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Study of the Effects of Potassium Chloride and Calcium Chloride on the Development of *Drosophila melanogaster*

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염화칼륨과 염화칼슘의 초파리 발생에 미치는 영향에 대하여

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적 요

초파리(*Drosophila melanogaster*)의 발생에 미치는 염화칼륨(KCl)과 염화칼슘($CaCl_2$)의 단독 영향 및 상호 작용을 검토하기 위하여 6가지 농도의 KCl이나 $CaCl_2$ 처리 메디아에 5계통의 초파리를 사육하여 우화율을 검토한 결과는 다음과 같다.

1. 우화율은 초파리 계통간에는 유의적인 차이를 볼 수 없으나, KCl이나 $CaCl_2$의 농도간에는 매우 유의적인 차이가 있으며, 그 농도가 커짐에 따라 우화율이 낮아진다.
2. 우화율에 미치는 $CaCl_2$의 억제적 효과는 KCl에 비하여 현저하게 크며, 이것은 초파리의 KCl에 대한 저항성이 $CaCl_2$에 대한 것 보다 크다는 것을 뜻한다.
3. KCl이나 $CaCl_2$ 메디아에 소량의 $CaCl_2$이나 KCl를 첨가하면 KCl이나 $CaCl_2$의 우화율에 대한 억제적 효과의 길항작용을 보이고 있으나, 좀더 다량을 가하면 억제적 효과가 더욱 촉진된다.
4. 따라서 초파리의 발생에 대한 K^+와 Ca^{++}의 억제적 효과에 있어서 상호 작용이 관여하고 있음을 알 수 있다.

INTRODUCTION

Many investigations of the effects of some chemicals on the development of the drosophilid flies have been carried out. The effects of the some salts (e. g., Na,

Ca) contained in the food media on the development have been discussed by Rubinstein *et al.* (1936), Kalmus (1943), King (1953) and Loeb (1965). According to Miyoshi (1959), the toxic effect of the agent upon developing flies was found to depend on the positive Na^+ ion, not on the negative Cl^- ion and both K^+ and Ca^{++} ions produced a similar effect. Miyoshi (1961) also obtained a result of his experiment that the resistibility to sodium chloride varied in different strains of *D. melanogaster*. Miyoshi & Nakamura (1968) examined the effects of sodium chloride upon the embryonic development and found that eggs were quite insensitive to sodium chloride in the medium unless they were dechlorionated but the mortality of embryo was markedly high when they were subjected to the NaCl medium after being dechlorionated by sodium hypochlorite. It was found by Kang *et al.* (1970), Chung & Kang (1971), Kang (1971), Kang & Chung (1971) that the emergence rates of *D. melanogaster* (resistibility to NaCl) was not significantly different among the strains but strikingly different among concentrations of NaCl, the emergence rate decreased as the concentration of NaCl increased. The effects of NaCl on the hatching rates (Chung & Kang, 1972) and the emergence rates (Chung, 1972) of *D. melanogaster* when pretreated sodium hypochlorite were studied and they found that the hatching rates and the emergence rates were heterogeneous among concentrations of NaCl when pretreated NaOCl and decreased as concentration of NaCl increased. Kang (1972) reported that the emergence rates of *D. melanogaster* were significantly different among concentrations of NaCl or KCl but not among strains and the resistibility to KCl was rather strong compared to the resistibility to NaCl. Chung & Kang (1973) designed an experiment in which the emergence rates of *D. melanogaster* were examined when it was raised in the medium of various concentations of NaCl and $CaCl_2$ in order to see if any effect of the food medium on the development of the six strains of the flies and obtained the results that the effect of $CaCl_2$ on the emergence rates was found to be greater than that of NaCl.

The present investigation is attempted to see if KCl and $CaCl_2$ affect the development of *D. melanogaster* and to examine the interaction of KCl and $CaCl_2$ on the emergence rates.

