Egypt. Acad. J. Biolog. Sci., 5(2): 25-31 (2013) B. Zoology
Email: egyptianacademic@yahoo.com ISSN: 2090 - 0759
Received: 25 / 4 /2013 www.eajbs.eg.net

Effects of food limitation on the life history of *Simocephalus expinosus* Koch (Cladocera: Daphniidae)

Berrak Hakima [1,2*], Chakri Khémissa [1,2], Samraoui Boudjéma [1,3]
1- Laboratoire de Recherche et de Conservation des Zones Humides, 8 Mai 45 University, Guelma, Algeria.berrakhakima@yahoo.fr
2- Department of Biology, Faculty of Sciences, Badji Mokhtar University, Annaba, Algeria. saidachakri@yahoo.fr
3- Center of Excellence for Research in Biodiversity, King Saud University, Riyadh, Saudi Arabia. bsamraoui@yahoo.fr
E-mail: berrakhakima@yahoo.fr

ABSTRACT

Life history features of the Cladocera *Simocephalus expinosus* were examined at ambient room temperature in the laboratory at three different food concentrations of *Saccharomyces cerevisiae*: high food (12 x 10^5cells/ml), intermediate food (65 x 10^4cells/ml) and low food (5 x 10^4cells/ml). Culture media and food were renewed each day. As food level increased, there was a reduction in the age at maturity. Early reproducing females at larger sizes are accompanied by the production of larger broods which generate an important number of neonates per reproductive female. On the contrary, when food level diminished, there was an increase in the age at maturity. Later reproducing females at smaller sizes induced smaller broods and consequently, generate a lesser number of neonates.

Keywords: *Simocephalus*, food quantity, life history, reproduction.

INTRODUCTION

Zooplankton plays an important role in food webs of aquatic ecosystems. It occupies a key position, thus allows the transfer of energy and matters from lower trophic levels to higher trophic levels (Banse 1995, Lampert & Somer 1997, Levinsen & Nielsen 2002). In addition, zooplankton has control of "top-down" on primary producers and actively participates in the remineralization of organic matter (Banse 1995).

On the other hand, zooplankton communities are very sensitive and react to a wide variety of environmental stresses (Harris *et al.* 2000) including the quantity of nutrients (McCauley & Kalff 1981, Pace 1986, Dodson 1992). This constitutes a major force in the structure, abundance and zooplankton diversity. Outside the temperature (Allan 1977, Threlked 1979, Sharma & Pant 1982, Samraoui & Touati 2002) and predation (Brooks & Dodson 1965, De Bernardi & Guissani 1975, Zaret 1980), the food is the most important single factor controlling the population dynamics of Cladocera. In addition, it influences their fecundity (Clark & Carter 1974).

Different studies on the influence of nutritional deficiency in Cladocera report a negative effect on growth and reproduction. In extreme conditions, Cladocera may produce resting eggs and disappear from the plankton. These findings were reported from both laboratory (Hall 1964, Lampert 1977, Porter *et al.* 1983) and field studies (Hebert 1977, Threlked 1979, Taylor 1981). Thus, this study was therefore conducted to test the influence of food ability in the laboratory on the life-history traits of a cladoceran *Simocephalus expinosus* Koch, a species reported in Northeast Algeria by previous works of Gauthier (1928), Samraoui *et al.* (1998) and Samraoui (2002).

