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Effects of pH on Survival, Growth and Reproduction Rates of The Crustacean, *Daphnia Magna*

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Abstract: Experiments were conducted to study the effect of both low and high pH on survival, growth and reproduction rates of *Daphnia magna*. It was treated chronically with sublethal concentrations at both low and high pH levels for 21 days. It was detected that survival and growth rates decreased as pH decreased from 4.66 to 4.44 and by increasing pH from 10.13 to 10.55. It is clear that groups of daphnids reared at pH 8.33 (control) recorded the highest survival and growth rates. The maximum number of progeny per female were recorded for daphnids reared at acidic pH 4.66 and alkaline pH; 10.13. From this study, it is concluded that the suitable range of pH for *D. magna* must be more than 4.55 and less than 10.13 and that the optimum condition is 7.9 to 8.3.

Key words: pH, acidic, basic, toxicity testing, *Daphnia.*

INTRODUCTION

The pH of surface waters is important to aquatic life because the pH of water affects the normal physiological functions of aquatic organisms, including the exchange of ions with the water and respiration. Such important physiological processes operate normally in most aquatic biota under a relatively wide pH range (e.g., 6-9 pH units).

Alabaster and Lloyd, (1980) identified the pH range that is not directly lethal to freshwater fish as 5.0-9.0. With few exceptions, pH values between 6.5 and 9.0 are satisfactory, on a long-term basis, for fish and other freshwater aquatic life. The pH of most inland fresh waters containing fish ranges from about 6 to 9 (Ellis 1937), with most waters, particularly those with healthy, diverse, and productive fish and macro invertebrates communities having a pH between approximately 6.5 and 8.5 units (NAS, 1972).

The sensitivity of aquatic organisms to pH changes can vary significantly among aquatic ecosystems. The change of pH in water bodies may be due to acidic rain or anthropogenic NaOH spills. NaOH is a very high production volume compound (estimated world-wide demand about 44 million tons), used for several industrial and domestic purposes. Due to emission patterns, chemical properties (high solubility, low vapor pressure), environmental fate properties (rapid neutralization and wash-out in the atmosphere, neutralization in soil) it is expected to be present in significant amounts only in water, where it is ionized in Na^+ and OH^-. On the other hand, acid rain occurs when pollution in the atmosphere (sulfur dioxide and nitrogen oxide) is chemically changed and absorbed by water droplets in clouds. When there is precipitation, the droplets fall to earth as rain, snow, or sleet. The polluting chemicals in the water droplets form an acid by combining with the hydrogen and oxygen in the water. These acidic droplets ($pH < 5$) can increase the acidity of the soil and affect the chemical balance of lakes and streams. It also contributes to acidification of rivers and streams.

Zooplanktons are important link in food chains of aquatic ecosystems and their disappearance or decline could drastically affect trophic relationships. Decline in zooplankton density in response to acid precipitation have been reported (Hendry and Wright 1976, Hendry *et al*., 1976, Lievestad *et al*., 1976). Davis and Ozburn (1969) found that *Daphnia pulex* would not thrive below a pH of 7; however, its potential for reproduction was limited to a fairly narrow range.

Effects of hydrogen ion concentrations (pH) on survival, growth and reproduction have been studied in cladoceran, *Daphnia longspina* (Moustafa, 2007). Also, the pH has effect on physiological characterization of *D. magna* (Glover and Wood, 2005). In acid water, crustaceans and fish have suffered retarded growth and skeletal deformity (Haines, 1981) and impaired ionic regulation (Hobe *et al*., 1984). Numerous studies have attempted to elucidate the responses of aquatic animals to different pH. Among these, results of field experiments and laboratory bioassays verified the lethal or sublethal effects of pH values of above 9 or below 6 on zooplankton species (Alibone and Fair 1981; Mitchell 1992; Vijverberg *et al*., 1996; Wang *et al*., 1997; Locke and Sprules 2000). Compared to lethal effects of extreme pH, sublethal effects of pH on zooplankton species are more common. Sublethal influences of hydrogen or hydroxyl ion have been noted as impairing survival, growth, reproduction and feeding of zooplankton species (reviewed in Mitchell 1992; Vijverberg *et al*., 1996). Considering the differential responses of zooplankton species to pH, the sublethal effects of pH indirectly alter the species interactions (e.g., competition, predator-prey) (Hessen *et al*., 1995; Fischer and Frost 1997;

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Locke and Sprules, 2000) and result in changes of distribution and abundance of populations and species, which ultimately influence the community structure (Kiesecker, 1996).

The aim of the present study is to investigate the effect of pH on survival, growth and reproduction rates of the crustacean, *D. magna* cultured in a synthetic freshwater media, under laboratory conditions.