MATERIALS AND METHODS

The three wild strains (Oregon-R, Kwangju, and Choon-chun) and the two SD strains (SD^{NH}-2 and R-1) of *Drosophila melanogaster* were used in the present experiment. The genetic constitutions of the SD strains were described in the preceding paper (Kang *et al.*, 1970). Oregon-R is the standard laboratory wild stock. The Kwangju and the Choon-chun strains have been kept in the constant

temperature room for a few years since originally captured from Kwangju and Choonchun area in Korea, respectively. The food formula used in the present experiment is presented in the preceding paper (Kang *et al.*, 1970). The present experiment was performed at 25±1°C, and the KCl medium was prepared by adding KCl at a concentration of 0.0M (as the control), 0.1M, 0.3M, 0.5M, 0.8M, and 1.0M to the standard medium and the $CaCl_2$ medium was made by adding $CaCl_2$ at a concentration of 0.0M, 0.1M, 0.2M, 0.3M, 0.5M, and 0.8M to the standard medium.

Eggs from populations of five pairs of three to five day old flies of each strain were transferred to the food medium of KCl or $CaCl_2$ seven to nine hours after being laid and the number of emerging flies were counted and the emergence rate was calculated for each vial and averaged for each concentration of KCl and $CaCl_2$ in each strain.

In order to see the interaction of KCl and $CaCl_2$, several combined media were prepared by adding 0.05M, 0.1M, and 0.2M of $CaCl_2$ (or KCl) to each of six kinds of the KCl (or $CaCl_2$) media.

RESULTS

Six vials (3×10cm), each of which contained 50 eggs were prepared for each concentration of KCl or $CaCl_2$ in each strain of the flies.

The emergence rates of the five strains of *D. melanogaster*, when various concentrations of KCl were treated, are presented in Table 1 and Figure 1 (number in parenthesis of each table in the text indicates the number of flies emerged). The emergence rate, when KCl was treated is not significantly different among strains (analysis of variance indicates: $F=2.04$, $n_1=4$, $n_2=20$, $p>0.05$) but strikingly different among concentrations of KCl (analysis of variance indicates:

Table 1. Emergence rates(%) of the five strains of *D. melanogaster* in the media containing various concentrations of KCl

Strain	No. of eggs tested	Concentration of KCl					
		0.0M	0.1M	0.3M	0.5M	0.8M	1.0M
SD^{NH}-2	300	87.7 (263)	86.7 (260)	82.3 (247)	70.7 (212)	50.3 (151)	31.7 (95)
R-1	300	90.3 (271)	41.7 (275)	84.7 (254)	71.3 (214)	54.7 (164)	33.3 (100)
Oregon-R	300	86.7 (260)	84.3 (253)	80.7 (242)	69.7 (209)	52.3 (157)	37.3 (112)
Kwangju	300	89.3 (268)	85.7 (257)	83.7 (251)	73.3 (220)	53.3 (160)	32.7 (98)
Choonchun	300	87.0 (261)	88.7 (266)	84.3 (253)	68.3 (205)	50.7 (152)	35.3 (106)

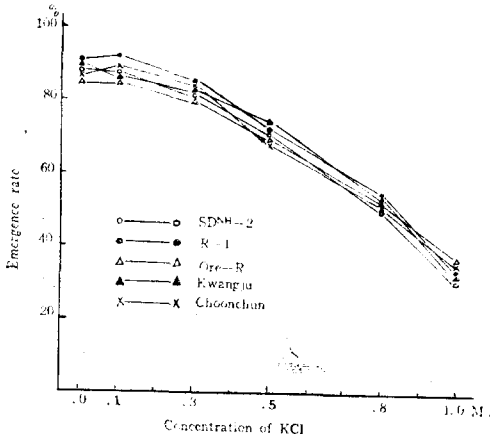

Fig. 1. Graph showing emergence rates listed in Table 1.

F=673.51, n_1=5, n_2=20, $p \ll 0.01$), as illustrated in Table 1 and Figure 1. The emergence rate is found to be almost constant from 0.0M to 0.1M of KCl but the rate decreases to about 81—85% at 0.3M, about 68—71% at 0.5M, and then drops markedly to about 50—55% at 0.8 M and to 32—37% at 1.0M of KCl. This suggests that the five strains of *D. melanogaster* in the present experiment is resistible from a concentration of 0.0M to 0.5M but susceptible from 0.5M or higher concentrations of KCl.

