trend was observed in 13, 14 and 15 ppt too. The conditioning time and lethal salinity experiments clearly reveal that larger clams are more tolerant to lower salinity levels than smaller ones, which get adapted faster to higher salinity ranges of 35 and 40 ppt.

A progressive delay in shell opening and activity with higher and lower salinities has been recorded in *Donax cuneatus* (Talikhedkar and Mane, 1976), *Meretrix casta* (Durve, 1963), *M. meretrix* (Randea and Kulkarni, 1973). *Katelysia opima* (Renade and Kulkarni, 1973; Mane, 1974) and *P. laterisulca* (Mane and Dhamne, 1980). By closing the valves indefinitely, the animal isolates itself from the unfavourable environment. The indefinite closure of valves beyond critical salinity was observed in the present study at 0 and 5 ppt treatments. However, the animal is unable to ensure complete closure for a prolonged period, which proves detrimental.

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TERRESTRIAL INSECTS IN FLOTSAM IN INDIAN OCEAN

ABSTRACT

Pleuston samples from Arabian Sea, Bay of Bengal and Indian Ocean contained a number of terrestrial insects/insect parts. The deposition of terrestrial insects in these regions varies from as low as 0.462 kg/km^2/yr. in Indian Ocean to 3.224 kg/km^2/yr. in Arabian Sea, values which are less than 0.01% of the phytoplankton productivity.

TRANSPORT of insects by wind from terrestrial to marine environments is well recognised now (Bowden and Johnson, 1976). However, much remains to be done to know the frequency with which insects are thus carried over the oceans, the aerial density of these insects over the lands of their origin as well as over oceans, their eventual fate, their number in the surface waters and their possible ecological roles. Zaitsev (1990) was the first worker to look at their eventual death in sea waters and possible contribution to the oceanic biomass. Cheng and Birch (1977, 1978) are the only other workers who had carried out this exercise in three coastal regions *viz.* the Gulf of California off Baja California, Mexico; eastern Pacific Ocean, off the coast of Oregon, USA and English channel off the coast of Britain.

Presented here is some data on terrestrial insects blown out to sea and deposited on surface waters in Arabian Sea (March-April 1996), Bay of Bengal (March-April 1995) and Indian Ocean (Jan.-Feb. 1996).

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MATERIAL AND METHODS

All samples were collected by standard surface plankton nets (mesh size 350-400 µm), towed at a speed of 4.5 km/h for 20 min/tow. Terrestrial insect/insect parts were separated from other pleuston organisms and identified as far as possible to their respective orders and families. Mean weight of an 'average' insects was assumed as 1 mg. Unidentifiable insect parts found in appreciable numbers in Arabian Sea and Bay of Bengal however, could not be weighed and their total biomass was assumed as one-tenth of the biomass of identified insects. Unidentifiable insect parts were not noticed in significant numbers from plankton samples collected from Indian Ocean.

RESULTS AND DISCUSSION

More significant results of the investigation are presented here. Detailed analysis is being done and will be published later.

Pleuston samples consisted of phyto and zooplankton, insects of terrestrial origin and insects endemic in the ocean *viz. Halobates* (Hemiptera : Gerridae). The observations on the endemic insects are being published separately and have therefore been excluded from this study. Insects of terrestrial origin, separated from the samples, could not have floated out to the sea from freshwater sources for the simple reason that the sampling stations were far away from the shores and the insects or their corpses are expected to disappear from the sea water in tropics within 2-3 days, either as a result of being eaten up by fish or due to disintegration by microbial action (Cheng and Birch, 1977).

It is surmised that in the absence of data of seasonal and/or diurnal variations in the deposition of insects, the present data indicates daily rates of deposition. Only a few orders of insects are represented in the samples collected (Table 1), unlike the samples of airbone insects collected by aerial nets and kites etc. (Hardy and Milne, 1937; Bowden and Johnson, 1976; Pathak and Parulekar, 1988; Pathak *et al.* 1998). Of the three areas of investigation, Hemiptera dominated the samples in Arabian Sea (55%) and Bay of Bengal (55.5%) but was unrepresented in Indian Ocean. Diptera and Hymenoptera are present in all the three areas. The contribution (in% of the total) of Diptera was 24.5 in Arabian sea, 11.1% in Bay of Bengal and 28.5% in Indian Ocean. Hymenopterans on the other hand had the highest proportion (57.1%) in Indian Ocean but had a small presence in Arabian Sea (8%) and Bay of Bengal (2.8%). Coleoptera were present in small numbers in Bay of Bengal (8.33%) and Arabian Sea (8%), but were absent from samples from Indian Ocean. Similar is the case

TABLE 1. *Summary of terrestrial insects in surface plankton tows in Arabian Sea, Bay of Bengal and Indian Ocean.*

