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THE BIOLOGY OF CEPHALOPODS (DECAPODA) AT DIGHA COAST (WEST BENGAL)

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INTRODUCTION

This is a preliminary study of the biology of squids and cuttle fish at Digha, West Bengal, undertaken during January 1993 to September 1994 and is expected to continue.

Cephalopods are a fascinating branch of invertebrates ; their highly developed brain and eyes, the most advanced in the invertebrate world, multiple heart, various pulsatile systems, the wide range of forms in 700 odd species from tiny *Idiosepius* to the giant Atlantic squid *Architeuthes* and the giant Pacific Octopus *Octopus dofleini* have gained the attention of physiologists, embryologists as well as of taxonomists. The squid axon is in great demand for certain physiolgical studies and the isolated cardiac system has been used for testing drugs and chemicals. Furthermore, in many parts of the world cephalopods are an important sector in marine fisheries.

In India too, cephalopods have been studied from the fisheries aspect, for example, Rao (1954) followed by many other reports (Abdul Rahim & Chandran, 1986 ; Seraimeetan, 1940 ; Vidyasagar & Deshmukh, 1992), but ecological, ethological, physiological and embryological studies have been very scanty,—such as on the breeding behaviour of *Octopus dollfusi* (Sarvesan, 1969). Substantial taxonomic work has been carried out at Madras coast (Jyothinayagam, 1987).

Since, to our knowledge, absolutely no investigations have been recorded on the cephalopods of Digha coast, the present study has been executed keeping in mind a long term follow up and the formation of a basic fund of knowledge eventually to be

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utilised by various researchers in or collaborating with the newly established Marine Aquarium cum Research Centre of ZSI at Digha.

We have, therefore, kept in our purview four broad areas—ecology, embryology, physiology and practical aspects of rearing the organisms in the Aquarium. The efforts, limited as they are at this stage by lack of personnel and equipments such as boats for eollecting specimen and circulating sea-water in the laboratory, may have still been worthwhile as, hopefully, indicated by the results presented.

MATERIAL and METHODS

Observations and collections of samples from rejected material of commercial catches by dragnets near the beach have been attempted at least twice a month commencing from January, 1993 up to September 1994. Cast off on sand the cephalopods quickly become disabled and morbid, especially in the hot season. Nevertheless, on occasions particularly during winter and spring it has been possible to rescue certain specimens which could swim in containers of sea-water for a short while. Some of these have been made use of for studying the isolatied pulsatile systems. Others have been measured and dissected.

All the specimens collected and observed were either the small squid *Loliolus investigatoris* or very rarely, *Loligo duvauceli* and the cuttle fish *Sepiella inermis.*

The lines of investigation were to determine :

1. *Seasonal availability*
2. *Breeding phase and Embryology*
3. *Stomach contents*
4. *Pulsatile systems, especially the gill*
5. *Practical data pertaining to rearing.*

1. Seasonal availability

RESULTS

As evident from Fig 1. there is a single lacuna in our knowledge namely the month May, 1993 when, due to adverse weather conditions, no nettings took place. *Loliolus investigatoris* and *Sepiella inermis* were always found except in the months of July and October-November. *Loligo duvauceli* were available only in June, 1993 and not at all in

1994 (up to September). In May 1994, very small immature *L. investigatoris* were obtained from catches in fine-meshed nets very close to the beach operated by collectors of

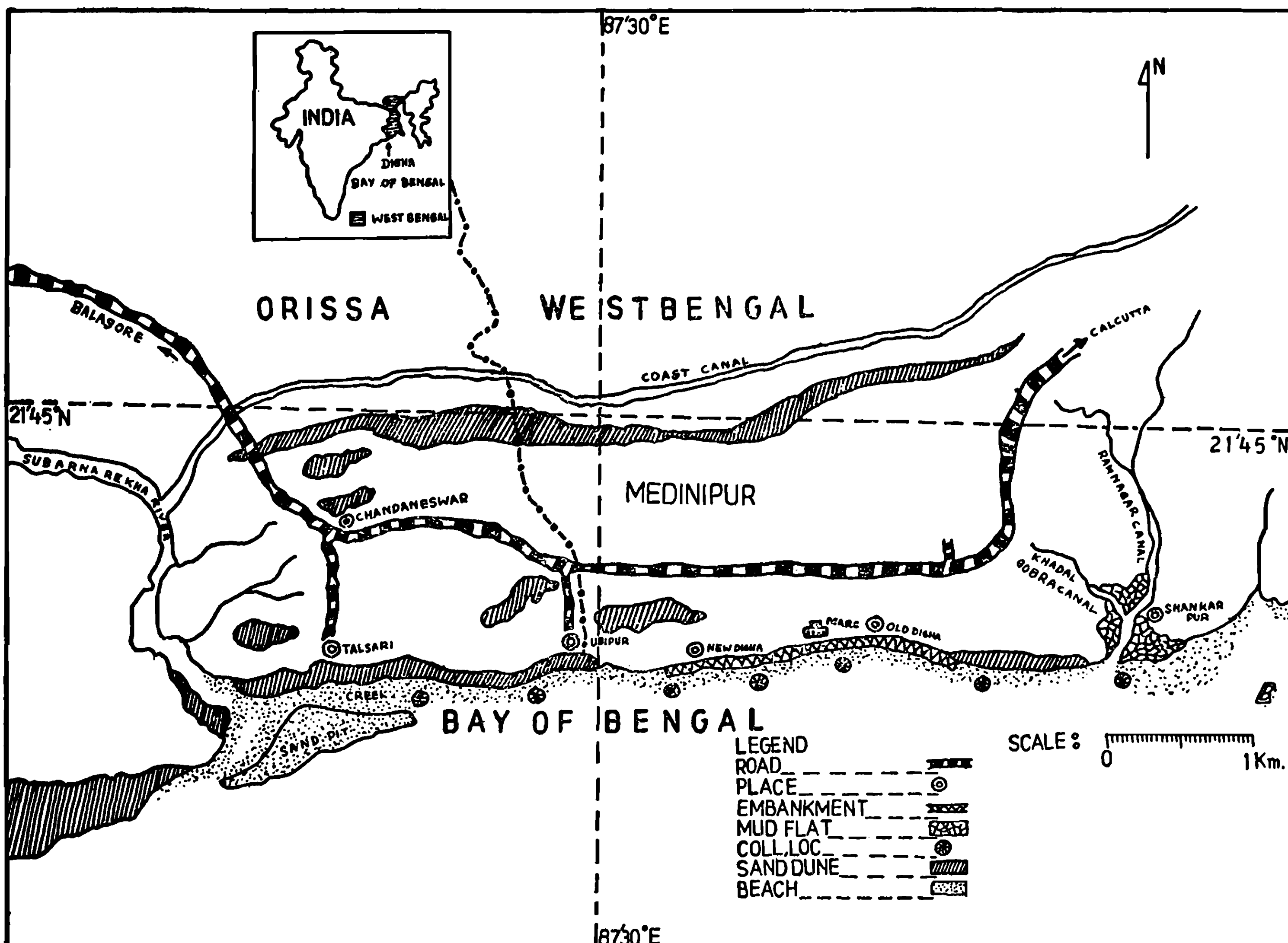


Fig. 1: MAP OF THE COLLECTION AREA

'Bagda shrimp' which procedure was adopted this year for the first time. This year in June, July and August no squids were caught in the usual drag nets, young *S. inermis* were collected in June & July, however. Juvenile *L. investigatoris* were caught in 'Bagda net' in July-August, 1994.