The single effect of $CaCl_2$ on the emergence rates is illustrated in Table 2, and Figure 2. The emergence rate, as seen in the table and the figure, is not significantly different among strains but markedly different among concentrations of $CaCl_2$. The analysis of variance also shows no significant difference among strains: F=2.75, n_1=4, n_2=16, $p>0.05$, and significantly different among concentrations of $CaCl_2$: F=39.68, n_1=4, n_2=16, $p \ll 0.01$. As seen in Table 2 and Figure 2, the emergence rate is almost homogeneous from the concentration of $CaCl_2$, 0.0M to 0.1 M but the rate decreases to about 58—67% at 0.2M and then drops continuously to about 20—27% at 0.3M. The rate decreases even more markedly at 0.5M (about 1%). No flies emerged from the medium of 0.8M of $CaCl_2$. This implies that the five strains of *D. melanogaster* in the present experiment are considerably resistible to the $CaCl_2$ from a concentration of 0.0M to

Table 2. Emergence rates(%) of the five strains of *D. melanogaster* in the media containing various concentrations of $CaCl_2$

Strain	No. of eggs tested	Concentration of $CaCl_2$					
		0.0M	0.1M	0.3M	0.3M	0.5M	0.8M
SD^{NH}-2	300	87.7 (263)	86.0 (258)	67.3 (202)	24.3 (73)	1.7 (5)	— (0)
R-1	300	90.3 (271)	88.3 (265)	64.7 (194)	26.3 (79)	1.3 (4)	— (0)
Oregon-R	300	86.7 (260)	84.3 (253)	61.3 (184)	27.0 (81)	2.3 (7)	— (0)
Kwangju	300	89.3 (268)	80.7 (242)	57.7 (173)	18.3 (55)	— (0)	— (0)
Choonchun	300	87.0 (261)	81.7 (245)	60.7 (182)	20.3 (61)	0.7 (2)	— (0)

0.1M but susceptible from 0.2M or higher concentrations fo $CaCl_2$. If the comparison of affecting pattern on the emergence rates between KCl and $CaCl_2$ is made, the considerable difference is found in the present experiment. As clearly manifested in Figure 1 and 2, the emergence rate, when $CaCl_2$ is treated, decreases more markedly than when KCl is treated. No flies emerged from the medium containing 0.8 M of $CaCl_2$, whereas quite a few flies emerged from the medium of 0.8M and 1.0M of KCl. This is the remarkable contrast between the affecting pattern of KCl and $CaCl_2$, on the emergence rates and this implies that the resistibility of $CaCl_2$ on the emergence rates and that the resistibility of Drosophila to KCl is greater than to $CaCl_2$.

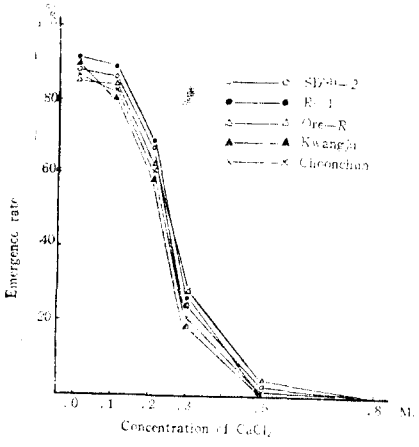

Fig. 2. Graph showing emergence rates listed in Table 2.

The interaction of KCl and $CaCl_2$ on the emergence rates is examined by preparing the combined media and the results are presented in Tables 3—8 and Figures 3—8. The emergence rates obtained from the media containing each concentration of KCl +0.05M, 0.1M, or 0.2M of $CaCl_2$ are illustrated in Tables 3—5 and Figures 3—5. As seen in Table 3 and Figure 3, no change is seen in the emergence rates when 0.05M of $CaCl_2$ is added to each concentration of KCl. Analysis of variance indicates that the emergence rate is not significantly different among strains of the flies ($F=2.89$, $n_1=4$, $n_2=16$, $p>0.05$) but significantly heterogeneous among concentrations of KCl ($F=175.95$, $n_1=4$, $n_2=16$, $p<0.01$). However, the affecting

