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Toxic and Antagonistic Properties of Na, K, Mg and Ca Ions on Duration of Life of Cambarus clarkii.

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The toxicity of pure solutions of metallic ions has been determined in the past for many marine species. Furthermore, the antagonistic properties of small amounts of certain ions to alleviate or even remove entirely the toxic effect of another ion is well known. In a survey of the literature covering this subject, the writer became aware of the extreme paucity of work in connection with fresh-water forms. Since the fresh-water crayfish was found to lend itself to this work and to be comparable to closely allied marine forms, a species *(Cambarus clarkii)* obtainable in abundance was used in the present work.

The poisonous effects of pure solutions of NaCl, KCl and $CaCl_2$ were determined in the following manner: 0.5 M solutions were prepared with distilled water as well as a series of weaker solutions having the strength of 90%, 80%, 60%, 40%, 20% and 10% of the 0.5 M solutions. Ten battery jars were each filled with 600 cc. of the solution to be tested and a crayfish placed in each jar. A record was kept of the time of immersion of the animals and hourly inspections made thereafter to determine the duration of life. To guard against possible asphyxiation due to low oxygen tensions, the animals were placed in fresh solutions every 12 hours. This likewise removed the possible toxic effects of waste materials liberated by the crayfish. Table I gives the average result of 10 individuals for each solution:

TABLE I.

Concentration of NaCl, $CaCl_2$ and KCl solutions	Duration of Life in Hours		
	NaCl	$CaCl_2$	KCl
100 cc. 0.5 M solution + 0 cc. distilled water	20.0	17.0	2.5
90 " " + 10 " " "	36.2	25.2	2.9
80 " " + 20 " " "	65.9	25.3	3.0
60 " " + 40 " " "	157.3(*7)	32.4	3.9
40 " " + 60 " " "	160.2(*6)	43.1	4.9
20 " " + 80 " " "	(*10)	78.8(*2)	6.5
10 " " + 90 " " "	(*10)	95.2(*1)	17.2
0 " " + 100 " " "	(*10)	(*10)	(*10)

* Denotes number living for 7 days when test was discontinued.

The results as shown in Table I clearly indicate the toxicity of certain metallic ions when applied in fairly high concentrations. The poisonous effect of the K ion is especially pronounced, being approximately 8 and 7 times more toxic, respectively, than equimolecular 0.5 M NaCl and $CaCl_2$ solutions.

The possible antagonistic properties of small amounts of other ions in minimizing the toxicity of K and Na ions were also investigated and results obtained as shown in Table II. The average life duration of 10 crayfish is given for each solution.

TABLE II.

Nature of the Solution	Duration of Life in hours
96 cc. 0.5 M NaCl + 4 cc. 0.5 M $MgCl_2$	22.7
" " + 4 cc. 0.5 M KCl	21.3
" " + 4 cc. 0.5 M $CaCl_2$	26.0
" " + 2 cc. M $MgCl_2$ + 2 cc. 0.5 M KCl	24.0
" " + 2 cc. 0.5 M $MgCl_2$ + 2 cc. 0.5 M $CaCl_2$	25.4
" " + 2 cc. 0.5 M $CaCl_2$ + 2 cc. 0.5 M KCl	33.8
96 cc 0.5 M KCl + 4 cc. 0.5 M $MgCl_2$	4.1
" " + 4 cc. 0.5 M NaCl	4.0
" " + 4 cc. 0.5 M $CaCl_2$	4.2
" " + 2 cc. 0.5 M $MgCl_2$ + 2 cc. 0.5 M $CaCl_2$	4.2
" " + 2 cc. 0.5 M $MgCl_2$ + 2 cc. 0.5 M NaCl	4.3
" " + 2 cc. 0.5 M $CaCl_2$ + 2 cc. 0.5 M NaCl	4.3

A comparison of the results as shown in Tables I and II will make evident the apparent antagonistic properties of the various ions tested. Mg, K and Ca ions all appear to partially offset the toxic effect of the Na ion, while the combination of small amounts of Ca and K ions would appear to be especially effective. Furthermore, Na, Ca and Mg ions appear to be considerably more effective in alleviating the poisonous effect of the K ion.

Experiments are in progress testing the toxic effect of pure $MgCl_2$ solutions and the antagonistic properties of combinations of ions to pure solutions of $MgCl_2$ and $CaCl_2$. The effect of increasing amounts of antagonistic ions in pure solutions of NaCl, KCl, $MgCl_2$ and $CaCl_2$ is also being worked out.