Tables 1B, 1C & 1D furnish data on the size of the two squid species.

DISCUSSION

It is clear that *L. duvauceli* is a rare visitor in this coast. *L. investigatoris* and *S. inermis* occur during most part of the year. The sudden disappearance in July, 1993 is intriguing. This is further confirmed by the findings of 1994. This might have something to do with

TABLE 1A

Length and width of *L. duvauceli* (in cm.)

	Total Length	Width (maximal)
1.	10·2	4·8
2.	6·8	3·4
3.	6·8	3·3
4.	8·9	3·3
5.	6·6	3·4
6.	4·9	3·3
7.	8·9	3·3
8.	5·1	3·9
9.	4·7	3·1
10.	4·5	2·7
11.	4·9	2·9
12.	4·7	2·9
13.	4·4	2·4
14.	3·8	2·0
15.	3·4	2·1
16.	3·6	1·8
17.	3·0	1·9
18.	3·4	1·7
19.	3·3	2·0
20.	2·3	1·9
21.	2·4	1·6

the lower salinity of coastal water during this period. Another problem arises in the non-availability during October-November 1993. Salinity during this period has to be ascertained.

All the decapods observed at Digha by various collectors are small in size, although in the Western coast, or even in the Eastern coast, at Paradeep to the west of Digha, larger specimen are available. Jothinayagam (1987) does not describe the *absolute sizes* of the animals and so direct comparisons cannot be made with Digha samples. Absolute values have been given in tables 1A, 1B, 1C & 1D which can later be compared with catches at Paradeep area.

TABLE 1B

Several dimensions of *L. duvauceli* (in cm.)

(TL, total length ; ML, mantle length ; MW, mantle width ; AL, Arm length ; HL, Head length ; FL, fin length ; FW, fin width)

* indicates egg-bearing female

TL	ML	MW	AL	HL	FL	FW
6·4	5·1	1·6	2·2	1·1	2·0	0·9
8·9	7·1	2·1	2·9	1·6	3·5	1·2
3·7*	2·8	1·4	1·3	0·8	2·0	0·9
5·2	4·3	1·7	2·5	1·5	2·6	1·1
5·0*	3·7	1.8	1·5	1·1	2·5	0·9
5·4*	4·1	2·0	1·7	1·2	3·7	1·1
5·5*	4·2	2·0	2·7	1·2	3·0	1·1
3·7	2·8	1·5	0·9	0·8	1·9	1·1
3·7	2·7	1·2	1·2	0·8	1·6	0·5
5·7*	4·1	1·7	1·8	1·8	3·0	1·1

All the egg-bearing *S. inermis* are 5·5 × 3·2 cm or bigger in size (with a single exception) no animal of size range 3·9 × 2·2 to 5 × 2·5 had eggs or spermatophores. (Table 2).

L. duvauceli is a very abundant species in the north-west coast. For example, of the 6 species of decapoda caught in the Gulf of Kutch, 83·5% is answered for by squids and of the squids, *L. duvauceli* constitutes 68·2% while *L. investigatoris* forms only 0·3%

(Siraimeetan, 1990). The picture is thus the very reverse at Digha. Another statistics of Saurashtra (Kasim, 1993) is that 67·8% of cephalopod catch is comprised of *L. duvauceli.*

In Bombay also *L. duvauceli* alone comprises 43·5% of the total cephalopod catch (Vidyasagar and Deshmukh, 1992).

TABLE 1C

Measurement of some preserved specimens of *L. duvauceli*

Sl. No.	ML	MW	TL
1.*	6·9	1·8	8·1
2.=	7·1	2·0	8·3
3.	6·3	1·9	7·6
4.*	5·8	1·6	7·2
5.=	6·3	1·8	7·3
6.	7·0	1·7	8·3
7.	6·5	1·9	7·9
8.=	6·5	1·6	8·0
9.	7·1	1·8	8·2
10.=	7·2	2·0	8·2

* Spermatophores (very good in 4), = Eggs (immature in 2)

It is worth noting that Rahim and Chandran (1988) recorded dorsal mantle length (absolute values) of *L. duvauceli* of the Madras coast. These values plus the head length indicate sizes that are much larger than those of Digha samples. Since the data of Rahim and Chandran (1988) record mature animals (though males only) and the Digha samples too, had mature eggs, a valid comparison can be made. It is clear that at Digha the same species is surprisingly smaller in size. The mantle length of the samples here ranged from 2·7 to 7·2 cm, while those of Rahim & Chandran (1988) ranged upto 19·5 cm, all individuals within the size range 10·5-19·5 cm, having spermatophores. At Digha mature eggs were found within the size range 2·8-4·1 cm (Table 1B). So at least the females attain only a small size.

TABLE 1D

Length and width (in cm.) of *L. investigatoris*

	Females with eggs		Males with spermatophore	
	L	W	L	W
1.	5·6	2·2	4·8	1·7
2.	5·0	1·9	4·7	1·6
3.	4·7	1·9	4·6	1·6
4.	4·4	1·8	4·6	1·5
5.	4·5	1·6		
6.	4·5	1·4		
7.	4·4	1·5		
8.	4·3	1·6		
9.	5·0	1·9		
10.	5·2	1·8		
11.	5·3	1·6		
12.	6·3	1·7		
13.	5·3	1·7		

TABLE 2

Length and width (in cm.) of *S. inermis*

	Females with eggs		Samples without egg/spermatophore	
	L	W	L	W
1.	9·5	4·5	5·0	2·5
2.	8·5	4·4	7·0	3·9
3.	7·5	4·4	4·5	3·0
4.	9·1	4·9	3·9	2·8
5.	9·0	4·7	3·9	2·2
6.	7·5	3·9	3·9	2·2
7.	5·5	3·2		

Very few mature males *L. duvauceli* were caught in the dragnets in Digha. Table (1C) shows the size of two spermatophores bearing individuals (No. 1 and No. 4). At least one of these (No. 4) had very well developed and abundant spermatophore tubes. So it seems that mature male *L. duvauceli* at Digha may attain half the size of their counterparts in the Madras coast.