Table 3. Emergence rates(%) of the five strains of *D. melanogaster* in the media containing 0.05M of $CaCl_2$ plus various concentrations of KCl

Strain	No. of eggs tested	Control	Conc. of KCl & 0.05M $CaCl_2$			
			0.1M	0.3M	0.5M	0.8M
SD^{NH}-2	300	87.7	86.3 (259)	84.7 (254)	73.7 (221)	59.3 (178)
R-1	300	90.3	88.7 (266)	85.3 (256)	72.3 (217)	57.7 (173)
Oregon-R	300	86.7	85.3 (256)	83.7 (251)	74.7 (224)	52.7 (158)
Kwangju	300	89.3	87.0 (261)	83.0 (249)	76.3 (229)	56.3 (169)
Choonchun	300	87.0	86.7 (260)	85.3 (256)	70.7 (212)	54.3 (163)

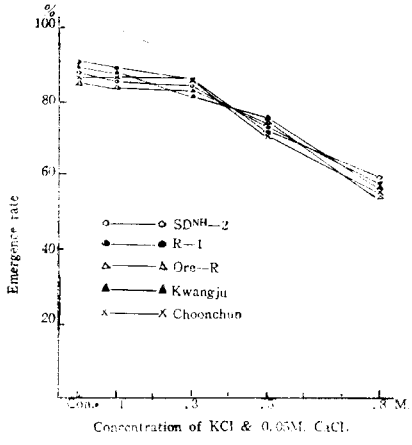

Fig. 3. Graph showing emergence rates listed in Table 3.

pattern of KCl on the emergence rates is influenced by the addition of $CaCl_2$ as its concentration is increased.

The emergence rates obtained from the medium containing each concentration of KCl +0.1M of $CaCl_2$ are pres ented in Table 4 and Figure 4.

As shown in Table 4 and Figure 4, the emergence rates are not significantly different among strains ($F=1.98$, $n1=4$, $n_2=16$. $p>0.05$) but significantly different among concentrations of KCl ($F=452.48$, $n_1=4$, $n_2=16$, $p\ll0.01$).

The emergence rate decreases as the concentration of KCl increases and this decrease is much more remarkable than in Figure 1, which is the case of no addition of $CaCl_2$ to the KCl medium, especially it decreases 14—21% at 0.8M of KCl. This implies that $CaCl_2$ may enhance inhibitory effect of KCl on the emergence rates.

The results of the experiment undertook by using food media containing 0.2M of $CaCl_2$ plus various concentrations of KCl are shown in Table 5 and Figure 5.

As illustrated in the table and the figure, the emergence rate is also significantly different among concentrations of KCl ($F=675.81$, $n_1=3$, $n_2=12$, $p\ll0.01$) but not different among strains ($F=2.87$, $n_1=4$, $n_2=12$, $p>0.05$).

As seen in the graph, the reducing rate of the emergence rates is much greater, as the concentration of KCl increases, than in the case of no addition of $CaCl_2$. The emergence rate begins to decrease from 0.1M (62—73%) and 40% at 0.3M,

Table 4. Emergence rates(%) of the five strains of *D. melanogaster* in the media containing 0.1M of $CaCl_2$ plus various concentrations of KCl

Strain	No. of eggs tested	Control	Conc. of KCl & 0.1M $CaCl_2$			
			0.1M	0.3M	0.5M	0.8M
SD^{NH}-2	300	87.7	88.3 (265)	82.7 (248)	70.3 (211)	21.3 (64)
R-1	300	90.3	86.7 (260)	84.3 (253)	67.7 (203)	15.0 (45)
Oregon-R	300	86.7	84.0 (252)	78.3 (235)	62.3 (187)	14.3 (43)
Kwangju	300	89.3	82.7 (248)	79.3 (238)	63.7 (191)	18.7 (56)
Choonchun	300	87.0	85.3 (256)	79.7 (239)	64.7 (194)	16.7 (50)

Table 5. Emergence rates(%) of the five strains of *D. melanogaster* in the media containing 0.2M of $CaCl_2$ plus various concentrations of KCl