MATERIALS AND METHODS

1.1. Experimental Animals and Food:

A freshwater *D. magna* strain that has been successfully grown in the Laboratory of Hydrobiology in National Research Center for more than 15 years in synthetic freshwater media (Fayed and Ghazy, 2000), was used as the test organism for this study. Gravid females were transferred at regular intervals to 1-L glass beakers, in which the culture medium; synthetic freshwater medium (pH; 7.9-8.3, total hardness; 90 mg/L as $CaCO_3$, alkalinity; 34 mg/L as $CaCO_3$, conductivity; 260 µmhos/cm) was renewed 3 times a week and were checked daily for the release of neonates to be used in starting experiments. In these beakers, the animals were fed 3 times a week with $14X10^7$ coenobia /ml of the green micro alga *Scenedesmus obliquus*; it was previously determined that this cell concentrations is an optimal food dosage for this strain (Ghazy, 1997).

The algal culture was renewed once a week to maintain the algae solution in good condition. The algae and daphnids were kept at a temperature 22± 2°C with a light period of 16 L: 8 D both during culturing and experimental periods.

1.2. Facilities and Protocols:

The experiments were carried out in 250-ml glass beakers, containing 100 ml synthetic freshwater media for control and inoculated with 10 neonates < 24 h for both control and all treatments in this study, and placed in a 70x60x30 cm aquarium.

Temperature was maintained at 22± 2º C by automatic heater. A mercury thermometer was used to measure temperature in test containers.

Treatments of pH; 100 ml dilution water for each container was adjusted with digital pH-meter (MlevelsL1010). Electrodes were calibrated with buffers 4.01, 7.01, 10.01. Low pH values (acidic) were adjusted with 1N, HCl and higher pH values (basic; alkaline) were adjusted with 1N, NaOH.

1.3. Toxicity Testing:

1.3.1. Acute Tests:

Acute toxicity testing were conducted in triplicates, where groups of 10 < 24 h-old daphnids were placed in 250-ml beakers, each containing 100 ml medium and subjected to test conditions for 48 h. Tests were run without food addition. The number of live organisms after the elapse of 48h was recorded. Control test was run in parallel.

Treatments with different levels of both low pH; 4.31, 4.42, 4.54, 4.60 and 4.74 and also high pH levels (10.7, 10.8 and 10.9) were performed to assess median lethal concentrations to *D. magna*.

1.3.2. Chronic Tests:

Ten neonates (<24h-old) were placed in each 250 ml - glass beakers containing 100 ml of synthetic freshwater media for control and for each treatment which were renewed with addition of fresh food three times a week. These experiments lasted for 21 days.

The sublethal concentrations 4.74, 4.66, 4.61, 4.54, 4.52, 4.48, 4.44 for low pH, and 10.13, 10.23, 10.31, 10.38, 10.44, 10.5, 10.55 for high pH were deduced from probit analysis, where each series is equivalent to LC10, LC15, LC20, LC25, LC30, LC35, LC40, respectively. The effects of these concentrations were investigated on survival, growth and reproduction of *Daphnia magna*. A control test was conducted in parallel with each series.

In these chronic tests, three times a week, daphnids were removed from their container and placed immediately into a new prepared synthetic freshwater media (pH 7.9 -8.3), as control and different pH-adjusted treatments containing algal food, *Scenedesmus obliquus* at $14x10^7$ coenobia/ ml.

Survival, growth and reproduction rates of daphnids were recorded three times a week. The survival rate was calculated by dividing the numbers counted every time by the initial number of neonates used at the beginning of the experiment.

Growth was determined from the body lengths which were measured under the microscope with an ocular micrometer (160 X magnification) from base of caudal spine to the anterior edge of the head.

The specific growth rate (SGR) of all surviving *Daphnia* was calculated according to El Dakar *et al*., (2007) using the following formula:

$$SGR = \frac{\text{Ln final length - Ln initial length}}{\text{Time (days)}} \times 100$$

The age of *Daphnia* at release of first brood was noted. After every reproduction the offspring were counted and taken away until the end of experiment to calculate the number of progeny per *D. magna* female. Also, the dry weight of adult females was determined by transferring triplicates of 10 individuals to pre-weighed aluminum baskets, drying in an oven for 24 hour at 60°C and weighting on microbalance. The mean individual dry weight was then calculated.

2. Statistical Analysis:

Probit Analysis was used to calculate the 48h-LC50s for acute tests on *D. magna* as described by Finney's method (1977). The terminology recommended by Sprague (1969), lethal concentration (LC) was used for survival as given here, represents an interpolation from three or more partial-effect concentrations.

Data were analyzed by ANOVA using the SAS ANOVA procedure (SAS, 1988). Fisher′s least significant difference test was used to compare treatment means.

