SALINITY AND TEMPERATURE TOLERANCE OF A COPEPOD *PSEUDODIAPTOMUS ARDJUNA* BREHM FROM BOMBAY COASTAL WATERS

ABSTRACT

Salinity tolerance, temperature tolerance and combined effects of temperature and salinity on survival were investigated in the laboratory on the copepod, *Pseudodiaptomus ardjuna* from Bombay coastal waters. Experiments on salinity tolerance were conducted at salinities from 35‰ (taken as 100% sea water) to 0‰ (fresh water) at ambient room temperature. The copepod could tolerate salinity down to 37% sea water when subjected to sudden exposure. Salinity acclimation increased the salinity tolerance and it could tolerate dilutions as low as 10% sea water after gradual acclimation. The upper and lower lethal temperatures were found to be 35°C and 8°C respectively, in full strength sea water. Investigations on the combined effects of temperature and salinity were carried out by subjecting the copepods to various combinations of salinities and temperatures within the tolerance limits. The animal exhibited better survival in various salinities at higher range of temperature. The experimental results were compared with the field observations and the effects of salinity and temperature on the distribution of *P. ardjuna* are discussed in the light of the above findings.

DIFFERENT species of the genus *Pseudodiaptomus* have been recorded (1) only from the sea, (2) in estuary and brackish water, as well as from the sea, (3) only in estuaries and brackish water and (4) only from fresh water (Sewell, 1934). Desai and Bal (1961) collected specimens of *P. ardjuna* from back waters of Bombay. No specimens were obtained from the offshore waters and, therefore, according to them, this copepod prefers low salinity. Ummerkutty (1960) is of the opinion that this copepod is an inshore dwelling species which gets into the saline creeks connected to the sea, where it experiences great variations in salinity and temperature.

P. ardjuna was found to occur in large numbers during May to July (premonsoon to monsoon period) in the shallow bay in the vicinity of the Taraporevala Marine Biological Research Station. The present investigation was, therefore, carried out to find out the effect of salinity and temperature separately and in combinations on *P. ardjuna* in the laboratory. The tolerance capacity of the copepod to these two important factors in captivity was then compared with the field observations. An attempt has also been made to explain the effect of salinity and temperature on the distribution of *P. ardjuna*.

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Material and methods

The copepods were collected from a shallow bay in the vicinity of the Taraporevala Marine Biological Research Station. Animals were captured with plankton nets and were immediately brought to the laboratory. They were maintained at air temperature and in sea water (about 35‰ salinity) from the circulatory system of the Taraporevala Aquarium for at least 24 hours before they were taken

for experimental studies. The copepods, in captivity, were fed with freshly hatched nauplii of *Artemia salina*. The experiments were conducted for 120 hours except the salinity acclimation experiments. The survival periods of individual specimens in each set were recorded to obtain the percentage survival. The dead animals were removed at regular intervals. In all the experiments, results were recorded at least in duplicate and mean survival periods were calculated.

Those salinities and temperatures in which at least 50% of the animals survived at the end of 24 hours exposure, have been considered to be within the tolerating rage and rest as lethal. Sea water required for the experiments was taken from the circulatory system of the Taraporevala Aquarium, having a salinity of 35‰ ; this sea water has been taken as 100% sea water. Various dilutions were made with distilled water. 200 ml of water with 10 animals, was used per experiment and the water was changed daily.

Experiments on salinity acclimation were conducted to determine the gain in salinity tolerance after the copepods were acclimated in various dilutions. Animals were acclimated by two procedures to understand the effect of rapid or gradual change in salinity. The experiments were carried out as follows :

(1) Batches of copepods, acclimated each in different dilutions for 24 hours, were directly transferred to the lethal dilution and dilutions below lethal (*i.e.* animals acclimated in 90% sea water for 24 hours and then transferred to lethal dilution and dilutions below lethal ; animals acclimated in 80% sea water for 24 hours and then transferred to lethal dilution and dilutions below lethal and so on).