Strain	No. of eggs tested	Control	Conc. of KCl & 0.2M $CaCl_2$			
			0.1M	0.3M	0.5M	0.8M
SD^{NH}-2	300	87.7	62.3 (187)	40.7 (122)	21.3 (64)	— (0)
R-1	300	90.3	72.3 (217)	44.7 (134)	23.3 (70)	— (0)
Oregon-R	300	86.7	73.7 (221)	46.7 (140)	21.3 (64)	— (0)
Kwangju	300	89.3	71.3 (213)	43.3 (130)	18.7 (56)	— (0)
Choonchun	300	87.0	68.3 (205)	42.0 (126)	14.3 (43)	— (0)

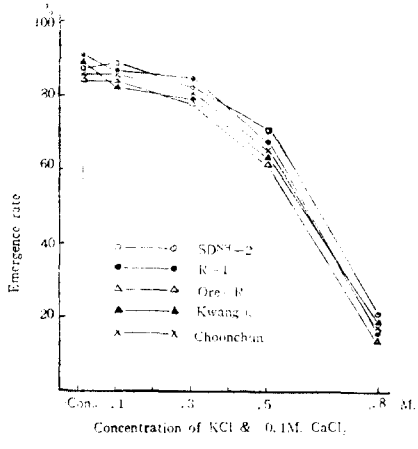

Fig. 4. Graph showing emergence rates listed in Table 4.

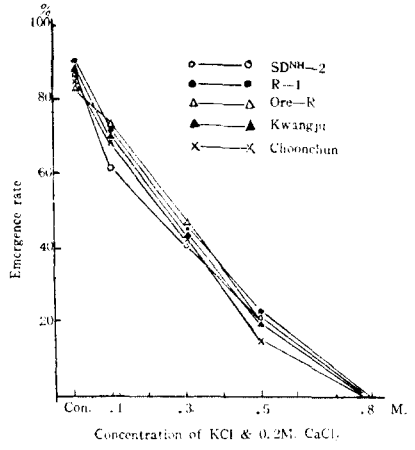

Fig. 5. Graph showing emergence rates listed in Table 5.

about 20% at 0.5M. No flies emerged from the medium containing 0.8M of KCl plus 0.2M. of $CaCl_2$. Here is also the conspicuous enhancement of inhibitory effect of KCl by the addition of $CaCl_2$, that is, the addition of $CaCl_2$ to the KCl medium results in weak resistibility of the flies to KCl.

In order to see any change in the inhibitory effects of $CaCl_2$ on the emergence rates of flies if any concentration of KCl is added to the $CaCl_2$ medium, several combined media (0.05M, 0.01M or 0.2M of KCl plus 0.1M, 0.2M, 0.3M, or 0.5M, of $CaCl_2$) are prepared and the emergence rates obtained from the media are presented in Tables 6—8 and Figures 6—8.

The emergence rate obtained from the media of 0.05M of KCl plus various concentrations of $CaCl_2$ is not significantly different among strains of the flies (analysis of variance: $F=0.13$, $n_1=4$, $n_2=12$, $p>0.05$), but strikingly different

Table 6. Emergence rates(%) of the five strains of *D. melanogaster* in the media containing 0.05M of KCl plus various concentrations of $CaCl_2$

Strain	No. of eggs tested	Control	Conc. of $CaCl_2$ & 0.05M KCl			
			0.1M	0.2M	0.3M	0.5M
SD^{NH}-2	300	87.7	86.7 (260)	71.3 (214)	38.7 (116)	— (0)
R-1	300	90.3	88.3 (267)	67.7 (203)	37.3 (112)	— (0)
Oregon-R	300	86.7	83.3 (250)	70.7 (212)	45.3 (136)	— (0)
Kwangju	300	89.3	80.7 (242)	73.3 (220)	36.7 (110)	— (0)
Choonchun	300	87.0	82.7 (248)	66.7 (200)	44.7 (134)	— (0)