RESULTS AND DISCUSSION

In acute tests, neonates of *D. magna* were exposed to different levels of low pH (4.31, 4.42, 4.54, 4.60 and 4.74) and high pH levels (10.7, 10.8 and 10.9), and the calculated LC50 after 48h by probit analysis was 4.37 for low pH and 10.66 for high pH.

From Probit analysis of acute tests , it was found that the sublethal concentrations for low pH were 4.74, 4.66, 4.61, 4.54, 4.52, 4.48 and 4.44 and that for high pH were 10.13, 10.23, 10.31, 10.38, 10.44, 10.5 and 10.55. These sublethal concentrations were corresponding to LC10, LC15, LC20, LC25, LC30, LC35 and LC40 for both pH studied, the effect of these sublethal concentrations as chronic tests for 21 days were studied on survival, growth and reproduction rates of *D. magna*.

Data illustrated in Table (1) and Figures (1a and 2a) show that the survival rate at the end of experiments was 47 % at pH 4.44 to 98% at pH 8.33 (control)and pH 4.74 (LC10). Thus, the significant survival rates ($P<0.05$) were recorded for pH 8.33, 4.74, 4.66, 4.61 and 4.54 (Figures 1a and 2a).

Table (1) and Figures (3a and 2B) show the effect of low pH on the growth rate of *D. magna* during the experimental period (21 days). It was found that the length of *D. magna* decreased as acidity increased from 4.74 to 4.44. the lowest significant ($P<0.05$) length was observed for those reared in concentration 4.48 and 4.44 corresponding to LC35 and LC40, respectively at the end of experiment which represented by 2.73 mm for both concentrations. The highest significant lengths ($P<0.05$) were recorded for control groups.

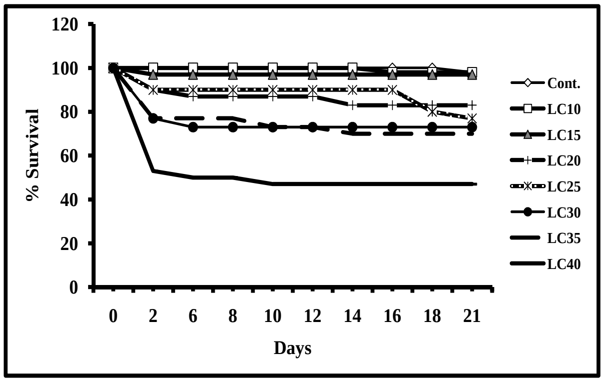
The highest SGR was observed for control group which represented by 7.29 followed by group cultured in concentration 4.74 (LC10) which represented by 6.62 (Table 1).

Table (1) and Figure (4a) show the effect of low pH on length of neonates which were produced from females. It was found that the highest significant ($P < 0.05$) mean length was observed for control group, 1.08 and 1.12 mm after 14 and 21 days, respectively. Results showed that there was no significant differences ($P >0.05$) in lengths between other treatments after 14 and 21 days. Strong negative correlation was noticed ($r = -0.77, -0.87$) after 14 and 21 days, respectively at $P<0.05$. The highest average weight of adult females at 21st days was 0.327 mg for those cultured at pH 8.33 (control). But the lowest one (0.19 mg) was noticed for those reared at pH 4.44 and 4.48.

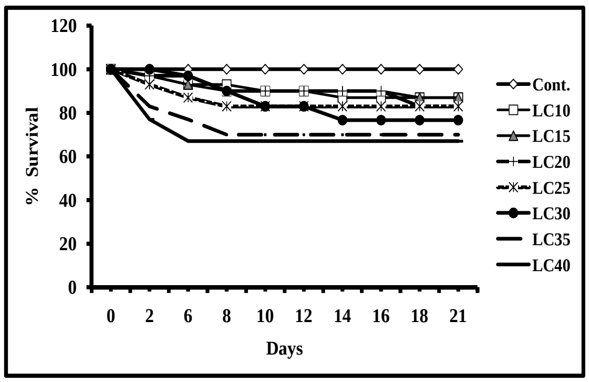
Table 1: Effect of different sublethal concentrations of low pH (acidic) on the survival, growth and reproduction rates of *D. magna* at 21st day.