2. Breeding phase and embryology

RESULTS

a) Breeding season : *L. investigatoris* and *S. inermis* had mature and/or immature eggs in *every month*, whenever they were available.

L. duvauceli in June, 1993 had mature and immature eggs.

b) Eggs :

Mature eggs of *L. investigatoris* and *S. inermis* are glass clear beadlets.

Dimensions :

i) *L. investigatoris*
1·7 mm × 1·2 mm

ii) *S. inermis*
2·4 mm × 1·9 mm

The number of mature and near-mature eggs was determined in a representative sample of each species.

L. investigatoris	—	643
S. inermis	—	314

c) Spermatophores :

Considerable size variation exists but representative values are :

i) *L. investigatoris*
1·2 mm × 0·06 mm

ii) *L. duvauceli*
1·4 mm × 0·09 mm

(*smallest division in the microscale was 0·02 mm.)

d) Artificial fertilization

Artificial fertilization can only be feasible after obtaining facilities for filtered circulating sea-water. Attempts were, however, made to ensure necessary conditions as a sort of rehearsal. Mature eggs and spermatophores were simultaneously collected after dissecting large numbers of the organisms. Good spermatophores were more readily found in *S. inermis.* Being larger these could be more easily crushed in order to yield the milky sperm-bearing fluid. (See Addendum)

DISCUSSION

Various organisms breed continuosly throughout the year (or the better part of it) in the tropics while the reproductive phase is more restricted in the northern (or southern) clime. *Loligo vulgaris* is known to have a peak breeding season in spring (February-April) in the Mediterranean followed by a second peak in September or so. In contrast, *L. investigatoris* as well as *S. inermis* at Digha are *always* in the breeding phase, i. e., whenever they are collected. We do not of course know the situation during the three months (July, October-November) when they are absent. The findings with the Bagda net, namely very young squids caught in July and August (1994) suggest that even during this period the adults which have migrated further are still in the breeding phase.

The number of spermatophore-bearing males was always significantly less than that of egg-bearing females and this might be due to the fact that the latter are easier to capture in nets.

Mangold (1987) described fecundity of cephalopods. Since the coeleoid cephalopods generally reproduce only once and then die, the number of eggs laid is an indication of fecundity. Mangold (1987) also listed the number of eggs and the size of eggs in various cephalopods. *Idiosepius pygmaeus*, the smallest known cephalopod has the smallest eggs laid in small numbers (25-64 eggs), while *Octopus bimaculoides* and *Bathypolypus sponsalis* may lay eggs as big as 12×5 mm and $15{\cdot}5 \times 6$ mm respectively. *Octopus tetricus* and *O. cyanaea* boast of 7,00,000 eggs. In all sepioids the relative egg size is large, the absolute value ranging from less than 1 mm (*Idiosepius*) to about 10 mm and the number of eggs vary from 50 to 200 in sepiolids while the well-known *Sepia officinalis* may lay as many as 600 eggs. The size and number of *S. inermis* eggs at Digha are well within the ranges mentioned above, though the exact number of immature eggs has not been counted. A rough estimate suggested that this number was less than that of the mature eggs (314).

Squids generally lay large numbers of eggs, hundreds of thousands, as listed in several species (Mangold, 1987). Two species, *Loligo pealei* and *Loligo plei* are variable egg-bearers, ranging from thousands to a few hundred or only a couple of hundred eggs (*L. plei*). The egg-size and egg-number in *L. investigatoris* at Digha is towards the upper side of the scale mentioned above. The number of mature eggs was 643 ; the number of immature eggs could not be determined but it could be 3 times the former.

For estimating and comparing the fecundity of the decapods at Digha with those listed by Mangold (1987) it will be necessary to rear adult animals and watch them lay eggs in the Aquarium and to determine whether this is staggered over a period with the immature eggs maturing and being laid later.

The largest spermatophore, 1 m, has been reported in *Octopus dofleini* (Mann *et al.*, 1970) and that of *L. investigatoris* as reported here is on the other end of the scale.

Artificial fertilisation of squids has been attempted with partial success (Marthy, Brahmachary ; see Brahmachary, 1989). The preliminary knowledge gained with *L. investigatoris* and *S. inermis* can now enable us to attempt these experiments in the immediate future.

3. Stomach content

RESULTS

a) *L. investigatoris*

Stomach contents of almost all the samples examined were nil. A very small amount of crustacean remains was found in one or two specimens.

b) *S. inermis*

Large amounts of stomach content were very frequent. The inflated reddish stomachs were striking and one could never fail to notice these organs except in very small samples. All the remains were those of crustacea, probably of a red shrimp frequently netted in the catches. However, shrimps of other colour may also turn red after death. The colour of the stomach is at least partly due to these shrimp remains.

Of 41 sepiella collected on five different dates 33 had stomachs inflated to different degrees ; only 8 had empty stomachs (Table 3).

TABLE 3

Full and empty stomach of *S. inermis*

Date of collection	No.	Full stomach	Empty stomach
3.12.93	6	4	2
4.12.93	4	3	1
6.12.93	17	13	4
8.3.94	9	9	0
9.3.94	5	4	1
Total	41	33	8

The dry weight of the oven dried stomach and contents was also determined in a preliminary initiative (Table 4).