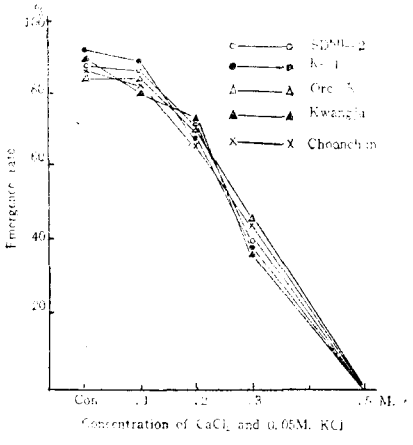

Fig. 6. Graph showing emergence rates listed in Table 6.

among concentrations of $CaCl_2$ ($F=200.81$, $n_1=3$, $n_2=12$, $p<0.01$), as seen in Table 6 and Figure 6.

If the comparison of the graph in Figure 6 and in Figure 2, it is found that the emergence rate in the addition of 0.05M of KCl to 0.3M of $CaCl_2$ (38—45%) is greater than in no addition of KCl to 0.3M of $CaCl_2$ (20—27%). This implies that the inhibitory effect of $CaCl_2$ on the emergence rates of the flies is counteracted by the addition of KCl.

The emergence rates obtained from the media containing 0.1M of KCl plus various concentrations of $CaCl_2$ are shown in Table

Table 7. Emergence rates(%) of the five strains of *D. melanogaster* in the media containing 0.1M of KCl plus various concentrations of $CaCl_2$

Strain	No. of eggs tested	Control	Conc. of CaCl & 0.1M. KCl			
			0.1M	0.2M	0.3M	0.5M
SD^{NH}-2	300	87.7	85.3 (256)	60.7 (182)	23.3 (70)	— (0)
R-1	300	90.3	85.7 (257)	63.3 (190)	24.7 (74)	— (0)
Oregon-R	300	86.7	82.3 (247)	65.7 (197)	30.3 (91)	— (0)
Kwangju	300	89.3	81.7 (245)	61.3 (184)	25.7 (77)	— (0)
Choonchun	300	87.0	83.7 (251)	59.7 (179)	22.7 (68)	— (0)

7 and Figure 7. As in other cases, there is a remarkable difference in the emergence rates among concentrations of $CaCl_2$ (analysis of variance also indicates $F=879.78$, $n_1=3$, $n_2=12$, $p\ll 0.01$) but not a significant difference among the five strains of the flies ($F=1.29$, $n_1=4$, $n_2=12$, $p>0.05$). The graph of Figure 7 is similar to that in Figure 2 with the exception that no flies emerged from the medium containing 0.1M of KCl plus various concentrations of $CaCl_2$ (a few flies emerged from the single $CaCl_2$ medium). This suggests that the addition of 0.1M of $CaCl_2$ medium neither enhance nor suppress the inhibitory effect of $CaCl_2$ on emergence rates of flies.

The emergence rates obtained from the media containing 0.2M of KCl plus various concentrations of $CaCl_2$ are listed in Table 8 and illustrated by graphs in Figure 8. As seen in the table and the figure, no difference of emergence rates is

Table 8. Emergence rates(%) of the five strains of *D. melanogaster* in the media containing 0.2M of KCl plus various concentrations of $CaCl_2$

Strain	No. of eggs tested	Control	Conc. of $CaCl_2$ & 0.2M KCl			
			0.1M	0.2M	0.3M	0.5M
SD^{NH}-2	300	87.7	73.7 (221)	38.7 (116)	2.7 (8)	— (0)
R-1	300	90.3	77.3 (232)	39.7 (119)	0.3 (1)	— (0)
Oregon-R	300	86.7	70.3 (211)	36.7 (110)	3.7 (11)	— (0)
Kwangju	300	89.3	72.7 (218)	40.3 (121)	1.3 (4)	— (0)
Choonchun	300	87.0	69.7 (209)	42.3 (127)	1.7 (5)	— (0)

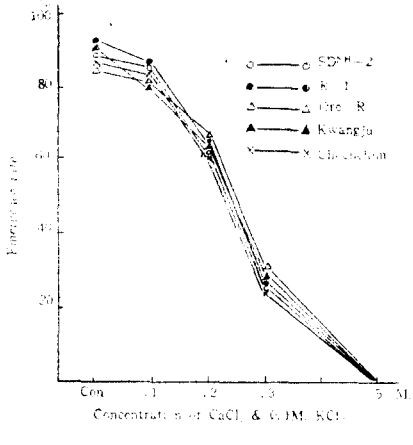

Fig. 7. Graph showing emergence rates listed in Table 7.