Ph	% Survival at 21st day	Time to the first brood (days)	Number of progeny per females at 21st day (Mean ± SD)	Mean length of adults at 21 st days in (mm) (Mean ± SD)	Mean length of neonates at 21 st days in (mm) (Mean ± SD)	Average weight of adult females at 21st days (mg) (Mean± SD)	SGR* at 21st days
Control (8.33)	98±3.46^{A}	7	42±5.82^{A}	3.85±0.07^{A}	1.12±0.05^{A}	0.33±0.03	7.29
LC10 (4.74)	98±3.46^{A}	10	40±2^{A}	3.35± 0.06^{B}	1.09±0.04^{B}	0.29±0.02	6.62
LC15(4.66)	97±5.77^{A}	12	67±11.31^{B}	3.24±0.07^{B}	1.04±0.06^{B}	0.25±0.02	6.47
LC20(4.61)	88±5.77^{A}	12	66±18.89^{B}	3.08±0.07^{C}	0.98±0.04^{B}	0.25±0.02	6.23
LC25(4.54)	77±5.77^{A}	12	54±11.78^{C}	3.01±0.16^{C}	0.98±0.05^{B}	0.22±0.03	6.12
LC30(4.52)	73±20.82^{B}	12	33±5.69^{D}	3.03±0.10^{C}	1.01±0.04^{B}	0.23±0.02	6.15
LC35(4.48)	70±26.46^{B}	12	30±4.48^{D}	2.73±0.07^{D}	0.99±0.07^{B}	0.19±0.02	5.65
LC40(4.44)	47±41.63^{B}	14	29±1.19^{D}	2.73±0.04^{D}	0.98±0.04^{B}	0.19±0.02	5.65

Means in the same column with different superscripts are significantly different ($P < 0.05$), *SGR: Specific growth rate.



(a)



(b)

Fig. 1: Effect of (a) low pH (acidic) and (b) high pH (alkaline), levels on the survival rate of *D. magna* during the experimental period (21 days)

The maximum number of progeny (67 neonates/ females) was recorded for daphnids reared at pH 4.66 corresponding to LC15. While, the lowest count was 29 neonates/females for those reared in concentration 4.44 (LC40). The time to the first brood was ranged from 7 at pH 8.33(control) to 14 days at pH 4.44 (Table 1 and Figure 2c).

From studying high pH levels, it was found that *D. magna* reared at pH 8.33 (control group) showed the highest significant ($P < 0.05$) survival rate represented by 100% along the experimental period, followed by those reared at both pH 10.13 and 10.23 which corresponding to LC10 and LC15 represented by 87% for both of them. Then the survival rate decreased with increasing pH levels ($r = - 0.74$), thus the lowest significant survival rate (67%) for daphnids reared at the highest pH; 10.55 (Table 2and Figures 1b and 5a).

From data presented in Table (2) and Figures (3b &5B), it is observed that the highest significant lengths ($P<0.05$) were found for control group which represented by 3.78 mm after 21 days, followed by those cultured in concentration 10.13. At the end of experiment the lowest length (2.36 mm) was observed for group of daphnids reared at pH 10.55 (LC40) which significantly differed than other treatment at $P< 0.05$. But there is no significant difference between lengths of daphnids reared at pH 10.23, 10.31, 10.38, 10.44 and 10.50.

The highest specific growth rate (SGR) was recorded for control group (7.20) but the lowest one was 4.96 for *D. magna* cultured in concentration 10.55.

The length of neonates produced from females cultured in different concentrations of pH from 8.33 to 10.55 are illustrated in Table (2) and Figure (4b). Data showed that neonates produced from control group recorded the highest mean length ($P<0.05$) which represented by 1.08 and 1.03 mm at 14 and 21st days, respectively. Whereas, the lowest significant length ($P<0.05$) of that produced from those cultured in concentration 10.55 (LC40) at the end of experiment was represented by 0.75 mm. Strong negative correlation was detected ($r = -0.955$) at $P<0.05$ at 21$^{st\ day}$. Average weight of adult females at 21st days was maximum (0.27 mg) at pH 8.33 (control) and the lowest average weight was 0.17 mg at pH 10.5 and 10.55.

Number of progeny per females at 21st day decreased gradually as pH increased from 10.13 to 10.55. Progeny per females along the experimental period ranged from 22 to 53. The maximum number was at pH 10.13 (LC10) and represented by 53 neonates/ female as showed in Table (2) and Figure (5C). The age at first reproduction was 12 days for all concentrations but was 7 days for those reared at pH 8.33 (control group).

Table 2: Effect of different sublethal concentrations of high pH (alkaline) on the survival, growth and reproduction rates of *D. magna* at 21 days.

