	..	..	..	*	824	*	..

* Data not available.

that *Noctiluca* are competitors for the food of oil-sardines, as both feed on diatoms such as *Coscinodiscus*, *Nitzschia* and *Fragillaria*. Recently, Enomoto (1956) reported that in the waters adjacent to west coast of Kyushu in Japan *Noctiluca scintillans* (Macartney) feed on a variety of diatoms, protozoa, cladocerans, copepods, *Oikopleura* and fish eggs, the chief food being diatoms. The *Noctiluca* occurring in this locality feed mostly on several species of diatoms and to a small extent on zooplankters. Plate XXXII (Photos 1–12) shows a selected number of organisms which form the food of *Noctiluca*. Among the ingested diatoms the following could be definitely identified: *Melosira sulcata*, *Rhizosolenia* sp., *Bacteriastrum hyalinum*, *Chætoceros diversus* and *Chætoceros* spp., *Triceratium favus*, *Biddulphia sinensis* and *Biddulphia* sp., *Grammatophora* sp., *Climocosphenia elongata*, *Thalassionema nitzschioides*, *Thalassiothrix frauenfeldii* and *Pleurosigma normanii*. It is likely that they feed on many more species of diatoms because in several cases the diatoms were so far digested that identification was not possible. In addition to the diatoms the *Noctiluca* were found feeding on tintinnids (*Tintinnopsis nordqvisti*, *T. gracilis*, *T. tocantinensis*, *Codonella ostenfeldii* and *Cyttarocylis ehrenbergi*), pelagic eggs of copepods and copepods, mostly the smaller ones. A few instances of their feeding on *Oikopleura* sp., *Sagitta* sp. and gastropod and lemellibranch larvæ were also noticed. No instance of feeding on fish eggs was noticed so far. In spite of the variety, diatoms undoubtedly form the most important item of food. This agrees with the observations of Enomoto (1956) who noticed that about 90 per cent. of the food of *N. scintillans* were diatoms and the rest zooplankton, chiefly micro-copepods. From these observations it becomes clear that the main food of *Noctiluca* is diatoms and that feeding is apparently not selective. The zooplankters can be considered only as subsidiary food.

SWARMING AND ITS EFFECTS ON THE PLANKTON COMMUNITY AND FISHERIES

In the light of the above-mentioned facts and considering the enormous number of *Noctiluca* that occur during the time of swarming, it is important to examine how far the swarm conditions will affect the diatom population, which forms the main source of food either directly or indirectly of fish, and ultimately the fisheries of the particular area. It was shown by Prasad and Jayaraman (1954) that when there is swarming of *Noctiluca* there is a significant reduction in the diatom population, the level being reduced almost to nil. This is evidently brought about by the voracious feeding of a vast number of *Noctiluca*. The number of *Noctiluca* when they occur in swarms is so large that within a relatively short period the diatoms are grazed down.

Such a rapid reduction in the diatom population will seriously affect the other grazers and it has been observed that during the swarming of *Noctiluca* there is a marked reduction in the other zooplankters which usually occur in the area, particularly the copepods (see Prasad and Jayaraman, 1954). It is likely that this is due to the 'exclusion mechanism' operating. *Noctiluca*, like some of the other flagellates, may be toxic or may produce ectocrines which are toxic and an almost monospecific swarm of such an organism is capable of excluding other organisms. Perhaps in addition to this, the absence of other animals, particularly the copepods and other grazers, in the area of *Noctiluca* swarms is due to the lack of diatoms in such areas. Bainbridge (1953) suggested that the exclusion mechanism as a means of producing inverse relationship is of restricted occurrence and that " It would well be envisaged as operating where there are intense, often monospecific, blooms of some toxic flagellate, as for example *Goniaulax*." However, the absence of copepods or for that matter the other zooplankters in general in the area of *Noctiluca* swarms cannot be attributed to predation, for, as pointed out previously, zooplankters form only a negligible portion of the diet of *Noctiluca* and the fact remains that there is a significant reduction in the 'useful components' of the plankton. Almost immediately on the decrease in the number of *Noctiluca*, the conditions return to normal; the diatoms begin to appear followed by the zooplankters.

These abrupt changes in the planktological conditions are reflected on the fish and fisheries. As stated earlier, it is quite unlikely that mere swarming of *Noctiluca* in an area will cause mortality of the fauna of that locality but it definitely causes certain adverse effects on the fisheries of that region (see Bhimachar and George, 1950; Prasad, 1953 and Nakai, 1954). The available information shows that the negative indication during the swarming of *Noctiluca* is chiefly confined to the clupeoids and possibly also to a few other pelagic shoaling fish like the mackerel. Bhimachar and George (1950) observed that along the west coast of India the shoaling species, the chief among them being the mackerel and allied forms, sardines and anchovies, did not appear in 'red water' caused by *Noctiluca*. Locally the negative indication was very clear in the case of clupeoids. It should be mentioned that forms like the silver-bellies (*Leiognathus* spp.) which are also plankton feeders and which constitute another important fishery of this area are not adversely affected. This is presumably because the clupeoids feed mostly at the surface, where the *Noctiluca* also concentrate resulting in the absence or exclusion of the 'useful components' of plankton which form the food of these fishes, while the silver-bellies are column feeders and consequently are not affected by the swarming. Regarding the effect of swarm-

ing on the mackerel fishery of this area it is not possible to make a definite statement because although mackerel do occur in this neighbourhood there is no regular mackerel fishery as such and only relatively small shoals appear here. There is, however, some indication that the catches are poorer when there is a swarming of *Noctiluca*. As sardines, anchovies and mackerel together form a very important fishery resource of India, the swarming of *Noctiluca* will have disastrous consequences if it coincides with the time and place of these fisheries.