TABLE 4

Dry weight of *S. inermis* stomach and contents

1.	0·57 g*
2.	0·67
3.	0·39
4.	0·28
5.	0·24
6.	0·24
7.	0·17
8.	0·13
9.	0·08
10.	0·13

* (Accuracy of measurement is up to 0·01 g of sartorious digital balance)

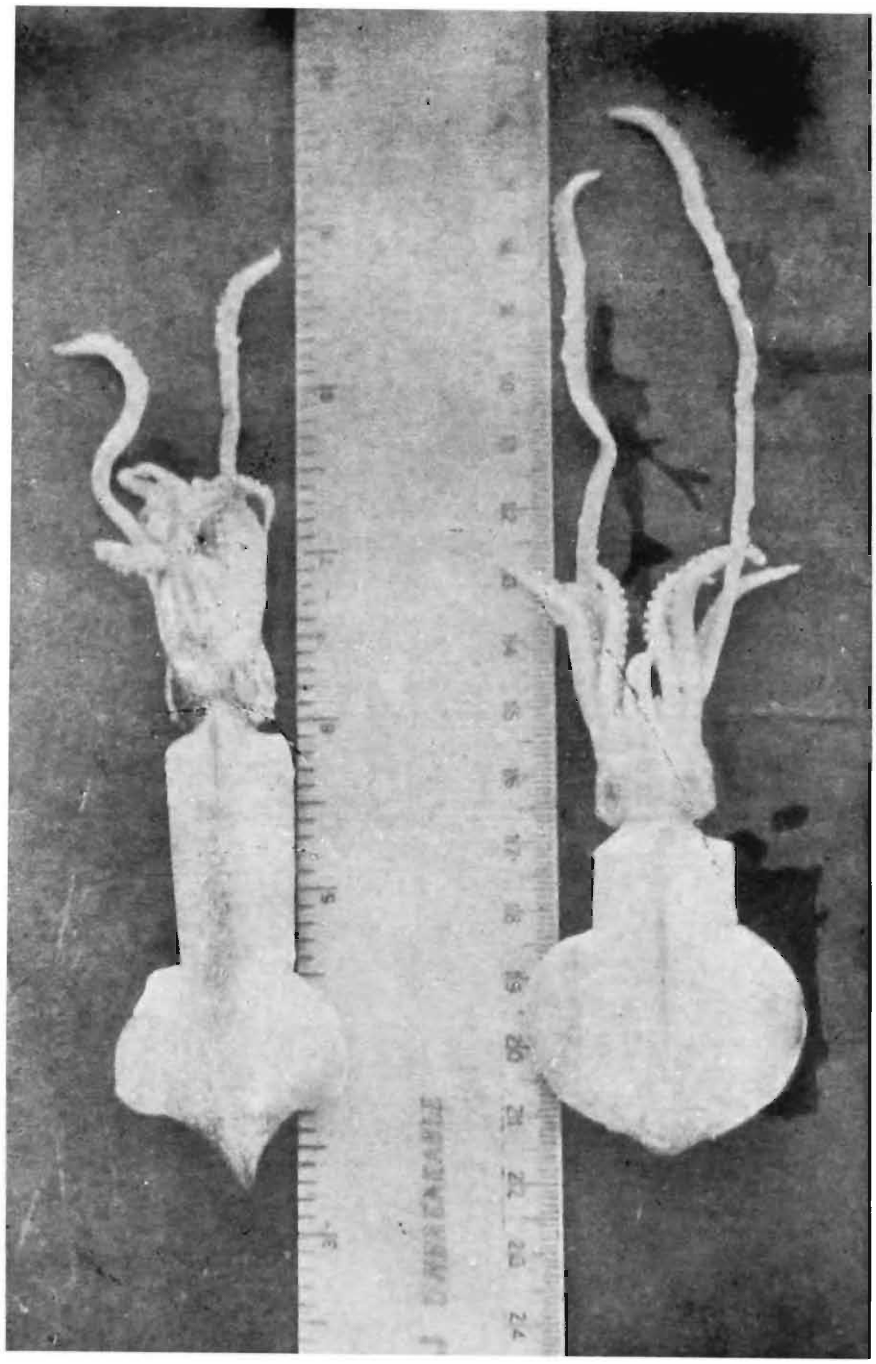


Fig. 1 : *Loligo cluvauceli* (left) and *Loliolus investigatoris* (Right)

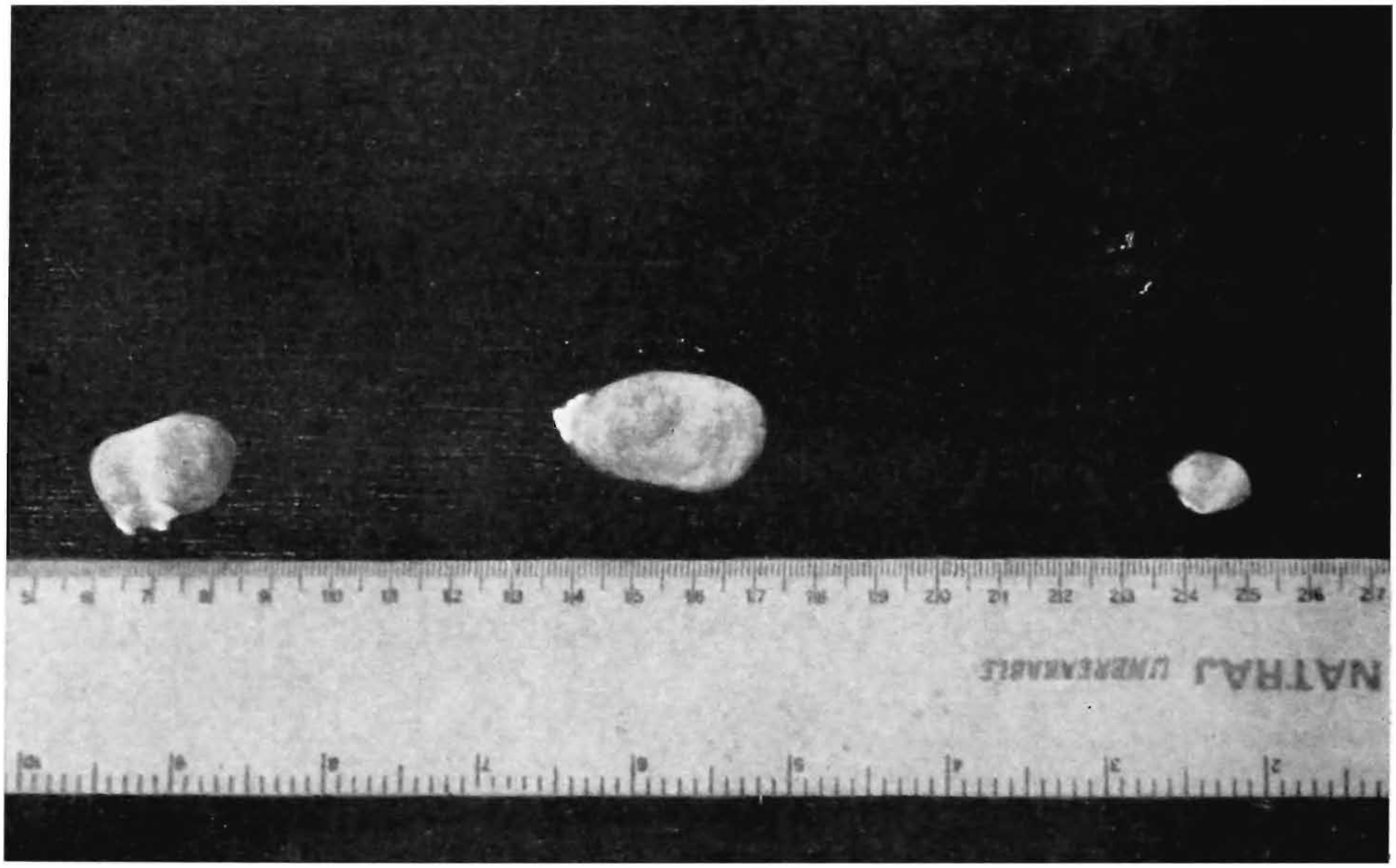
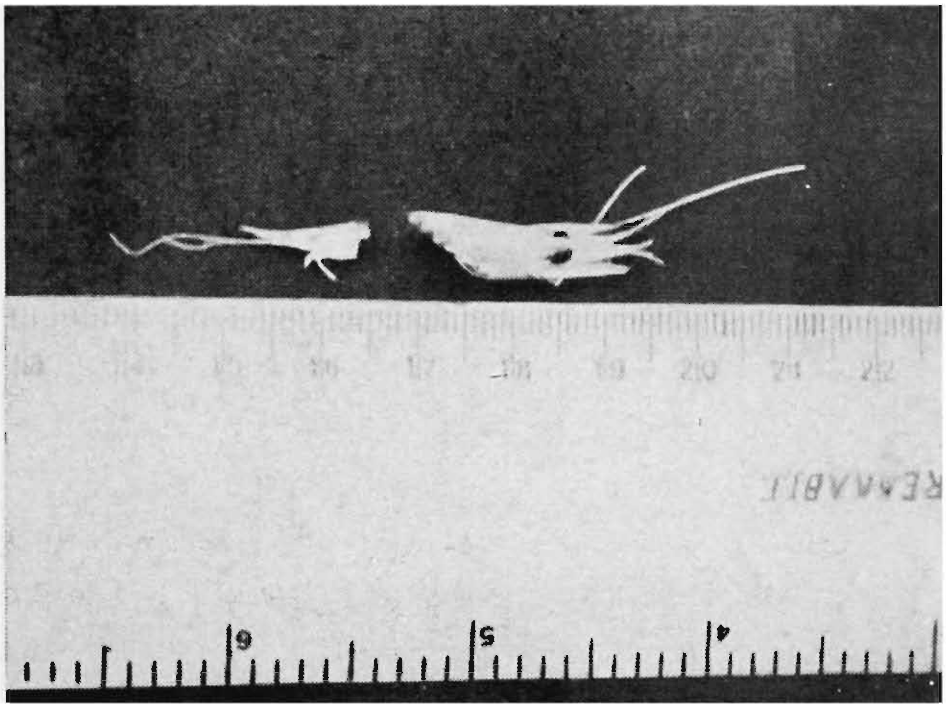