pH	% Survival at 21st day	Time to the first brood (days)	Number of progeny per females at 21st day (mm) (Mean ± SD)	Mean length of adults at 21 st days in (mm) (Mean ± SD)	Mean length of neonates at 21 st days in (mm) (Mean ± SD)	Average weight of adult females at 21st days (mg) (Mean ± SD)	SGR* at 21st days
Control (8.33)	100±0^{A}	7	40±5.82^{B}	3.78±0.12^{A}	1.03±0.06^{A}	0.27±0.03	7.20
LC10 (10.13)	87±11.55^{AB}	12	53±6.33^{A}	2.69±0.13^{B}	0.88±0.05^{BC}	0.22±0.03	5.58
LC15 (10.23)	87±5.77^{AB}	12	46±5.95^{B}	2.56±0.16^{C}	0.85±0.04^{CD}	0.19±0.02	5.35
LC20 (10.31)	83±20.82^{AB}	12	45±5.54^{B}	2.52±0.06^{C}	0.82±0.02^{DE}	0.2±0.02	5.27
LC25 (10.38)	83±20.82^{AB}	12	45±2.66^{B}	2.50±0.06^{C}	0.80±0.04^{DEF}	0.19±0.02	5.23
LC30 (10.44)	77±5.77^{AB}	12	43±8.68^{B}	2.52±0.13^{C}	0.81±0.03^{DE}	0.18±0.02	5.27
LC35 (10.5)	70±0^{B}	12	32±1.52^{C}	2.50±0.06^{C}	0.79±0.05^{EF}	0.17±0.04	5.23
LC40 (10.55)	67±20.82^{B}	12	22±4.17^{D}	2.36±0.07^{D}	0.75±0.04^{F}	0.17±0.04	4.96

Means in the same column with different superscripts are significantly different (P <0.05), *SGR: Specific growth rate.

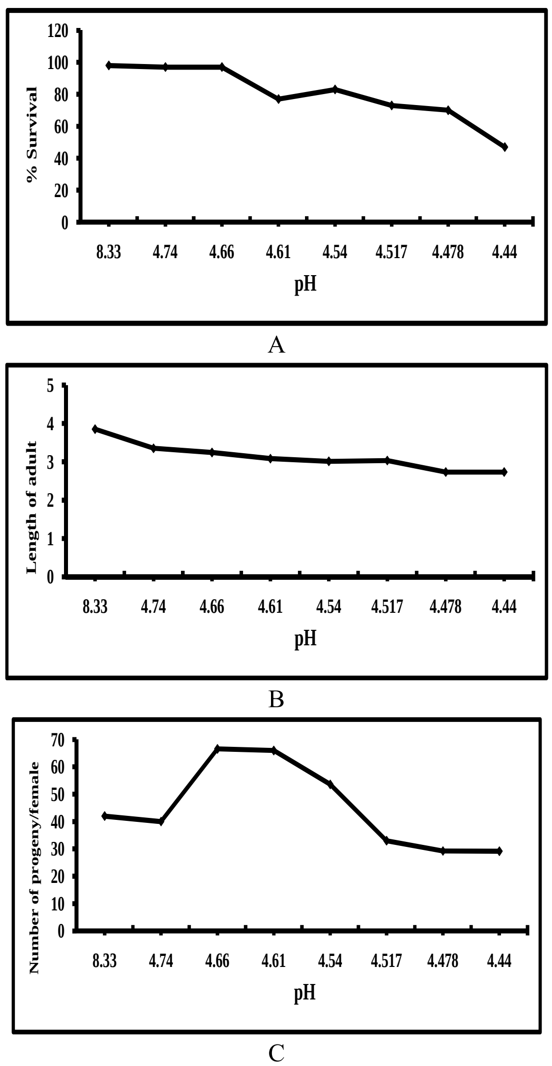
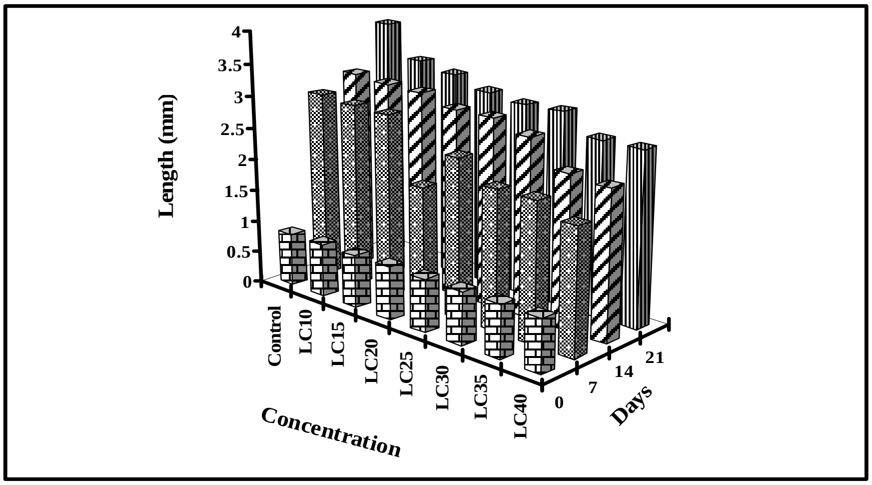
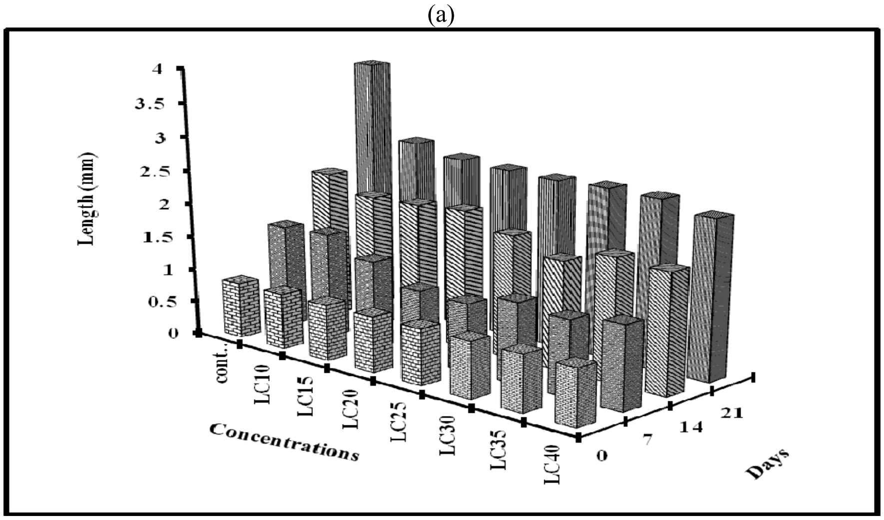