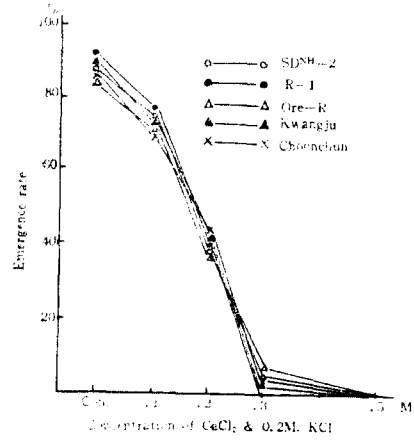

Fig. 8. Graph showing emergence rates listed in Table 8.

observed among the five strains of the flies ($F=0.74$, $n_1=4$, $n_2=12$, $p>0.05$) but a significant difference appears among concentrations of $CaCl_2$ ($F=154.44$, $n_1=3$, $n_2=12$, $p\ll0.01$). As illustrated in Figure 8, the addition of 0.2M of KCl to the $CaCl_2$ medium enhances strongly the inhibitory effect of $CaCl_2$ on the emergence rates of the drosophilid flies.

In short, $CaCl_2$ influences the effect of KCl on the emergence rates of the flies much more conspicuously than KCl does, and this becomes manifested as the concentration of KCl or $CaCl_2$ increases.

DISCUSSION

The present experiment is undertaken to see the single effect and the interaction of KCl and $CaCl_2$ on the, emergence rates of *D. melanogaster* and the results show that the emergence rate is not significantly different among strains of the flies but conspicuously heterogeneous among concentrations of KCl or $CaCl_2$. This is agreed with the results of the previous papers in which the effects of NaCl on the emergence rates of the drosophilid flies were examined (Kang *et al.* 1970, Kang & Chung 1971, Kang 1971, 1972, Chung & Kang 1971, 1973). Thus it is clear that both of KCl and $CaCl_2$ have an inhibitory effect on the emergence rates of drosophilid flies as NaCl does.

It is also found from the present experiment that the inhibitory effect of $CaCl_2$ on the emergence rates is greater than that of KCl. This may be due to the strong inhibitory action of $CaCl_2$ on the hatchability of the flies. Kang (1972) compared the effect of NaCl to KCl on the emergence rates of *D. melanogaster* and obtained a result that the inhibitory effect of NaCl on the emergence rates was greater than those of KCl, implying that the resistibility of the flies to KCl was greater than to NaCl. Chung & Kang (1973) indicated that the inhibitory effect of $CaCl_2$ on the emergence rates was greater than that of NaCl; in other words, the resistibility of the flies to NaCl was greater than to $CaCl_2$. Thus, the order of resistibility of *D. melanogaster*, as Chung & Kang (1973) pointed out, might be $KCl>CaCl_2$.

The examination of the interaction of KCl and $CaCl_2$ on the emergence rates results in the finding that the addition of very small amount of $CaCl_2$ or KCl (0.05M) to the KCl or $CaCl_2$ media counteracts the inhibitory effect of KCl or $CaCl_2$. The addition of a little greater amount of $CaCl_2$ or KCl (0.1M and 0.2M) to the KCl or $CaCl_2$ media, on the other hand, enhance the inhibitory effect of KCl or $CaCl_2$. This implies that there may be some antagonism between ions (K^+, Ca^{++}) and moreover some special concentration ratio may be involved in this antagonism. Miyoshi (1959) found that the toxic action of high concentration of

NaCl was counteracted by the addition of a small amount of either K^+ or Ca^{++} ions. Thus the result of the present experiment may be interpreted by Miyoshi's finding.