MATERIALS AND METHODS

Females of *S. expinosus* were isolated from a temporary pond, reared in an aquarium containing filtered pond water and oxygenated continuously. Pond water was filtered through a 0.45 µm to remove bacteria, algae and fine detritus. Females are kept at room temperature and fed daily with *Saccharomyces cerevisiae*. The *Simocephalus* are acclimatized to the conditions to be tested. The stock of cultures of *S. expinosus* has been maintained in this laboratory for about two years. Genetically, identical neonates from the first brood and aged less than 16 h were isolated and placed individually in tubes of 20 ml of filtered pond water. Three treatments were applied. In the first treatment, neonates are fed daily of *S. cerevisiae* at a concentration of 12 x 10^5 cells/ml. This concentration of food will be called high food. In the second treatment, females are fed daily with *S. cerevisiae* at a concentration of 65 x 10^4cells/ml. It will be called the intermediate food, while in the third treatment neonates receive food daily at a concentration of 5 x 10^4cells/ml and will be called the low food. Culture medium was prepared each day. Neonates in the three treatments are monitored daily from birth to death. The medium was changed every day. Before each change, the tubes are prepared, and individuals are transferred one by one using a pipette. The cells of *S. cerevisiae* were estimated using a hemacytometer. Room temperature, which was measured daily at 12 a. m, was about 19.99 ±0.61. Size (body length) was measured with an ocular micrometer, to the nearest of 0.05 mm from the top of the head to the base of the body (Perrin 1988).

We determined the following parameters:

- age at maturity (the first day of appearance of eggs in the brood pouch);
- size at maturity;
- First brood size and successive broods in order to determine the mean brood size per female;
- Total number of broods per female;
- Total number of neonates produced during the life cycle of the female.

We used analysis of variance to compare means. All analyses were performed with Minitab.

RESULTS

Data revealed that age at maturity of females reared at low food level is extended. By contrast, it is shortened under high food conditions (Fig. 1). Statistical analyses showed that the differences are significant (Table 1).

Table 1: One way ANOVA testing for the effect of food concentration on the age at maturity of *Simocephalus expinosus.*

Source of variance	DF	SS	MS	F Ratio	P
Factor	2	383,849	191,925	517,81	<0,001
Error	65	24,092	0,371		
Total	67	407,941			

DF: degrees of freedom, SS: sum squares, MS: mean squares.

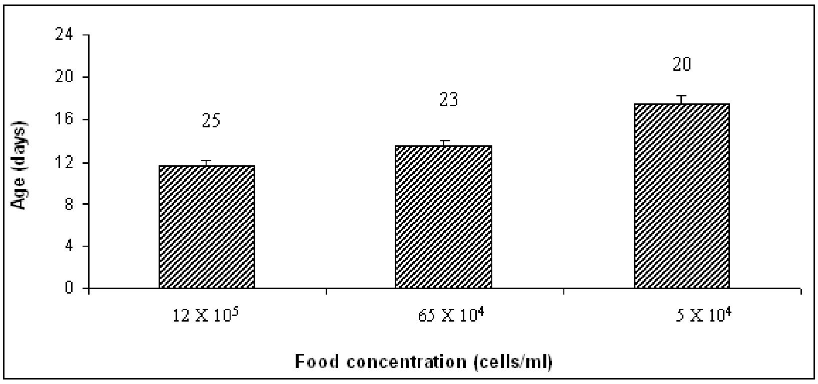

Fig. 1: Influence of food concentration on the age at maturity of *Simocephalus expinosus.*

The results showed that females reared under low food conditions grew significantly at smaller sizes than those reared under high food level (Fig. 2, Table 2).

Table 2: One way ANOVA testing the difference in the size at maturity of *Simocephalus expinosus* in relation to food concentration.

Source of variance	DF	SS	MS	F Ratio	P
Factor	2	1,19973	0,59986	197,74	<0,001
Error	65	0,19718	0,00303		
Total	67	1,39691			

DF: degrees of freedom, SS: sum squares, MS: mean squares.