Fig. 2 : Guts of *Sepiella inermis* of three different sizes.



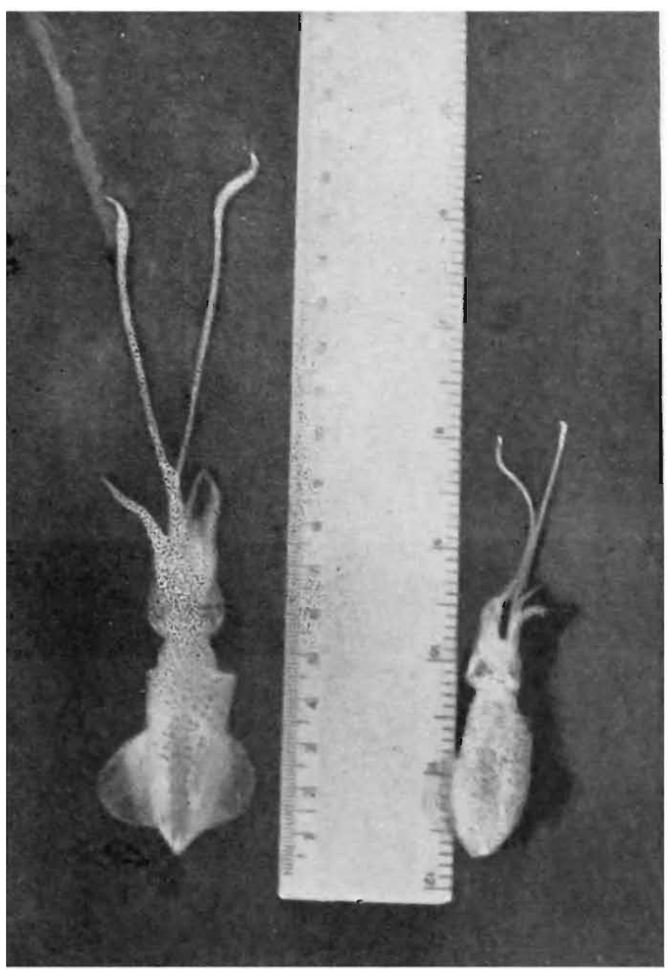


Fig. 3 : Heads of shrimps decapitated by *S. inermis*.

Fig. 4 : *Loliolus investigatoris*.

Fig. 5. Upper Row—*Lolislus investigatoris*
Lower Row—*Loligo duvauceli*

DISCUSSION

The usual way of ascertaining cephalopod diet is by examining the stomach content of newly captured animals (Boucaud-Camou and Boucher-Rodoni, 1983). These authors also