(2) Animals were transferred down to lethal dilutions and dilutions below lethal after they were gradually acclimated in each dilution for 24 hours (*i.e.* animals acclimated in 100% sea water for 24 hours were then acclimated in 90% sea water for 24 hours and so on, and then finally transferred to lethal dilution and dilutions below lethal). Each dilution differed by 10% sea water but smaller differences were used at the lower ends of the salinity range.

For experiments on higher temperatures, the conical flasks, containing the animals, were partially immersed in glass aquaria of 30 × 23 × 23 cms with 100 watt immersion heater controlled by thermostats with sensitivity of ± 0.5°C. For experiments below room temperature, a refrigerated water equipment was used.

Various combinations of temperature and salinity were made within the temperature and salinity range of the animal for experiments on combined effect of temperature and salinity. Details of the methods have been described elsewhere (Bhattacharya and Kewalramani, 1972).

Results

Salinity tolerance

Details of the survival of the copepod in sea water and its dilutions for 24 hours to 120 hours exposure are given in Fig. 1 a. The animal exhibited better survival in the range of 80% sea water to 60% sea water than in 100% and 90% sea water. The animal could tolerate salinity as low as 37% sea water and the lethal salinity was found to be 35% sea water.

Salinity acclimation

In the experiments of direct acclimation (Table 1) the first indication of a change in lethal salinity was observed when the animal was acclimated in 60% sea water for 24 hours. The copepods could tolerate salinity down to 30% sea water when it was acclimated in 37% sea water for 24 hours.

TABLE 1. *Percentage survival of* Pseudodiaptomus ardjuna, *after acclimation, in lethal salinities and salinities below lethal at the end of* 24 *hours*

Acclimation salinity (% sea water)	Lethal salinity (% sea water)	Salinities below lethal (% sea water)		
	35	30	20	10
100	40	0	0	0
90	40	0	0	0
80	45	0	0	0
70	45	20	0	0
60	50	20	0	0
50	60	30	0	0
40	70	35	30	0
37	90	50	40	0

TABLE 2. *Percentage survival of* Pseudodiaptomus ardjuna, *after acclimation, in lethal salinities and salinities below lethal at the end of* 24 *hours*

Gradual acclimation salinity (% sea water)	Lethal salinity (% sea water)	Salinities below lethal (% sea water)				
	35	30	20	10	5	3
100	40	0	0	0	0	0
90	40	0	0	0	0	0
80	45	0	0	0	0	0
70	55	40	0	0	0	0
60	80	60	0	0	0	0
50	100	80	0	0	0	0
40	100	100	10	0	0	0
37	100	100	20	0	0	0
35		100	30	0	0	0
30			60	20	0	0
20				50	0	0
10					20	0
5						0

In the other experiments of gradual acclimation (Table 2), the first indication of a change in lethal salinity was observed after the animal was acclimated down to 70% sea water. It exhibited 100% gain in salinity tolerance only down to 30% sea water when it was acclimated to 37% sea water. It could tolerate salinity as low as 10% sea water, when the change to salinities was effected gradually down to 20% sea water.

Temperature tolerance

Initially, the upper and lower lethal temperatures were determined and they were found to be 35°C and 8°C respectively. Further, experiments were carried out on the survival in various temperatures within the upper and lower lethal range (Fig. 1 b). The animal showed best survival in 30-31°C at the end of 96 hours and a slightly higher or lower temperature reduced the percentage of survival. It exhibited a very sudden change in survival pattern at the upper limit of the temperature range. The percentage of survival in 35°C was reduced to 0% from 80% in 34°C, at the end of 24 hours.

Combined effects of temperature and salinity on survival

Experiments were carried out for 24 hours to find out the effect of temperature on lethal salinity, as well as effect of salinity on lethal temperature. In these studies of 24 hours survival, the percentage survival also served as an indicator of tolerance in various temperature salinity combinations.

