water temperature of 32°C were observed on the day of the second mortality on 15.5.75. On the last occasion (20.10.75) there were incessant rainfall totalling 149 mm on the preceding 7 days, with overcast skies and practically no sunshine. There was heavy discharge of gaseous fumes (probably sulphur dioxide) into the atmosphere on the day preceding the 1st mortality reported on 6.11.74.

The probable cause for the mass mortalities observed on the 4 occasions is believed to be due to sudden large scale discharge of acids from the Fertilizer Factory. The Fertilizer Factory also discharges suphur dioxide which if let into water forms sulphurous acid which is an additional source of acidification. *p*H range in the north-western arm is always on the acidic side ranging from 5 to 6. A further lowering is always possible when there is a sudden and abnormal discharge of the industrial acid wastes. In enclosed bodies of water such as harbours, estuaries, lagoons and bays rich in bicarbonate content, fairly high concentrations of CO_2 can be liberated by the addition of strong mineral acids[4]. Nikolsky[5] noted that CO_2 in even relatively small doses causes the death of fishes. While the amount of free CO_2 in sea water is very small and at neutrality only 10% of it is said to exist[6], lowering of *p*H to 5 results in almost all the CO_2 being present in the form of undissociated acid[7], and at *p*H 4 only free CO_2 exists[6]. Present observations have shown that diurnally, the CO_2 content reached the maximum in the early hours of the day due to absence of photosynthesis during the night and the assimilation of the available oxygen by the organisms for their respiration and liberation of free CO_2. Basu[8] has experimentally indicated that increased CO_2 levels reduce the rate of oxygen consumption of fishes maintained at a constant level of oxygen and at a steady rate of acidity. Doudoroff and Katz[9] remarked on the ability of CO_2 to penetrate into the living tissues, where its effects may be related to its acidic nature. These authors have opined that free CO_2 concentrations between 100 and 50 ppm or even lower also may be lethal after prolonged exposure or when associated with abnormally low though not ordinarily lethal oxygen tensions. Nikolsky[5] pointed out that the mechanism of injurious action of CO_2 on fish consists of the reduction of blood's capacity to absorb oxygen and the effect is enhanced under low dissolved oxygen tensions[9].

The dissolved oxygen content in the harbour waters is generally low in the early hours of the day especially when there is a rich phytoplankton growth, which depletes the oxygen content during night when there is no photosynthesis. Consequently, it could happen that sublethal amounts of toxic substances might prove relatively innocuous during the day, when sufficient dissolved oxygen is present, but lethal at night when the dissolved oxygen concentration falls.

It may thus be surmised that a combination of factors beginning with the sudden and large scale discharge of acid waste water, incidence of appreciable amounts of free CO_2 and drastic depletion of dissolved oxygen during night hours, aided by extremes of local weather conditions are the probable causes for the large scale fish mortalities reported in the Visakhapatnam Harbour.

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Biology of the Squid *Loligo duvauceli* d'Orbigny Obtained in the Night Catches

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Food and feeding habit and sex and maturity of the squid *L. duvauceli* obtained in the trawl nets operated during night were studied. Carnivorous habit and cannibalistic behaviour were observed in this squid. Fishes and crustaceans were found to be its main diet. Occurrence of empty stomachs was less in the squids obtained during night.

INFORMATION on the cephalopod mollusc and its potential resources is much less compared to many other sea animals. Practically no detailed work on the cephalopod biology, fishery and potential resources has been carried out in waters around India, except for some isolated works[2-5]. Cephalopods never formed a seasonal or a distinct fishery in Cochin area, but they are present in small quantities in the trawl net catches throughout the year[4]. No attempt has been made so far in India to carry out studies on the night catches of cephalopods. This paper presents results of a study on the night catches of a squid (decapod cephalopod), *Loligo duvauceli* d'Orbigny, obtained from Cochin area.