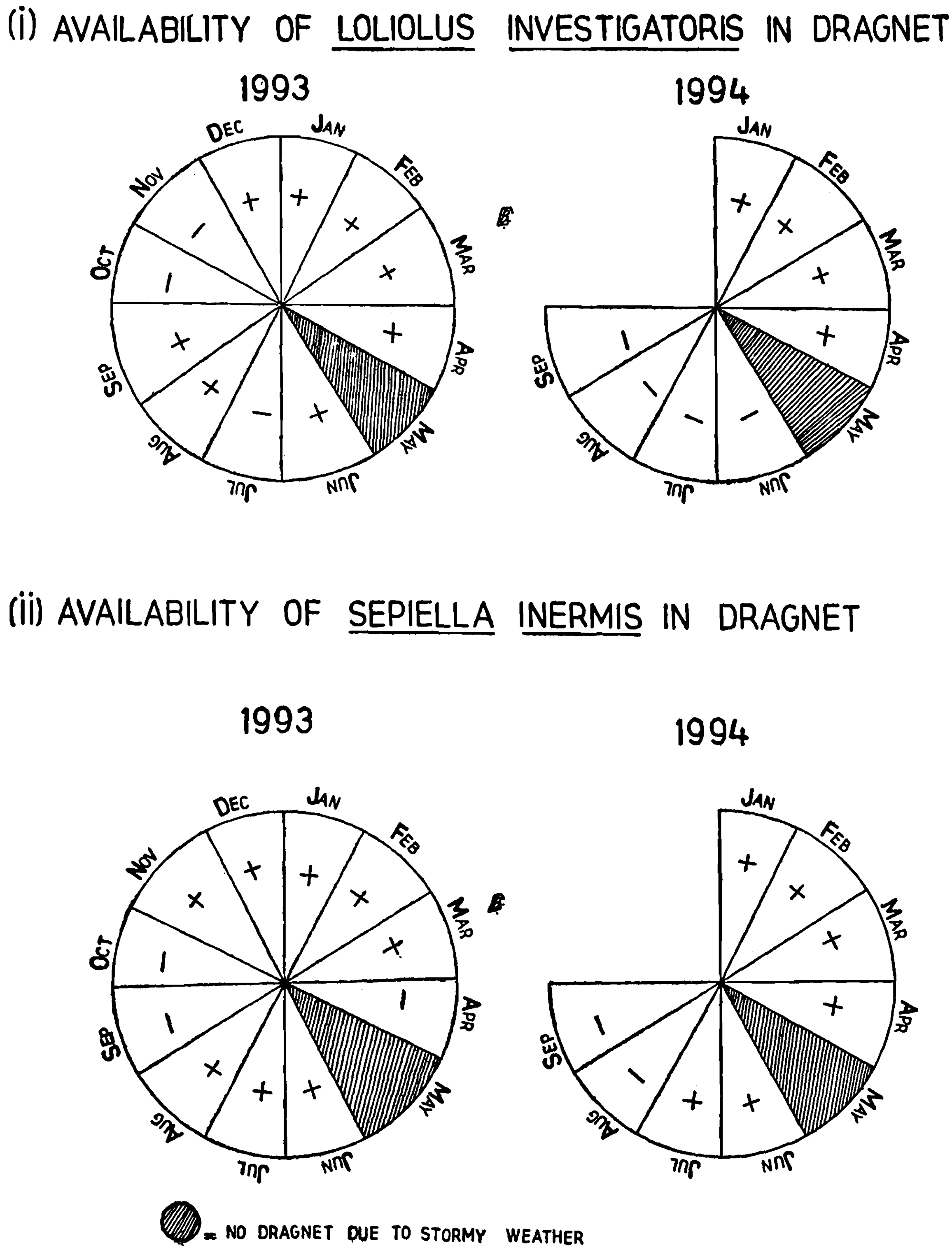


FIG-II

sum up the data based on a number of large scale studies on material from commercial catches. Various crustacea form the principal fraction of the stomach content but fish, cephalopods and even sea-weed have been found.

Digestive mechanism is basically the same in all cephalopods ; the digestive gland has a dual function, as the provider of the bulk of the digestive enzymes and to act as the site of absorption (Boucher-Rodoni *et al.*, 1987). In *Loligo* "the digestive gland is not involved in absorption" and digestion is a very rapid process. The lack of gut contents in *L. investigatoris* emphasizes on the same physiological process. The very scanty remains of crustacea fit into the general picture of cephalopodan diet.

The frequent gut contents of *S. inermis* at Digha is worth commenting on. The digestion, as expected, is far slower and the size of the stomach is also far larger than those of *L. investigatoris.* Nixon (1987) furnishes the data on sepioid and sepielloid diet. Stomach contents of 500 *Sepia officinalis* in the gulf of Tunis were crustacea, bony fish and molluscs, including cephalopods, polychaete and nemertean worms. 150 *S. officinalis* in the Atlantic coast of Spain revealed crabs as 67·5% of their diet while teleost fish answered for 23·5%. Of 72 *S. elegans* in the same waters, crustacea were again the major prey (80%). *S. inermis* (Tang and Khoo, 1974, See Nixon, 1987) is known to lie half buried in the sand and wait for prey. The food of juveniles was only crustacea while that of the adults was fish, followed by prawn and crab.

S. inermis in Digha seems to feed on only crustacea, prehaps very largely on the local shrimps. (For feeding habit in captivity, see later).

Nixon (1987) also marshalls the data on Loliginid squids. Almost 50% of 622 *L. forbesi* in the Azores sea contained food remains in which fish were the major item, followed by cephalopods including *L. forbesi.* Of 1000 *L. Opalescens* 33% had stomach contents that could be analysed and of these 42% indicated crustacean diet, 19·6% fish and 13·6% polychaetes and miscellanea. About 50% of *L. pealei*, caught in area off Rhode Island, had food remains in the stomach. Crustacea and fish/other squids predominated in the diet of young and adult respectively. Of 629 *Sepioteuthi arctipinnis* in Palk bay, India, more that 50% had remains of bony fish in their stomachs while only 21 had fed on crustacea (Rao, 1954).

Compared with all these squids, *L. investigatoris* of Digha seems to have a surprisingly rapid digestion and elimination of undigested crustacean remains. Perhaps the enzymes of the digestive gland of this organism warrant a special study.

4. **Pulsatile systems**

RESULTS

a) Isolated branchial heart of *L. investigatoris.*

This was preserved in pasteurized sea-water (PSW) in the refrigerator (4°C—17°C) after washing in PSW. PSW was changed at least once per day. Autonomous pulsations were easily observed under low magnification after a few minutes at room temperature. A representative sample is shown in Table 5A.

TABLE 5A

Pulsating rhythm of isolated branchial heart of *L. investigatoris.* Numbers indicate the period in seconds.

Pulsation number	Period
1.	15
2.	20
3.	20
4.	17
5.	48

The period is 15-20 seconds for the first four pulsations but the fifth took much longer. A rather similar pattern is evident in the system after two days of preservation (Table 5B).

TABLE 5B

Pulsations of the branchial heart preserved for 48 hrs.

Pulsation number	Period
1.	25
2.	50
3.	14
4.	19
5.	93

Isolated systemic heart of *L. investigatoris.*

Under conditions similar to those described above the pulsations of two systemic hearts were observed (Table 5C).

TABLE 5C

Pulsations (in seconds) of systemic heart.

	No. 1	No. 2
11-30 AM	6	7
	12	9
	8	10
	14	9
	13	12
03-50 PM	11	11
	12	11
	9	13
	18	11
	15	12
	13	14
	11	13
	15	12
	13	12
	25	12
	10	

Another systemic heart was utilized for studying the effect of a drug, adrenalin tartrate.

