Effect of Solar Radiation on Uptake of Copper and Cadmium in Penaeid Shrimp Larvae

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Summary: The presence of sunlight or solar radiation was found to be important factor for considering the effect of copper and cadmium on the survival of penaeid shrimp. The survival rate was inversely proportional to the intensity of light at each larval stage of penaeid shrimp. The effect of solar radiation on the uptake of copper and cadmium was expressed by linear regression. The coefficient of regression was used to determine the effect of solar radiation on uptake of copper and cadmium.

The temperature of the experimental chamber also increased, during the day at 12.00h. Showing that the sunlight may have acted synergistically with temperature for permeability of Cu and Cd.The LC_{50} value was calculated at each larval stage for copper and cadmium separately.

Introduction

By considering the major factors that generally influence the rearing of zooplankton, the solar radiation is one of the closest factors to the animal's natural conditions. [1] has been investigated that direct sunlight killed all specimens of *Sinocalanus tennellus* and complete darkness prohibited the reproduction of this animal. All open oceanic surfaces are under direct inter connection to the solar radiation, getting more energy from the sun, which may enhance productivity of shrimp larvae. The uptake of copper and cadmium in the solar radiation also related to their nutrient like behavior, alongwith the depth of the sea as decrease intensity of sunlight [2]. It may be concluded that profile distribution of Cu in the seawater and its interaction with the sunlight is a complex phenomenon [3]

The level of heavy metal accumulated by marine organisms is a function of water quality, diet, seasonal factors like solar radiation [4]. The effect of heavy metals for example coppers and cadmium on developmental stages of crustacean larvae is still not clear. Sofar very little experimental work.

Either field or in laboratory conditional has been conducted to determine the effect of light intensity, wavelength and duration on the behaviour and growth of penaeid shrimp. According to the literature survey (very few references were found still needs more extensive work in this sequence.

The aim of present study was to determine the effect of solar radiation on the uptake of copper and cadmium to the two penaeid shrimp species i.e. *Penaeus monodon* and *Penaeus penicillatus.* We have tried to explain the effect of solar radiation on the uptake of copper and cadmium uptake by relating it to the life cycle of shrimp that is at each larval stage.

Results and Discussion

The effect of solar radiation (effect of sunlight on accumulation of metal determined by AAS Table 1) was not same for every larval stage, and also varies with time of day depending upon the intensity of light. It was equally observed at every larval stage, under sunlight as the exposed concentration of metal increased the survival rate was decreased. Number of alived larvae shown that maximum survival rate was observed in the morning between 7 to 9 a.m. and in the evening between 5 to 7p.m that is at sunrise and sun set. There was no significant correlation between the survival rate and concentration of metal in experimental chamber.

Results to the 24-28h exposure of Cu, Cd and Cu:Cd (1:1)are presented in Table 1 and 2 for *P.monodon* and *P.penicillatus* respectively. 98% mortality was occurred for nauplii at 400µg/L and postlarvae at 400µg/L of Cu exhibited less than 50% mortality (Figure 1). A 24h Lc_{50} was estimated to be

100µg/L for all stages zoea, 10µg/L for nauplii and 200µg/L in average for mysis and for postlarvae it was 400µg/L.The Lc_{50} for 24h exposure experiment for cadmium, was found to be higher than that of Cu depending upon the date and duration of solar radiation. The 24h Lc_{50} for Cd was 50µg/L for nauplii, 200µg/L for zoea 400µg/L for mysis and postlarvae (Figure 2). The uptake of metals determined by AAS is shown in Table 1 and 2. Multiple linear regression was used to determine the combined effect of both metal uptake and solar radiation on the larval stage of both species. The relationship between uptake of Cu, Cd and mixture and the simultaneous effect of solar radiation during exposure is expressed by the regression shown in table 3.It was noted that sharp sunlight at almost 12.30p.m also affect the movements of every specimen, When sun was at peak all larvae seems to be settled down at the bottom of beakers thus having no movement that shown the variation in intensity of solar radiation decreased as level of water or depth in the beaker increased. It means light adopted (especially as other

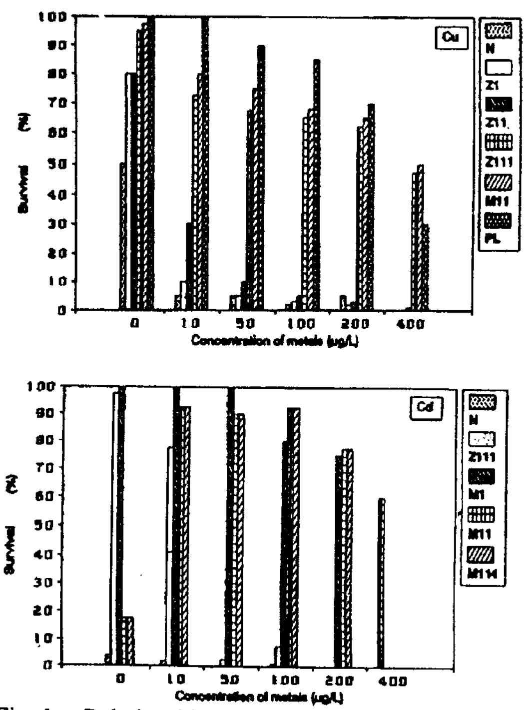

Fig. 1: Relationship between survival rate and exposed concentration of metals under solar radiation in *P. monodon* larvae (average photoperiod 15h).

specimen. After 3-4 p.m. all larvae become signify-cantly mobile in all exposing chambers of levels. This movement was found to be gradually decline with respect to the metal concentration of every metal.