Fig. 2: A-Survival, B-Growth and C-Reproduction of *D. magna* grown at different sublethal concentrations of low pH (acidic) at 21 st day.



(a)

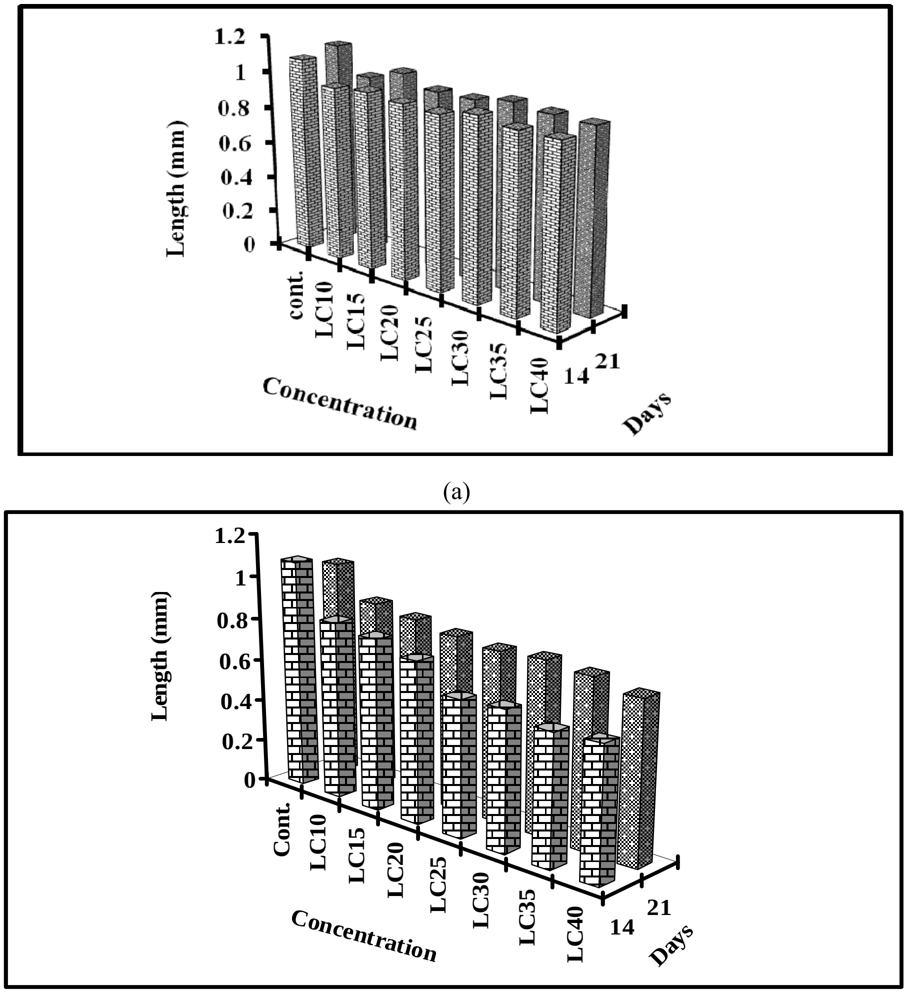


(b)

Fig. 3: Length of *D. magna* reared at different sublethal concentrations of (a) low pH (acidic) and (b) high pH (alkaline), during the experimental period (21 days).