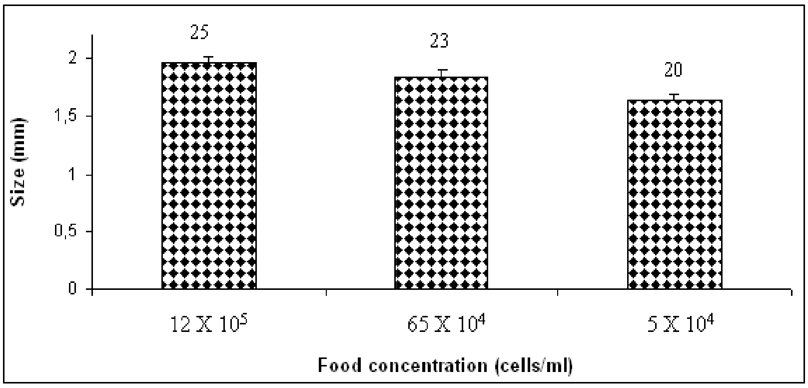

Fig. 2: Size at maturity of *Simocephalus expinosus* in relation to food concentration.

First brood size and mean brood size per reproductive female are smaller in females reared under low food conditions compared to those reared under high food conditions (Fig. 3). Statistics reveal a significant effect of food level (Table 3).

Table 3: One way ANOVA testing for the influence of food concentration on the 1rst brood size and mean brood size during the life cycle of reproductive female of *Simocephalus expinosus.*

	Source of variance	DF	SS	MS	F Ratio	P
First brood size	Factor	2	115,08	57,54	28,72	<0,001
	Error	49	98,15	2,00		
	Total	51	213,23			
Mean brood size/female	Factor	2	142,71	71,35	21,34	<0,001
	Error	49	163,84	3,34		
	Total	51	306,55			

DF: degrees of freedom, SS: sum squares, MS: mean squares.

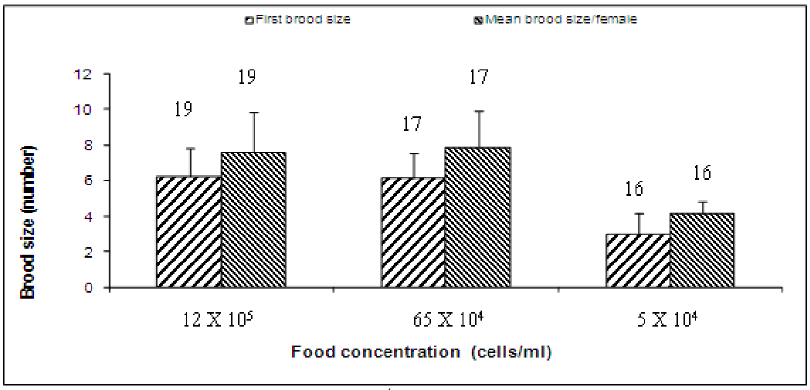

Fig. 3: Effect of food concentration on the 1rst brood size and mean brood size per female in *Simocephalus expinosus.*

According to the data reported in figure 4 and table 4, we established that the number of broods per female is not affected by food level.

Table 4: One way ANOVA testing for the effect of food concentration on the number of broods per reproductive female of *Simocephalus expinosus.*

Source of variance	DF	SS	MS	F Ratio	P
Factor	2	15,59	7,80	2,61	0,083
Error	49	146,10	2,98		
Total	51	161,69			

DF: degrees of freedom, SS: sum squares, MS: mean squares.

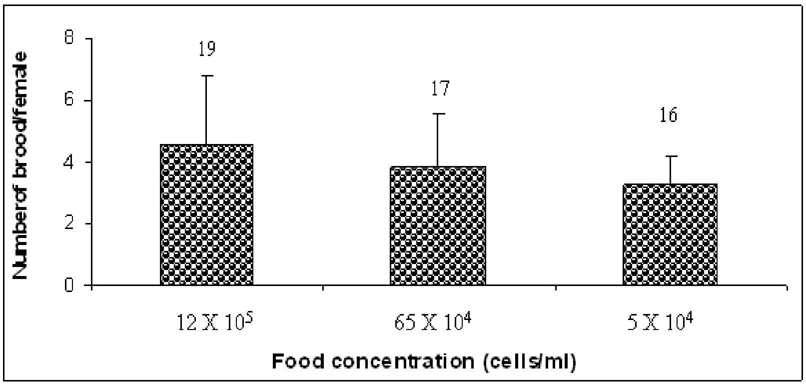

Fig. 4: Number of brood per female in relation to food concentration in *Simocephalus expinosus.*

On the contrary, the number of neonates produced by reproductive female increases significantly with increasing food level (Fig. 5, Table 5).