Nakai (1954) remarked that *Noctiluca* can be useful as it " reveals fishing grounds of sardines through phosphorescence at night." At the same time he remarked that these can affect the catches because " fish evades the nets through luminosity."

SUMMARY AND CONCLUSIONS

It becomes evident from the above facts that the effects of *Noctiluca* swarms on fisheries are more adverse than beneficial. Swarming takes place only when the sea is calm and there is an abundant supply of diatoms, the outbursts being usually preceded by diatom blooms. *Noctiluca* voraciously feed on several species of diatoms and to a very small extent on some of the smaller zooplankters. The presence of a large number of *Noctiluca* in an area seems to exclude other zooplankters, particularly the copepods. The rapid grazing down of diatoms and the exclusion of other zooplankters result in an almost monospecific population of these abnoxious cystoflagellates. Such a plankton adversely affects the important fisheries for sardines, anchovies, mackerel, etc., as these fishes do not occur in the presence of *Noctiluca* swarms. The negative indication continues as long as the swarms persist but transient swarms do not seriously affect either the plankton community or fisheries.

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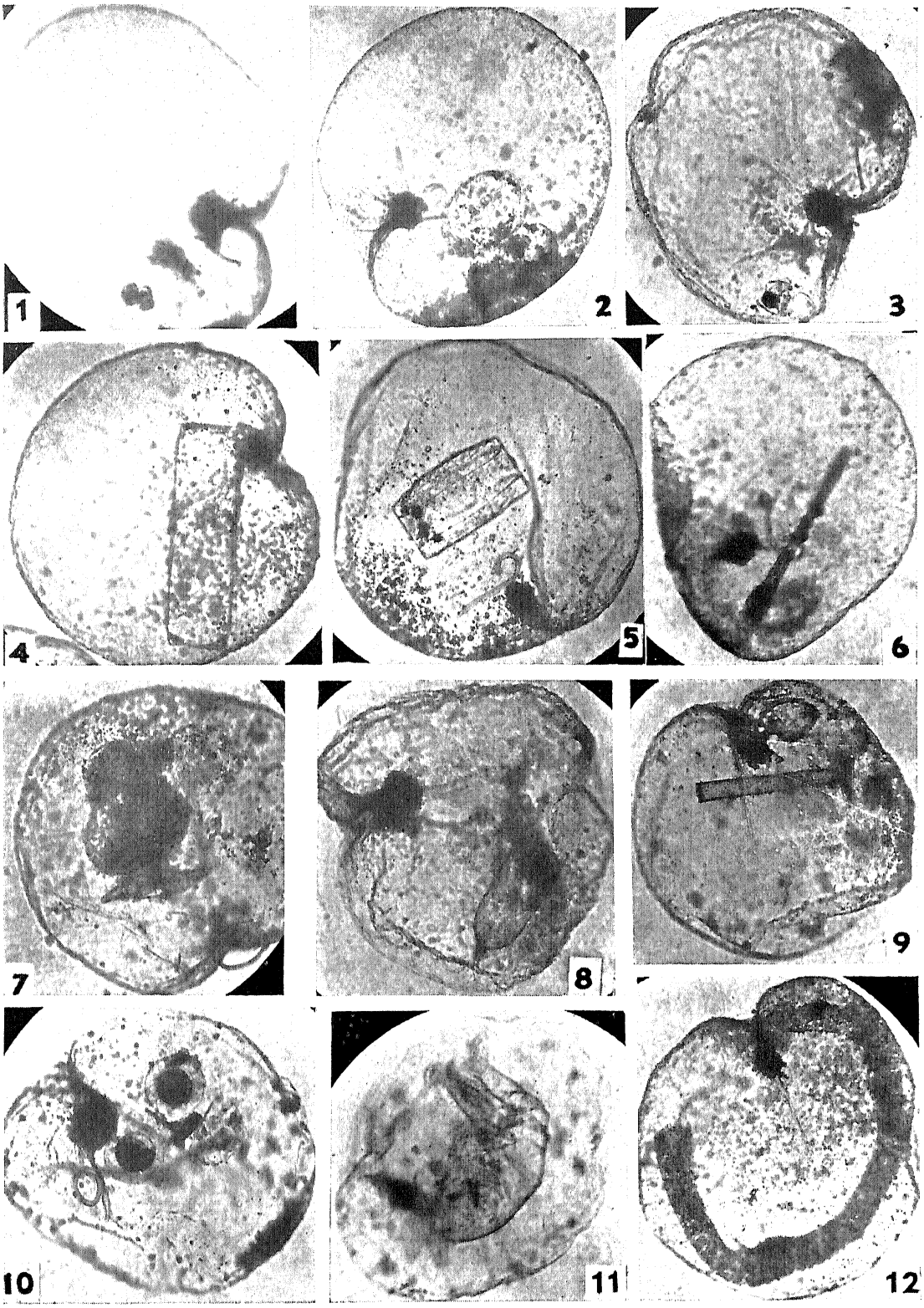

PHOTOGRAPHS 1–12 show *Noctiluca* with various ingested organisms. 1. *Melosira sulcata*. 2. *Bacteriastrum hyalinum*. 3. *Chætoceros diversus*. 4. *Biddulphia* sp. 5. *Grammatophora* sp. 6. *Climacosphenia elongata*. 7. *Pleurosigma normanii*. 8. *Cyttarocylis ehrenbergi*. 9. *Tintinnopsis nordqvisti*. 10. Pelagic copepod eggs. 11. Copepod. 12. *Sagitta* sp.

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