Hydrogen ion concentrations have been affected survival, growth and reproduction rates of Cladocera (Walton *et al*., 1982 and Moustafa, 2007). In the present study the 48h-LC50 was 4.37 for low pH and 10.66 for high pH. For low pH the highest survival rate (98%) was at both pH 8.33 and 4.74 (LC10), while the lowest survival (47%) was found at pH 4.44 (LC40) at the end of experiment. This finding was in agreement with Brehm and Meijering (1998) who recorded that low pH values may lead to increase the mortality of *Daphnia* sp. This mortality may be due to the depression of O_2 uptake rates according to Alibone and Fair (1981).The pH level below 5.0 may kill several species of *Daphnia.* It was noticed that exposure of *Daphnia* for several days to pH 4.5 was lethal. Exposing *Daphnia magna* and *D. middendorffiana* at low pH indicated that net loss of Na^+ was due to accelerated efflux rather than influx of Na^+ (Havas, 1985). Also, this concurred with Bulkowski *et al*., (1985) who observed that *Daphnia* sp. has been shown to be more sensitive to low pH than *Cyclops* sp. However, exposure to pH 3 and 4 result in their eventual disappearance of Crustacean, Cladocera (*Daphnia* sp.), while exposure to pH 4.5 for 48 hour resulted in 50% mortality and exposure to pH 5 and 5.5 population showed higher survivorship and growth rates but reproduction parameters were significantly reduced as compared to those grown in pH 7 and 8.2 (Chandini, 1987).

In the present results, the highest significant lengths ($P<0.05$) were recorded for control group from the first week till the end of experiment and represented by 2.94, 3.15 and 3.85 mm after 7, 14 and 21 days, respectively. Whereas, the lowest significant ($P<0.05$) length was observed for those reared in concentration 4.48 and 4.44 corresponding to LC35 and LC40, respectively at the end of experiment which represented by 2.73 mm for both concentrations. In acid water, crustaceans and fish have suffered retarded growth and skeletal deformity (Haines, 1981) and impaired ionic regulation (Hobe *et al*., 1984).



(a)

(b)

Fig. 4: Length of neonates produced from females cultured at different sublethal (a) low pH (acidic) and (b) high pH (alkaline) at the 14th and 21st days.

The number of egg production per female were reduced in lower pH, also the abundance of *Daphnia* was higher in neutral water than in acidic one (Andrea and Sprules, 2000). In our Study, the maximum number of progeny (67 neonates/females) was recorded for daphnids reared at pH 4.66 corresponding to the sublethal concentrations LC15. While, the lowest count was 29 neonates/females for those reared at pH 4.44 corresponding to LC40. At sublethal concentrations of low pH 4.66 (LC15), 4.61 (LC20) and 4.54 (LC25), the number of progeny/female was more than that of control, it was noticed that these neonates were weak, unhealthy and some of these neonates were dead. These results are in agreement with that obtained by Doyle and McMahon (1995) who reported that Exposure of *Artemia franciscana* (Crustacea: Anostraca), to acidic seawater significantly affected hatching success, survival and whole body salt concentrations.

Also, Zhuang and Dehui (1994) stated that the acute toxicity threshold of low pH to *Daphnia magna* was observed within the range of pH 5- 5.5 and also found that at 14 day chronic test, both survival and growth was affected by pH 4.75 and not affected by 5 but reproduction was affected by pH 5 and not affected by 5.5. Low pH may also occur when water interacts with acid-sulfate soil which contains iron pyrite, and when water receives acidic effluent and seepage (Boyed, 1990). Locke and Sprules (2000**)** reported that *Daphnia pulex* was affected by pH and phytoplankton composition with decreased egg production and body size or abundance.

On the other hand, upon studying high pH levels, it was found that *D. magna* reared at pH 8.33 (control group) showed the highest significant ($P < 0.05$) survival rate represented by 100% along the experimental period, followed by those reared at both pH 10.13 and 10.23 corresponding to LC10 and LC15 respectively. The lowest significant survival rate for daphnids reared at the highest pH (10.55) corresponding to LC40. The mortality of juveniles and adults of *Daphnia* did not increase with increase pH in the range of 9-10.5 as reviewed by Vijverberg *et al*., (1996) which disagree the present data.