Table 5: One way ANOVA testing for the difference in the total number of neonates produced per reproductive female of *Simocephalus expinosus* in relation to food concentration.

Source of variance	DF	SS	MS	F Ratio	P
Factor	2	5149	2575	9,77	<0,001
Error	49	12915	264		
Total	51	18064			

DF: degrees of freedom, SS: sum squares, MS: mean squares.

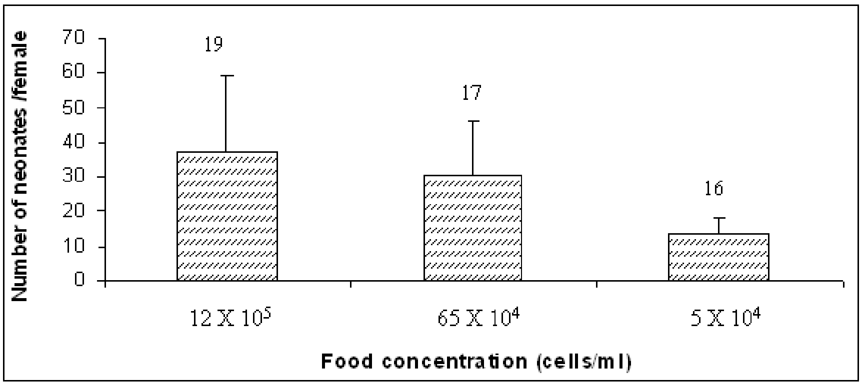

Fig. 5: Total number of neonates per reproductive female in function of food concentration in *Simocephalus expinosus.*

DISCUSSION

It is recognized that the life history traits of Cladocera change depending on the quality and quantity of the resource (Urabe & Strener 2001). The results of this study confirm this finding. The food quantity affects life history parameters of the cladoceran *S. expinosus*. Indeed, females of this species extend their sexual maturity when food concentration decreases. Late maturity observed in these females is accompanied by a significant decrease in their size. Many studies with various *Daphnia* species reported that the age and the size at maturity increase and decrease respectively in response to food limitation (Vijverberg 1976, Orcutt & Porter 1984, Tillman & Lampert 1984, Taylor 1985, Foran 1986, Lynch 1989, Guisande & Gliwicz 1992, Riessen & Sprules 1992). There appear to be not exceptions to this pattern.

The results show clearly the influence of food conditions on brood size. Thus, females treated with low food produce smaller broods. The reduction in brood size with food depressions observed in this study is consistent with certain data collected both in the laboratory and in natural conditions on *Daphnia pulex (*Taylor 1985, Lynch 1989, Ebert & Yamposky 1992), *Daphnia longispina* (Lampert 1978), on *Daphnia magna* (Ebert & Yamposky 1992) and on *Daphnia pulicaria* (Gliwicz & Boavida 1996). It should be noted that the preliminary experiment of our study revealed the existence of a threshold concentration of growth and reproduction corresponding to 5 x 10^4cells/ml.

In general, the overall result of this study shows that there is a relationship between brood size and food resources. Thus, brood size could act as an indicator of trophic levels. Previous works have developed the index of the nutritional status in Cladocera based on the number of eggs in the brood pouch (Hutchinson 1967).

The results of this study indicate that females of *S. expinosus* reared under low food level matured slowly, at smaller size produced smaller broods and consequently generate a lesser number of neonates per female.

On the above evidence it may be concluded that the low food level exercises a negative influence on the reproduction in three different ways: by causing an increase in the age at maturity, by lowering the size at maturity and by decreasing the brood size.

Overall, this study showed that the food deficiency is a major cause of reduced fertility of S. expinosus. Applied to natural populations, nutritional quantity therefore, determines fertility, in extreme cases of insufficient food resources, populations of S. expinosus may suppress any phenomenon of reproduction which lead to its disappearance.