Specimens were collected from the catches of trawl nets, operated during night in Cochin area, within the depth range of 15 to 30 m in March 1974. Usually a purse seine was operated just after 3 hr of underwater illumination. The 'light fishing' programme was carried out for 16 days and 11 successful purse seine sets were made and nearly 1·5 tons of fishes and squid were caught. Table 1

shows the percentage composition of different species obtained during these operations. The catches obtained were immediately stored in sufficient quantity of ice. The squids as well as other species of fishes were sorted and weighed separately on the shore. The squids were then taken immediately to the laboratory. In the laboratory each specimen was given a registration number, after which it was measured for the dorsal mantle length and weighed. Then the animal was opened and sex and sexual maturity noted. The extent of feed was also noted and this was assessed by noting the state of distension of the stomach and the amount of food contained in it. On the basis of this the stomachs were grouped into 6 categories, full, $\frac{3}{4}$ full, $\frac{1}{2}$ full, $\frac{1}{4}$ full, meagre and empty. Then the stomach was removed and transferred to numbered specimen tubes containing 4% neutral formalin. Each preserved stomach was later slit open and its contents were analysed by the volumetric method. By volumetric analysis it is possible to assess with sufficient accuracy the relative composition of food constituents. Relative volumes of food constituents which were often crushed or reduced to pulp were estimated by Pearse's method[6]. According to this method the contents of each sample is considered as unity, the various items being then expressed in terms of percentage by volume to it by rough estimate. Volumes in percentages were roughly estimated and recorded for different constituents of the food. During the present study 167 specimens of *Loligo duvauceli*, weighing about 7·85 kg, were obtained in 11 purse seine sets.

Food and feeding — Critical examination of stomach contents revealed that these animals are carnivores. In almost all cases the food contents were in an advanced stage of digestion, so that identification of the contents up to species level was very difficult and always not possible. So an attempt was made to collect information regarding the species of animals caught in the trawl nets along with these squids (Table 1). There was no significant difference in the food preferences or in the composition of diet between male and female, and the caeca of all the specimens were partially or wholly filled with food particles.

Out of the 167 specimens examined, 8·4% were with empty stomachs and the remaining were in different stages with varying degrees of digestion. Table 2 shows the state of the stomach in different degrees of fullness in male and female. In the case of female the empty stomachs were absent, and they were with 76·9% of 'full' stomachs. Oommen[4] noted more than 50% of empty stomachs for *L. duvauceli*. Kore and Joshi[5] also noted the same amount of empty stomachs for this squid, but those studies were carried out on the collections made in the daytime. From the present study it can be seen that the percentage of empty stomach was less during night.

It was possible to group the stomach contents of *L. duvauceli* into 3 main categories, fishes, crustaceans and squids. Table 3 shows the relative importance of the food items in the stomachs of male and female examined. The food remains

TABLE 1 — PERCENTAGE COMPOSITION OF DIFFERENT SPECIES OBTAINED IN THE TRAWL CATCHES DURING MARCH 1974

Species	Percentage of total wt	Species	Percentage of total wt
Megalaspis cordyla	65·44	*Chorinemus tala*	0·25
		Sphyraena jello	0·18
Sardinella spp.	27·19	*Thryssa mystax*	0·05
Anchoviella spp.	4·48	*Leiognathus* spp.	0·01
Rastrelliger kanagurta	0·29	*Loligo duvauceli*	0·54
		Miscellaneous	1·57

TABLE 2 — PERCENTAGE CONDITION OF STOMACH IN *L. duvauceli*

	Male	Female	Total
Full	41·1	76·9	46·7
$\frac{3}{4}$ full	7·8	11·5	8·4
$\frac{1}{2}$ full	17·7	11·6	16·8
$\frac{1}{4}$ full	6·5	—	5·3
Meagre	17·0	—	14·4
Empty	9·9	—	8·4

TABLE 3 — PERCENTAGE COMPOSITION OF STOMACH CONTENTS IN *L. duvauceli*

	Male	Female	Total
Fishes	80·2	85·6	81·1
Crustaceans	13·8	13·0	13·7
Squids	6·0	1·4	5·2

were identified as fish by the presence of their hard tissues like scales, eyeballs, fin rays, vertebral parts, etc. The crustaceans were distinguished by the presence of their eyes, chelipeds, fragments of appendages and segments, etc. The cephalopods were separated by the presence of their beaks, chitinous rings of suckers, pigmented portions of skin, etc.

Fishes formed the most important food item of *L. duvauceli* (Table 3) the common forms identified from the contents being anchovies, sardines, leiognathus and chorinemus. Crustaceans formed second important food comprising prawns. Often crustacean appendages alone were noticed in the stomach of this squid. Squid remains were rare in the food. The commonest constituent of this item of food was the pieces of the same species.