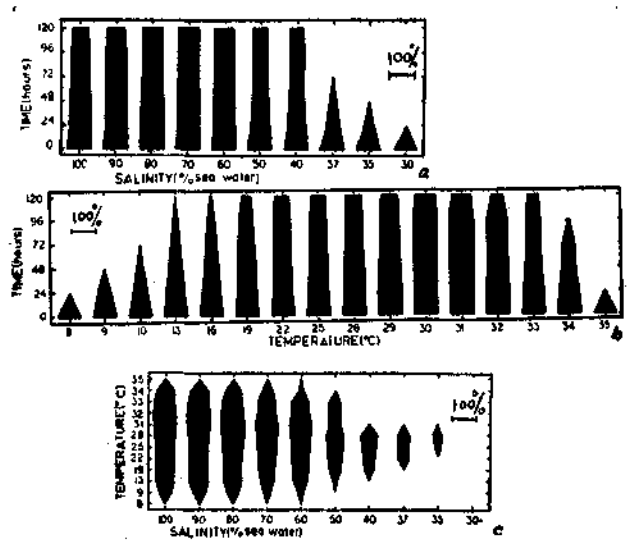

Fig. 1 a. Percentage survival at different salinities (% sea water), b. percentage survival at different temperatures (°C), and c. percentage survival in different temperature-salinity combinations at the end of 24 hours.

The experiments indicate (Fig. 1 c) that the copepods could tolerate salinity in the range of 100-37% sea water at 22°C to 28°C. It showed 100% survival at 31°C at salinities ranging from 100 - 60% sea water. The results also indicate that temperature below 22°C affected the survival more in lower than in higher salinities. The range of lethal salinity was reduced by both high and low temperatures. The lower and upper lethal temperatures did not change at the upper limit of salinity range.

Discussion

P. ardjuna exhibited best survival in salinities ranging from 80% to 60% sea water. However, it could not tolerate salinity lower than 37% sea water when subjected to sudden exposure. The salinity acclimation experiments (Table 2) indicate that it could tolerate salinity as low as 10% sea water when acclimated gradually to the lower salinities. The copepods were collected from the bay during May to July. The salinity of the bay during this period varied from about 36‰ to about 21‰, although minimum salinity recorded upto 5.5 m in the monsoon, is 13.03‰ (Gogate, 1960). This change in salinity may be rapid or gradual depending on the amount of rainfall. However, these variations in salinity during monsoon possibly bring about acclimatisation of this copepod in natural habitat. The salinity tolerance experiments (Table 1) indicate that the animal could not show much gain in salinity tolerance when acclimated directly in any salinity down to 40% sea water for 24 hours. The lowest salinity that the copepod could tolerate was 30% sea water when acclimated directly in 37% sea water for 24 hours from pure sea water. It may, therefore, be expected that any sudden change in salinity below about 30% sea water in coastal waters or any coastal inlet is detrimental to the copepod. The experiments also suggest that *P. ardjuna* has the capacity to tolerate salinities down to 10% sea water if acclimated gradually to the lower dilutions.

Experiments on temperature tolerance indicate that any change of temperature in the range of 90°C to 34°C is within the tolerance limit of the animal. However, it showed better survival in higher range of temperature indicating its capacity to survive in inshore waters and also in backwaters or estuaries. The animal may be expected to tolerate even higher temperature depending on the thermal pre-history.

Observations made on the combined effects of temperature and salinity suggest that there was no change in salinity tolerance in the range of 22°C-28°C. However, low temperature decreased the salinity tolerance range, on the other hand, upper lethal temperature was decreased in lower salinities. Better survival in various salinities at higher limit of the temperature range was exhibited by the animal.

It may, therefore, be concluded that *P. ardjuna* is an euryhaline form. It can tolerate a wide range of salinity (100%-37% sea water) when exposed to sudden exposure. It may tolerate even further dilutions (down to 10% sea water) if it is gradually acclimatised in nature. This copepod may, therefore, be expected to occur in coastal waters or any coastal inlet having salinity as low as about 10% sea water. However, high mortality at the upper range of salinity with increase in exposure time probably explains its absence in off-shore areas. Better survival in various salinities at high temperature also explains its adaptability to survive in saline creeks with great variations in salinity and temperature.

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