REFERENCES

Allan JD (1977). An Analysis of seasonal dynamics of a mixed population of *Daphnia,* and the associated Cladoceran community. Freshwater Biology 7: 505-512.

Banse K (1995). Zooplancton. Pivotal role in the control of ocean production. ICES Journal of marine Science 52: 265-277.

Brooks J L and Dodson SI (1965). Predation, body size, and composition of plankton, *Science* 150: 28-35.

Clark AS &Carter JCH (1974). Population dynamics of cladocerans in Sunfish Lake Ontario. *Canadian Journal of Zoology* 52: 1235-1242.

De Bernadi R & Guissani G (1975). Population dynamics of three Cladocerans of Lago Maggiore related to predation pressure by a planktophagous fish, *Verh. Internat. Verein. Limnol* 19: 2906-2912.

Dodson S (1992). Predicting crustacean zooplankton species richness. *Limnology and Oceanography* 37: 848-856.

Hebert PDN (1977). Niche overlap among species in the *Daphnia carinata* complex. *Journal of animal Ecology* 46: 399-409.

Foran JF (1986). A comparison on the life history features of a temperate and a subtropical *Daphnia* species. *Oikos* 46: 185-193.

Gauthier H (1928). Recherches sur la faune des eaux continentales de l'Algérie et de la Tunisie. Alger. Imp. Minerva, 419 p.

Gliwicz ZM and Boavida MJ (1996). Clutch size and body size at first reproduction in *Daphnia pulicaria* at different levels of food and predation. Journal of Plankton. Research., 18: 863-880.

Guisande, C. and Gliwicz, M. Z. (1992). Egg size and clutch size in two *Daphnia* species grown at different food levels. J. Plankton Research, 14: 997-1007.

Hall DJ (1964). An experimental approach to the dynamics of natural population of *Daphnia galeata mendota*. Ecology 45: 94-112.

Harris RP, Wiebe P, Lenz J, Skjodal HR and Huntley M (2000). ICES Zooplankton Methodology Manual. Academic Press, San Diego.

Hutchinson GEA (1967). Treatise on Limnology. II. Wiley, New York. 1115 p.

Lampert W (1977). Studies on the carbon balance of *Daphnia pulex* De Geer as related to environmental conditions. II. The dependence of carbon assimilation on animal size, temperature, food concentration and diet species. *Archiv für Hydrobiologie Supplement* 48: 310- 335.

Lampert W & Sommer U (1997). Limnoecology: the ecology of Lakes and Streams. Oxford University Press, New York.

Lampert W (1978). A field study on the dependence of fecundity of *Daphnia* spec. on food concentration. *Oecologia* (Berlin) 36: 363-369.

Levinsen H and Nielsen TG (2002). The trophic role of marine pelagic ciliates and heterotrophic dinoflaellates in arctic and temperate coastal ecosystems: a cross-latitude comparison. *Limnology and Oceanography* 47:427-439.

Lynch M (1989). The life history consequences of resource depression in *Daphnia pulex*. *Ecology*. 70:246-256.

McCauley E & Kalff J (1981). Empirical relationships between phytoplankton and zooplankton biomass in lakes. *Journal canadien des sciences halieutiques et aquatiques* 38, 458-463.

Orcutt JD and Porter KG (1984). The synergistic effects of temperature and food concentration on life history parameters of *Daphnia*. *Oecologia* (Berlin) 63: 300-306.

Pace ML (1986). An empirical analysis of zooplankton size structure across lake trophic gradients. *Limnology and Oceanography 31: 45-55.*

Perrin N (1988). Why are offspring born larger when it is colder? Phenotypic plasticity for offspring size in the cladoceran *Simocephalus vetulus* (Müller). *Functional Ecology* 2: 283-288.

Porter KG, Orcutt JD and Gerritsen, J (1983). Functional response and fitness in a generalist filter feeder, *Daphnia magna* (Cladocera : Crustacea). Ecology 64: 735-742.