The carnivorous habit was observed for this squid by Oommen[4] and Kore and Joshi[5]. Bidder[7] stated that all known living cephalopods studied are active predators, swimming in pursuit of their prey. Verrill[8] and Squire[9] identified crustaceans and fishes from the stomach contents of *Illex illecebrosus*. Bidder[10] also observed the same items in the food contents of *Loligo forbesii*. Sasaki[11] noted squids, crustaceans and fishes in the stomach of *Ommastrephes sloani pacificus*.

Cannibalistic behaviour was noted by Oommen[4] and Kore and Joshi[5] for this squid. This habit was also noted in other squids, viz. *L. pealeii*[8,12], *Alloteuthis* spp.[10] and *O. sloani pacificus*[13].

The presence of pelagic fishes like anchovies and sardines as well as the bottom dwelling forms like

prawns in the food contents indicate that this squid comes to all level to catch its prey.

Sex and maturity — Of the 167 specimens examined 141 were males and 26 were females giving a male to female sex ratio of 5·4:1. Among females 38·4% were with eggs. In the present study sex was differentiated in the 38 mm long specimen, which was the smallest obtained during this study. The length of the egg-carrying specimens ranged from 100 to 145 mm.

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Early Development of *Podophthalmus vigil* (Fabricius) in the Laboratory & Its Fishery off Porto Novo*

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After an incubation period of 12-13 days, the berried crab, *P. vigil*, releases the larvae hatched out mostly in prezoeal and a few in first zoeal stage. Descriptions of early larval stage of *P. vigil* and the salient features of corresponding stages of some Portunids are given. Contribution of *P. vigil* to a regular commercial fishery off Porto Novo waters has been stressed.

GENUS *Podophthalmus* has a wide distribution in the west Indo-Pacific region[1-5]. *Podophthalmus vigil* (Fab.) has been reported from both east and west coasts of India[6,7]. Except for a brief account on moulting and growth of *P. vigil*[8], nothing is known about its biology or development. Presently the early larval stages of this species and its contribution to a regular commercial fishery off Porto Novo are described.

Ovigerous females collected from the trawl catches off Porto Novo (11°30'N and 19°46'E) were brought to the laboratory in sea water and maintained in rectangular glass aquaria (48×30×25 cm). The tanks were provided with 3 cm layer of washed, cleaned and sun-dried beach sand as substratum and filled with filtered sea water (salinity 30±1‰ and temperature 27°±1°C). The crabs were fed with pieces of fresh fish and prawns in the evening and the left over food was removed the next morning. Water and sand of the aquaria were changed on alternate days.

The species was found to be hardy and the ovigerous females were not very aggressive. They seldom fed and practically starved for 3 days prior to hatching of eggs. The egg mass was bright yellow in colour and was very compact but as the development proceeded, the colour changed to light brown and finally to brownish black. The eggs, ranging from 122 to 402 μm (Fig. 1A), were covered with 2 transparent membranes. The fecundity of this species ranged from 14640 to 30517 in specimens of 58 to 85 mm size carapace width (Table 1).

The movement of the larva and its heart beat could be seen through the egg capsule in the advanced stages of development (Fig. 1, C to E). The hatching process lasted for about 3 hr. The newly hatched prezoea (Fig. 1F) remained at the bottom of the tank for sometime and made whirling movements to free its appendages. Just hatched larvae were mostly in the prezoeal stage (Fig. 1G).

Prezoea: with rostral spine lying between the eyes inwardly curved; the posterior spine curved forward over the carapace; short lateral spine one on each side of the carapace. The prezoea acquired all the characters of the first zoea within 2 hr (Fig. 1G-I).

Table 1 — Number of Eggs in *P. vigil*

Sl No.	Carapace		Crab wt (g)	No. of eggs in the berry
	Width (mm)	Length (mm)		
1	58	28	24·75	14640
2	67	30	31·62	18762
3	68	30	33·52	21579
4	79	37	44·04	20642
5	75	35	50·55	30158
6	76	34	51·52	25164
7	78	36	51·21	21009
8	80	38	54·38	30364
9	85	40	56·02	29559
10	85	39	58·04	30517
Average	—	—	—	24238

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