At 2-30 PM 29 recordings of this heart (No. 3) showed a range of 5-12 seconds. Just before addition of 0·2 mg. adrenalin (in 2ml PSW), the pulsation rates were 17,15,10,8 seconds. Immediately after the addition of the drug pulsations became irregular. After 30 minutes the rate was slowed down significantly ; the heart was then thoroughly washed in PSW and again after 30 minutes the recordings showed a quickening (Table 5D).

b) Isolated branchial system of *L. investigatoris.*

Pulsations and irregular movements were noticed in isolated gills. Merely by frequently changing PSW, gills could be kept in active, though progressively deteriorating, condition up to the fifth day (99 hours of observation). Deterioration was at least partly due to infection.

Three different types of rhythms of pulsations were noticeable.

(i) A rapid "ticking" presumably due to the peristalsis of blood vessels (see discussion) in freshly excised gills.

1st observation : More than 1/second
2nd observation : 1/second
(This continued for 50 seconds)

3rd observation : 10/12 seconds
4th observation : 19/20 seconds

This rhythm is the first to disappar (within hours of preservation).

(ii) Highly irregular movements not amenable to study.

(iii) Bulk movement.

TABLE 5D

Recovery of the systemic heart from the effect of high dose of adrenalin (0·1mg/ml). Numbers indicate interval of pulsations in seconds.

A. (Thirty minutes after addition of drug)	B. (Thirty minutes after washing)
24	17
23	13
26	19
18	16
23	12
24	12
12	12
25	12

TABLE 6A

Periodicity of rhythmic intervals (in seconds) of the movement of gill-tip of *L. investgatoris*

Gill No.	Periodicity	Gill No.	Periodicity	Gill No.	Periodicity
1	35	2	39	3	6
	75		20		14
	35		24		19
	42		17		11
	83		37		12
	42		11		17
	57		17		15
	44		28		37
	54		32		21
	70				

End or tip of the gill can be observed during movement of the gill as a whole. Sometimes the tip is seen to clearly execute an oscillation. Table 6A indicates some representative data.

Table 6B shows the rhythmicity of movements of gill tip.

TABLE 6B

Periodicity (in seconds) of rhythmic movement of two injured tips of *L. investigaloris* gill

Gill No.	Periodicity	Gill No.	Periodicity
1	36	2	10
	35		20
	27		11
	58		26
	101		7
	30		9
			9
			10
			12
			11
			9
			10
			11
			15
			11
			6
			10
			9
			6
			6
			5
			4
			5

Likewise, the isolated gill of *L. duvauceli* executes similar movements. The periodicity of a gill tip is shown in Table 6C.

TABLE 6C

Periodicity (in seconds) of the tip of an isolated gill of *L. duvauceli*

15
14
14
18
23
45
16
25

The gills of *S. inermis* also show similar rhythms (Table 6D).

TABLE 6D

Periodicity in the isolated gill of *S. inermis*

No. of oscillations	Seconds
10	57
10	85
10	66

After about 24 hrs. of preservation, a similar periodicity was noticed (Table 6e).

TABLE 6E

Periodicity in the isolated gill of *S. inermis* after 24 hrs. of presevation.

No. of oscillations	Seconds
10	70
10	80

On isolation, a large gill from a large specimen of *S. inermis* began to swim like an independent organism. Only one such large specimen was found.

c) Other pulsatile systems

Tips of arms of *L. investigatoris* sliced off and preserved in PSW exhibited pulsations.

Also, a very small structure near or with spermatophore, when isolated by accident, showed a rhythm of 10 pulsations/30 seconds to 10/58.

Pulsations at 08·45 AM :
10/30, 10/45, 10/44, 10/40
At 09·15 the rates were :
10/35, 10/35, 10/35, 10/40, 10/48, 10/58, 10/47.

DISCUSSION

It has long been known that there are various pulsatile systems in cephalopods. Some of these might be utilized for studying the biological clock-like rhythms after isolating these from the influence of the whole body. Action of ATP and ATPase on such systems is worth investigating, as well as of such anti-metabolites as Actinomycin D in order to determine the function of newly synthesized RNA, if any.

Again, these systems are also of value for testing drugs. It is known that isolated systemic heart behaves predictably *in vitro* (See Wells, 1983). The (isolated) "Systemic ventricle will continue to beat for many hours if perfused with a pressure head of blood or seawater". If acetylcholine (ACH) is added the beat slows, amplitude decreases and it may altogether stop. ACH is the inhibitory transmitter in these hearts, apparently. Interestingly the effect of ACH is annulled by previous treatment of the well-known drug, curare. The present data on adrenalin are relevant in this context.

Thus, isolated pulsatile systems of cephalopods, particularly the heart, might serve as a test model for various drugs, including the bioactive substances extracted from marine animals. Although mammalian models are the most desirable for medical research, the cephalopod system may also be useful for a preliminary study.

Again, it is interesting *per se* that isolated gills maintain their rhythms for days in merely PSW. Deterioration is largely due to infection and so it might be possible to considerably prolong the activity simply by working under near aseptic conditions.

As early as in 1905 Carlson (See Eno, 1987) noted that most blood vessels of *Loligo* were capable of peristaltic contractions and *isolated* lengths of arm vein were seen to pulsate (Mislin and Kruffmann, 1948; See Eno, 1987). These are probably the cause of the twitchings of isolated arm tips and the "ticking" clock of gill lamellae of *L. investigatoris* described here. Isolated gills of *Octopus australis* have been reported to contract regularly (Evans and Darling, unpublished ; see Eno, 1987).

The autonomous nature of the movements of isolated gills is particularly evident when the gill is excised from an animal that is no longer lively. Soon after isolation the gill becomes more active as the animal itself dies ; it is as if the gill, now liberated from the dying cephalopod, evinces a brisk rhythm. The indepedent "Swimming" of the large *S. inermis* gill, caused by its twitchings, is also a similar phenomenon. From the evolutionary point of view such autonomy in invertebrates may have made possible the separate existence of the cormidium that breaks away from *Muggiaea*, a siphonophore (Hyman, 1940 ; see Wilson, 1977).

5. **Data pertaining to rearing in Aquarium**

RESULTS

a) Longevity of captured animals.

Since there is at present no boat for MARC, live cephalopods collected from nets cannot immediately be transferred to containers of sea-water. Instead, animals cast off on the beach are collected, transported to the laboratory in inadequate vessels within which they spray ink and pollute the ambient. Furthermore, there is no circulating sea-water available at the moment.