S.No.	Order	Area of Investigation								
		Arabian Sea			Bay of Bengal			Indian Ocean		
		Lat 16°N 21°N	Long 68°E to 73°E		Lat 20°N to 0.5°N	Long 78°E to 92°E		Lat 14°N to 05°S	Long 60°E to 76°E	
		Number of families	Insects Number	%	Number of families	Insects Number	%	Number of families	Insects Number	%
1.	Hemiptera	8	27	55	3	20	55.5	0	0	0
2.	Diptera	6	12	24.5	2	04	11.1	2	2	28.5
3.	Hymenoptera	4	04	8	1	01	2.8	3	4	57.1
4.	Coleoptera	4	04	8	2	03	8.3	0	0	0
5.	Neuroptera	1	02	4	1	01	2.8	0	0	0
6.	Thysanoptera	0	00	0	0	00	0	1	1	14.3
7.	Unidentified	0	00	0	?	07	19.4	0	0	0
	Total	23	49			36		7	7	
Number of tows and duration			22 of 20 min each			11 of 20 min each			11 of 20 min each	
Number of insects per tow			2.22			3.27			0.29	
Area covered per tow			1848 m^2			1848 m^2			1848 m^2	
Number of insects / km^2			0.265×10^5			0.194×10^5			0.038×10^5	
Insect Biomass (g)			26.5			19.4			3.8	
Biomass of unidentifiable parts			2.65			1.9			0	
Total Insect Biomass			29.05			21.3			3.8	

of Neuroptera which were 4% of the total catch in Arabian Sea, and 2.8% in Bay of Bengal but was unrepresented in Indian Ocean. Thysanoptera on the other hand was present in the Indian Ocean but was absent from the other two areas.

Expressed in terms of insects/km^2, the 'standing crop' was estimated to be in the range of 0.265×10^5 for the Arabian Sea, 0.194×10^5 for the Bay of Bengal and 0.038×10^5 for the Indian Ocean. Taking the mean weight of an average insect to be 1 mg, the estimated biomass per km^2, at the period of our taking the samples, comes to 29.05,21.3 and 3.8 g respectively, for the three regions. The only other published estimates for terrestrial insects at sea, indicate biomass of about 2 g/km^2 in North Pacific Ocean in winter (Cheng, 1975, and 25 g/km^2 for Black sea in summer (Zaitsev, 1970). Biomass values of Cheng and Birch (1977) for the three coastal regions referred above are in the range of 20-170g/km^2. Bowden and Johnson (1976) estimated that in August, at any one time, there may be as much as 1kg/km^2 of insect biomass available on land for being transported over the North sea. However, insect biomass at sea, must be varying greatly with seasons, wind direction and velocity, distance from the nearest landmass in wind direction and other factors. Higher values in case of the coastal regions including Gulf of California off Baja California, Mexico, coastal region off Oregon coast, USA and English channel may be due to the fact that these areas are too close to the shore and at least in two cases have landmasses on two sides. In the present investigation, on the other hand, the areas of study are open oceans and much farther from land.

The biomass contribution of insects per unit time may be estimated if we assume that an average insect remains identifiable only for 2-3 days before being eaten up or getting disintegrated by microbial action. To maintain 'standing crop' of the sizes indicated above, insects would have to be deposited at annual rates of 4-29 × 10^2/km^2 i.e. about 0.4 to 2.9kg/km^{2}yr. We may note that this range of values, about 1mg/m^2/yr. is less than 0.01% of the productivity of the phytoplankton in relatively unproductive ocean waters (Bowden and Johnson, 1976). These values are much lesser than what was expected from tropical seas. The reason for the same is not known. However, it can be stated that although the remains of the terrestrial insects do constitute an appreciable contribution to the pleuston, they are of only minor importance as a food source in open oceans.

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ON THE SPAWNING AND LARVAL DEVELOPMENT OF *SPARUS SARBA* FORSKAL

ABSTRACT

Twenty eight specimens of *Sparus sarba* Forskal of length 30-35 cm, collected from the coastal waters of Gulf of Aden and stocked in the open air tanks at the laboratory in December 1990, spawned in February 1991. The spawning was fractional and prolonged with very high fecundity. Though the initial level of mortality was very high, afterwards it was reduced when it started feeding on food like *Chlorella* and oyster larvae. The developmental stages and larval characters have been studied. The 36 days old larvae resembled a miniature adult because of the high fecundity, prolonged and fractional spawning *Sparus sarba* is suitable for large scale culture.

SPARUS SARBA belonging to the family Sparidae is one of the most economically important groups of fishes in the Gulf of Aden. The biology and early life history of this fish need detailed study as it is a potential species for aquaculture. Tomiyama (1974) has provided a detailed pictorial illustration of the sea Bream culture and Johnson (1978) compiled some information on the development of Sparidae groups of the mid Atlantic Bight. The only