SUMMARY

In order to see the single effect and interaction of potassium chloride (KCl) and calcium chloride ($CaCl_2$) on the development of *Drosophila melanogaster*, the emergence rates of the five strains of the flies were examined from the media containing 0.0M, 0.05M, 0.1M, 0.2M of $CaCl_2$ or KCl plus various concentrations of KCl or $CaCl_2$, and the results are presented as follows:

1. The emergence rate of *D. melanogaster* is not significantly different among strains but strikingly different among concentrations of KCl or $CaCl_2$; the emergence rate decreases as concentration of KCl or $CaCl_2$ increases.

2. The inhibitory effect of $CaCl_2$ on the emergence rates is greater than that of KCl, implying that the resistibility of the flies to KCl is greater than to $CaCl_2$.

3. The addition of small amount of $CaCl_2$ or KCl to KCl or $CaCl_2$ media counteracts the inhibitory effect of KCl or $CaCl_2$, but the addition of a little greater amounts of $CaCl_2$ or KCl to the KCl or $CaCl_2$ media enhance the inhibitory effect of the salts.

4. Thus, there may be some interaction of K^+ and Ca^{++} ions in the inhibitory effect on the develpoment (emergence rates) of *Drosophila melanogaster*.

REFERENCES CITED

Chung, Y. J., 1972. Study of the effects of sodium chloride on the emergence rates and the SD action of *Drosophila melanogaster* with preteatment of sodium hypochlorite. *Kor. J. Breeding* **4** : 33—44.

____, and M. J. Kang, 1971. Study of the effects of sodium chloride on segregation-distorter action in *Drosophila melanogaster*. 2. Treatment of sodium chloride on the larval stages. *J. Kor. Cult. Res. Inst. Better Living* **6** : 53—64.

____, 1972. Study of the effects of sodium chloride on the hatchability of *Drosophila melanogaster* with or without pretreatment of sodium hypochlorite. *J. Kor. Res. Inst. Better Living* **8** : 193—203.

____, 1973. Study of the effects of sodium chloride and calcium chloride on the development of *Drosophila melanogaster*. *J. Kor. Res. Inst. Better Living* **11** : 341—346.

Kalmus, E., 1943. A factorial experiment on the mineral requirements of Drosophila culture. *Am. Naturalist* **77** : 376—379.

Kang, M.J., 1971. Study of the effects of sodium chloride on segregation-distorter action

in *Drosophila melanogaster*. 3. Treatment of sodium chloride on the first instar larval stage. *Kwangju Teacher's College Review* **6** : 263—271.

____, 1972. Study of the effects of food media on the development and the SD action of *Drosophila melanogaster* in Korea. *Kwangju Teacher's College Review* **7** : 321—339.

____, and Y.J. Chung, 1971. Study of the effects of sodium chloride on segregation-distorter action in *Drosophila melanogaster*. 4. Treatment of sodium chloride on the pupal stages. *Kor. J. Zool.* **14** (3) : 125—131.

____, and K.J. Kim, 1970. Study of the effects of sodium chloride on segregation-distorter action in *Drosophila melanogaster*. 1. Treatment of sodium chloride on whole developmental stages. *Kor. J. Zool.* **13**(1) : 21—25.

King, R.C., 1953. Effects of alkali metal ions on development of Drosophila, with special reference to lithium incubed abnormalities. *Proc. Natl. Acad. Sci. U.S.* **39** : 403—406.

Loeb, J., 1965. Salt requirement for development. *J. Biol. Chem.* **23** : 431—434.

Miyoshi, Y., 1959. Effects of some alkali metal ions on the development of *D. melanogaster*. *Drosophila Inform. Serv.* **33** : 148.

____, 1961. On the resistibility of Drosophila to sodium chloride. I. Strain difference and heritability in *Drosophila melanogaster*. *Genetics* **46** : 935—945.

____, and K. Nakamura, 1968. On the resistibility of Drosophila to sodium chloride. II. Difference in the resistibility at different developmental stages. *Jap. J. Genetics* **43** : 356—376.

Rubinstein. D.L., H. Burlakwa and W. Lwowa, 1953. Sodium and calcium requirements of Drosophila. *Biochem.* **2**. 278 : 418—427.