Under these circumstances, adult *L. investigatoris* have been in the swimming stage for only one hour or less after being transferred to the laboratory and even this is possible only on cool or overcast days.

A *S. inermis* of relatively large size survived for at least 10·5 hours in a tray of sea-water (from 11 AM to 8-30 PM). Water was changed only twice with mugs. It died some time at night.

Another *S. inermis* survived for more than 20 hrs. under nearly identical conditions (from 11·5 AM to 8-30 AM next day) but was dead soon after.

b) Feeding the captive animal.

A single case of feeding, namely the *S. inermis* that survived for 20 hrs. has been possible but this is worth recording (see discussion).

In the evening the *S. inermis* was left in the tray together with a shrimp about as long as the total length of the former. The tray was partly covered, Next morning, the head and rostrum of the shrimp was found in the tray, neatly sliced off and turned red by now. There was no trace of the body either in the tray or on the floor.

c) *S. inermis* larva

The larvae were in the process of hatching when the egg mass was brought. Table 7 indicates their dimensions at this stage.

TABLE 7

Dimensions of *S. inermis* hatchlings (in mm)*

Larva No.	Length from base of tentacles to the posterior tip	Width maximal width without the extension of mantle on both sides
1	5·25	5
2	11	5·5
3	12·25	5

* 1 division of the scale was 0·5 mm.

These larvae survived for at least 9 hours (from 1 PM to 10 PM) in small petridish with sea-water. Those in a tray were actively swimming at least up to 34 hours.

d) Juvenile *L. investigatoris* caught in 'Bagda net'.

3 remained active for about 5 hours (5-30 AM to 10-30 AM) in normal temperature. Another was actively swimming under similar conditions for three hours (5-8 AM), but then began to sink to the bottom of the container. with artificial aeration, it immediately responded and became active again and this continued for 2 more hours (See e).

e) Cryobiological data

The effect of low temperature on these animals of hot clime has been studied, at first on the comparatively hardy larvae of *S. inermis.*

After 10 hours of cold shock at 12°C they all looked devoid of the pigment and immobile, resembling dead bodies. After about 10 minutes at room temperature they all recovered ; they wore a blanched look even after 2 hours though they were mobile.

The 3 Juvenile *L. investigatoris* mentioned in (d) were put at about 12°C at the end of 4 hours of survival in normal temperature. One of these survived for three more hours (total 7 hrs.). The animal that survived for 5 hours at room temperature (aeration during the last 2 hours) was put at$\sim$4°C at 10 AM. It survived up to at least 6·40 PM i.e., for more than 13 hrs. One *S. inermis* remained alive for about 6 days (140 hrs.) in a trough of sea-water with a 14 hour regimen of aeration per day. This was in the cool weather.

DISCUSSION

The very scanty data on survival still indicate the possibility of rearing *S. inermis* of Digha in circulating sea water after quick transport to Aquarium during cold weather. Feeding with crustacea like shrimp in the dark or in dim light should be possible.

About 10% of the known 700 cephalopod species have been maintained, reared or cultured in captivity (Hanlon, 1987). Maintenance connotes only holding wild-caught specimen for a short while and rearing denotes development of wild-caught *juveniles* to near maturity ; only 12 species have been truly cultured in captivity, i. e., hatchlings have been grown to maturity and the birth of second generation has been noticed (Hanlon, 1987). The concept that cephalopods are too delicate to survive or grow in captivity is therefore no longer valid. Casting the catch on hot tropical sands leads, however, to a special difficulty that may be overcome if the research station has a boat at disposal wherein the catch can directly be transferred to containers of sea-water.

ETHOLOGICAL ASPECT

Cephalopods, especially the decapods are known to be dim-light feeders (Boucaud-Camou and Boucher-Rodoni, 1983). The single case of feeding by the captive *S. inermis* recorded here also took place in the hours of darkness but not in the preceding hours of daylight.

Although as yet we have a single case of eating the shrimp, the process that occurred is of interest to behavioural science. The neat decapitation of the shrimp and rejection of the head and rostrum is remarkable. In this organism of a relatively small size, this rostrum and head would injure the stomach if it could be negotiated at all. To our knowledge such behaviour in the decapoda has not been recorded. Massenger (1977) describes the procedure of prey capture, especially prawn, by sepia. The prey is quickly captured and swallowed, no rejection of the head part has been noticed. Again, the squid *Alloteuthis subulata* dart and capture prawns and shrimps and ingest them within a few seconds (Nixon, 1987) and there is no report of immediate regurgitation of the head part.

Some octopus species neatly remove flesh from exoskeleton and hole-boring in shelled molluscs by octopus has been well studied (Boucher-Rodini et al., 1987) but no example is known of decapitating and rejecting the head and rostrum. This may have been a unique behaviour pattern developed in the small *S. inermis* of Digha in order to prevent injuries to its stomach. Further records of this behaviour pattern would be of interest and this will be looked for in the near future.

GENERAL REMARK

Cryo-conditions may be useful for rearing young cephalopods by cutting down their metabolic rate when, for example, food (like *Artemia*) are not available or circulating sea-water has ceased for some time etc.

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ADDENDUM

1. Survival : One *Sepiella inermis* survived up to 16 days in the trough under the regimen of 14 hrs. of aeration per day, with partial replacement of sea water once a day. The experiment had to be discontinued for lack of electricity for a long spell so that the aerator could not be used.

2. Shrimp decapitation by *Sepiella inermis* : A total of three cases has now been recorded suggesting that *Sepiella inermis* cut off the heads of Shrimps which are too big for them to negotiate. Two more *S. inermis* (of two different sizes) decapitated Shrimps in our presence (Photograph). These two heads considerably differ in their sizes. It was also noticed that extremely hungry *S. inermis* might not decapitate the shrimp.

3. Two spermatophore bearing *S. inermis* measured 8·4 cm. and 7·00 cm., respectively (Total length). Spermatophore dimensions : 5·5 mm x 0·3 mm.

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Note : In References, JMBAI denotes Journal of Marine Biological Association of India.

ERRATA

Page 32, 4th line from bottom :
For "Fig. 1" read "Fig. 2"

Page 33, last line :
For "tables 1B-D" read tables 1A-D

Page 43, 10th line from bottom :
For "L. Opalescens" read "L. opalescens"
8th line from bottom :
For "area" read "an area"

Page 46, 3rd line from top :
For "disappar" read "disappear"

Page 49, 11th line from top :
For "these from" read "from"
2nd line from bottom :
For "Kruffmann" read "Kauffmann"

Page 50, 9th line from bottom :
For "8-30 PM" read "9-30 PM"
6th line from bottom :
For "11·5 AM" read "11-30 AM"