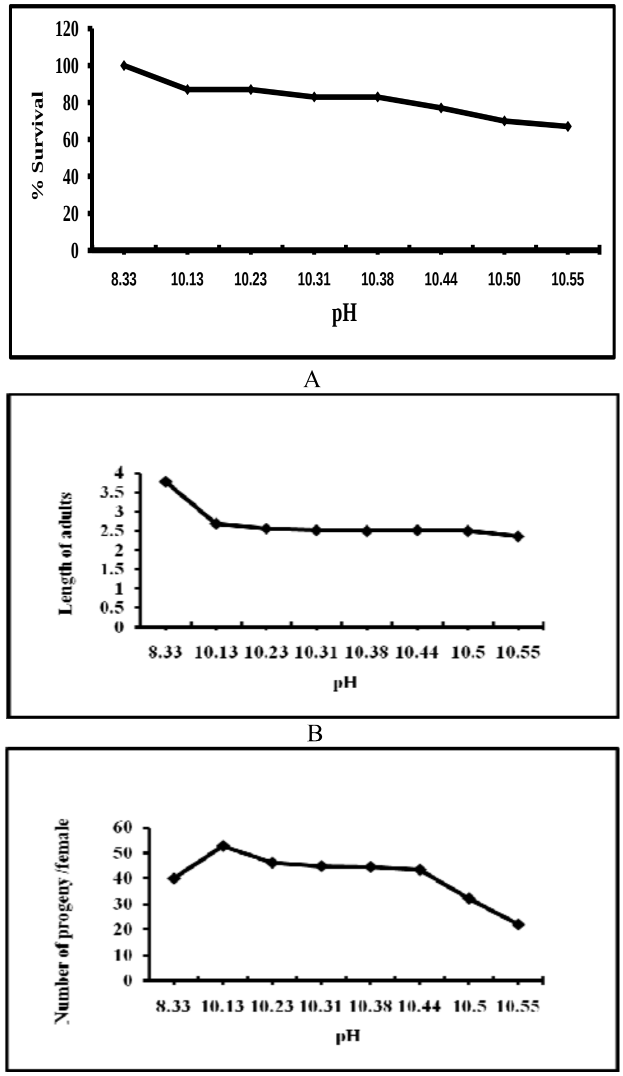


Fig. 5: A-Survival, B-Growth and C-Reproduction of *D.magna* grown at different sublethal concentrations of high pH (alkaline) at 21st day.

The highest significant lengths ($P<0.05$) in our results were found for control group followed by those cultured at pH 10.13; LC10. The lowest length was observed for group of daphnids reared at pH 10.55 (LC40) which significantly differed than other treatment at $P< 0.05$. The pH level below 5.0 may kill several species of *Daphnia*. Therefore, the optimum range for these organisms lies in the alkaline range (Moustafa, 2007). These data are in agreement with Havas (1985) who recorded that pH values have positively affected offspring length, the highest offspring length recorded at pH 8 followed by 7 and 9. Moreover, the present study is consistent with Moustafa (2007) who detected that a high offspring number and higher length of *D. longspina* were produced at pH 8 than at pH 7 and 9.

In the current study, the maximum count of progeny in this study was at pH 10.13 (LC10). The lowest number of progeny was observed for those cultured at the highest pH 10.55 corresponding to LC40. It is important to mention that at the sublethal concentrations of pH 10.13 (LC10), 10.23 (LC15), 10.31 (LC20), 10.38 (LC25) and 10.44 (LC30), the number of progeny per female was greater than that of control group, but that progeny were weak, unhealthy and some released dead. Benndorf *et al*., (2001) reported that pH between 6.5 and 9.5 is acceptable for *Daphnia* species, also high ammonia levels with high pH will drastically reduce production of *Daphnia* species but will not affect the actual health of animal themselves which concurred to our study. Vijverberg *et al*., (1996) stated that both egg mortality and population growth rate markedly affected by pH between 10.5 and 11.5 and noticed that the threshold value for mortality of *D. galeata* is between 10.5 and 11.5. Yin and Niu (2008) studying the effect of pH on survival, reproduction, egg viability and growth rate of five closely related rotifera (*Branchionus*) species, reported that at acid pH (pH 5 or 6) high egg mortality was observed for each species. *B. urceolaris* and *B. patulus* could tolerate a broad range of pH, while the population of *B. calyciflorus*, *B. quadridentatus* and *B. angularis* declined at acid conditions. The age-specific survivorship curves within a species were not significantly different at pH 6-10. The optimal pH for each species in near-neutral pH (pH 6-8), and the fecundity decreased as the pH deviated from these values.

Conclusion:

In conclusion, the 48h-LC50s of low and high pH on *D. magna* were 4.37 and 10.66, respectively. Survival and growth rates at 21^{st} day decreased by decreasing pH from 4.74 to 4.44 and by increasing pH from 10.23 to 10.55. It was noted that the highest number of progeny was recorded at acidic pH 4.66 and at alkaline pH 10.13. It is worth mentioning that great number of these neonates released weak, unhealthy and dead. However, control group recorded lower number of progeny per female comparing to those of acidic (4.66) and alkaline (10.13) pH, but these neonates were in healthy manner. From this study, it is concluded that the suitable range of pH for *D. magna* must be more than 4.55 and less than 10.13 and the optimum condition is 7.9 to 8.3.

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