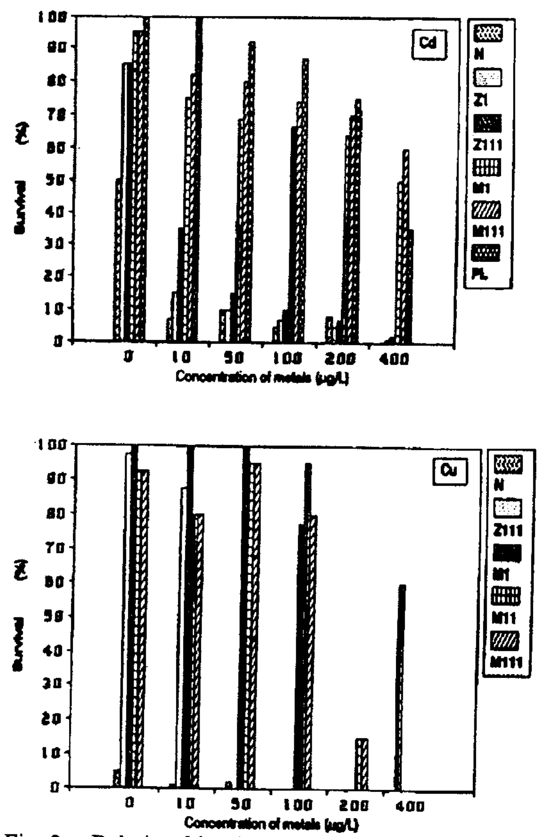

Fig. 2: Relationship between survival rate and exposed concentration of metals under solar radiation in *P. penicillatus* larvae (average photoperiod 15h).

The 24h Lc_{50} values for nauplii, zoea, mysis and postlarvae of Cu and Cd at Constant salinity and variable temperature (temperature was not same during the whole exposure period) represent generally intermediate values when compared to those values which are documented for other marine zooplankton [5]. This study approved the results on the solar radiation as one of the most important factors controlling the survival of crustacean larvae and an uptake of Cu, Cd and their mixture, [6]. The accumulation of metals in marine organisms can be affected by many environmental factors including

Table 1. *P.monodon*. Mean concentration of Cu and Cd determined by AAS at each larval stage under solar radiation after exposure of different concentrations.

	Larval stage	Exposed metal concentration ug/L		Date and Duration	Conc.Determine by AAS dry wt.ug/g	
					Cu	Cd
1	Naupli	Cu	10	24h16/4/94	0.095	0.040
2	"	Cu	50	28h22/4/94	3.450	1.8047
3	"	"	200	27h"	26.11	0.129
4	"	Cd	100	24h17/4/94	0.346	13.840
5	"	Mix	100	24h24/4/94	3.573	2.4053
6	Z1	Cu	10	28h18/4/94	5.092	3.4456
7	"	"	100	26h"	12.650	5.530
8	"	Cd	50	26h"	0.075	4.0560
9	"	"	200	28h"	2.105	8.010
10	"	Mix	50	28h"	3.410	3.0150
11	"	"	100	26h"	2.105	1.9810
12	"	Cu	20	24h20/4/94	3.521	-
13	Z11	"	100	26h"	13.256	4.6761
14	"	Cd	10	28h"	2.521	0.9360
15	"	"	200	28h"	1.5140	14.510
16	"	Mix	200	26h"	8.3401	7.9201
17	"	"	400	27h"	4.9610	5.7321
18	"	Cu	100	26h19/4/95	4.6105	3.0131
19	Z111	"	50	28h"	2.2121	3.8820
20	"	Cd	200	26h"	4.375	-
21	"	"	100	28h"	2.0167	4.5412
22	"	Mix	20	28h"	0.4670	0.9821
23	"	"	200	24h"	6.0730	7.0310
24	"	Cu	100	28h28/4/94	7.0310	1.2161
25	M1	Cd	200	26h"	2.0210	6.4671
26	"	Mix	100	30h"	7.350	6.2560
27	"	Cu	10	30h10/5/94	1.6760	0.9240
28	M11	"	400	30h"	24.614	3.1670
29	"	Cd	50	32h"	1.001	2.6510
30	"	"	200	29h"	1.931	15.167
31	"	Cu	200	28h12/4/95	15.3410	2.1035
32	M111	Cd	50	26h"	1.0150	1.5671
33	"	Mix	10	26h"	0.9205	0.2981
34		Cu	10	28h4/5/94	0.3130	0.0680
35	Pl	Cd	10	30h"	0.1256	0.4670
36	"	Mix	200	28h"	1.730	0.2460