Riessen HP and Sprules WG (1990). Demographic costs of antipredator defenses in *Daphnia pulex*. *Ecology* 71:1536-1546.

Samraoui B, Segers H, Maas S, Baribwegure, D. and Dumont, H. (1998). Rotifera, Cladocera, Copepoda and Ostracoda of N. E. Algeria. *Hydrobiologia* 386: 183-193.

Samraoui B (2002). Branchiopoda (Ctenopoda and Anomopoda) and Copepoda from eastern Numidia, Algeria. *Hydrobiologia* 470: 173-179.

Sharma PC and Pant MC (1982). Population dynamics of *Simocephalus vetulus*(O.F. Muller). *Journal of Plankton Research* 4: 601- 618.

Taylor BE (1981). Population dynamics of the crustacean zooplankton of Hall Lake, Washington - Ph. D. dissertation, Univ. Washington, Seattle, WA. 171 p.

Taylor BE (1985). Effects of food limitation on growth and reproduction of *Daphnia*. *Archiv für Hydrobiologie, Ergebnisse der Limnologie* 21: 285-296.

Threlked ST (1979). The midsummer dynamics of two *Daphnia* species in Wintergreen Lake, Michigan. *Ecology* 60: 165-179.

Tillman U & Lampert W (1984). Competitive ability of differently sized *Daphnia* species: an experimental test. *Journal of Freshwater Ecology* 2:311-323.

Touati L. and Samraoui B (2002). The ecology of *Daphnia chevreuxi* Richard in Northeast Algeria (Crustacea: Anomopoda). *Revue des Sciences et de la Technologie Synthèse* (numéro spécial D) 75-81.

Urabe J and Sterner RW (2001). Contrasting effects of different types of resource depletion, on life- history traits in *Daphnia*. *Functional Ecology* 15:165-174.

Vijverberg J (1976). The effect of food quantity and quality on the growth, birth-rate and longevity of *Daphnia hyalina* Leydig. *Hydrobiologia* 51: 99-108.

Zaret TM (1980). Predation and freshwater communities. Yale, University Press, New Haven, Connecticut. 180 p.

ARABIC SUMMARY

تأثير تحد يد الغذاء على ثوابت تاريخ حياة *Simocephalus expinosus* (CLADOCERA: DAPHNIIDAE)

براك حكيمة [1، 2] ، شاكري خميسة [1، 2] ، سمراوي بوجمعة [1، 3]

1- مخبر البحث و حماية المناطق الرطبة، جامعة 08 ماي 45، قالمة، الجزائر.

2- قسم البيولوجيا، كلية العلوم، جامعة باجي مختار، عنابة، الجزائر

3- المركز الممتاز للبحث و التنوع البيولوجي، جامعة الملك سعود، الرياض، المملكة العربية السعودية

في ظروف درجة حرارة المخبر، تمت دراسة ثوابت تاريخ حياة متفرعة اللوامس *Simocephalus expinosus* على ثلاثة تراكيز مختلفة من الغذاء *Saccharomyces cerevisiae*: تركيز عالي (12 10×10^5 خلية/ مل)، تركيز متوسط (65 $\times 10^4$ خلية/ مل) و تركيز ضعيف (5 $\times 10^4$ خلية/ مل). تم تغيير الماء والغذاء كل يوم.

أظهرت النتائج أن الإناث التي تغذت على تركيز عالي من الغذاء، نضجت بسرعة و بحجم كبير، مع إنتاج عدد كبير من الصغار في الوضع الواحد و بالتالي عدد أكبر من الصغارللانثى في حياتها. على العكس من ذلك، عندما تنقص كمية الغذاء، يتأخر النضج الجنسي لدى الإناث مصحوبا بحجم صغير، مما ينتج عنه عدد قليل من الصغار في الوضع الواحد و بالتالي عدد اقل من الصغار في حياة الأنثى.