Table 2. *P.penicillatus* .Mean concentration of Cu and Cd determined by AAS at each larval stage under solar radiation after exposure of different concentration

S. No.	Larval stage	Exposed metal concentration ug/L		Date and Duration (h)	Concentration Determine by AAS dry wt.ug/g	
					Cu	Cd
1	Naupli	Cu	10	22h1//94	0.1034	0.0145
2	"	"	100	24h"	1.3601	0.9341
3	Z1	"	-			
4	Z11	Cu	20	25h	3.1250	0.6014
5	"	Cu	200	27h5/4/94	8.9201	0.0254
6	"	Mix	10	26h"	2.0073	2.1014
7	Z111	Cu	10	26h6/4/94	2.0012	0.0256
8	"	Mix	200	27h"	6.0738	1.5106
9	"	Cd	10	28h "	0.1459	1.6740
10	"	Cd	200	28h10/6/94	2.105	8.010
11	M1		--	--	-	-
12	M11	Cu	100	28h12/6/94	4.6760	1.2670
13	"	Cd	200	29h"	4.6760	1.2670
14	M111		--	--	-	-
15	PL	Cu	100	29h"	0.5466	0.1030
16	PL	Mix	400	28h"	13.1539	10.1030

solar radiation, thus demonstrating their potential as sentinel accumulation of heavy metals (the amount case death up to 5%). Although, copper is an essential trace element in living organisms, it may become toxic at increased concentrations [7]. Cadmium is regarded as a priority pollutant because of the toxicity in marine organism [8].

Langhurst [9] has been studied the effects on the photostactic response of zooplankton. The reason for the remarkable sensitivity of the phototactic response of these larvae towards the metals is not clear. [10] has speculated that it could be due to the effect of the metals upon their nervous systems or their swimming mechanism but it clearly provides a relatively simple but very sensitive means for the estimation of sub-lethal toxicity of metals. During present study also confusing results were obtained because at the exposed concentration of Cu higher survival was found or vice versa (Figure 1 and 2).

Post larvae at maximum sunlight to be more immobile than nauplii, without considered the interaction between environmental factors. Those may play important role to the uptake of copper and cadmium by larvae. No matter how much contradictory results were found for nauplii, zoea, mysis and postlarvae but the response of the survival of every stage larvae to solar radiation was inversely proportional (Fig.1 and 2). Results by AAS have shown that uptake of Cu and Cd insignificantly followed the pattern of exposed concentration. The variation on uptake of these metals alongwith increasing intensity of sunlight remains unclear. This study may be affirm the suggestion that Cd concentration in the surface of relatively pristine sea water are commonly below 10ug/L [11]. In all exposed chambers larvae seem to be moved away from surface water to the bottom due to intensity of sunlight. Similar may occur in ocean but in fact, dilution factor is also very important. The role of solar radiation in ocean can also be explained on the basis of complexes of Cu and Cd in the ocean.

Seawater in the photic zone is super saturated with respect to calcite, especially carbonate ions, influenced by biological activity, which directly or indirectly enhance Cd absorption on biogenic calcite surface resulting low Cd concentration [12]. A review of the Cu concentration in seawater also suggested the same pattern of contamination therefore, the surface water are relatively uncontaminated as compared to depth. [13]. There is a large variability exists among the reports about the concentration of Cu in surface water and in the deep water But, results in general indicated a significant degree of Cu compellation with organic legends in the surface waters [14]

It is fact that short-term exposure of Cu and Cd under solar radiation for every larval stage may provide the basic information about the behavior of these larvae, or relative toxicity of both metals for penaeid shrimp. This information is essential to determine "safe" concentrations for water quality criteria [15]. But, the long-term multiple generation chronic tests in this regard may be controlled environmental pollution could provide sufficient toxicity information [16] In this sequence, parallel experiment with temperature, salinity and pH under light and dark conditions were also necessary for the determination of combined effects on environmental pollutant uptake by marine organisms. In ocean all these ecological factors are correlated to each other [17].

In conclusion, results of this study indicate that solar radiation should be taken in to consideration as an important factor in estimating the toxicity of Cu and Cd in marine environment. So, far data has been recorded regarding the role of solar radiation in the uptake of copper and cadmium is scaring. The effect of solar radiation on the toxicity of heavy metals must be studied more extensively to find the best environmental condition for the growth of shrimp larvae.

Experimental

Like previous study of other factors [18] the larvae of both species used in this study were obtained from a hatchery near to laboratory at Xiamen University. All larvae were first acclimatized in the laboratory with room environmental light and temperature. All experimental conditions were same [19] except after exposing to metal concentrations, all beakers were kept outside in a place where they could remain in direct sunlight, covering with a fine and broad gauzy appearance muslin cloth in order to avoid any external object interference to larvae. The exposure experiment remained continue for 24h with 12h: 12h light- dark regime. Taking care of the weather, all these experiments were completed in full sunny days. After completion of 24hrs period all beakers were emptied on sieve and specimen were preserved for determination of amount of uptake copper and cadmium by AAS [19].

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