

Aspects of the life cycle of *Chydorus pubescens* Sars, 1901 (Cladocera, Chydoridae).

SANTOS-WISNIEWSKI¹, M.J. , ROCHA², O. & MATSUMURA-TUNDISI³, T.

¹ Universidade Federal de Alfenas (UNIFAL-MG), Departamento de Ciências Biológicas.

R. Gabriel Monteiro da Silva, 714, CEP 37130-000 - Alfenas MG, Brasil, czw@uol.com.br

² Universidade Federal de São Carlos - Departamento de Ecologia e Biologia Evolutiva, CP 676, 13565-905 - São Carlos SP, Brasil

³ Instituto Internacional de Ecologia, R. Bento Carlos, 750, 13560-660 - São Carlos SP, Brasil.

ABSTRACT: Aspects of the life cycle of *Chydorus pubescens* Sars, 1901 (Cladocera, Chydoridae).

Information about the life cycle of a species is of considerable relevance to the ecologist because it provides a basis for understanding a variety of ecological aspects of the species such as its as those related to geographic distribution, population dynamics and secondary productivity. In the present study, some life-cycle traits of *Chydorus pubescens* (Cladocera, Chydoridae) maintained under controlled conditions in laboratory cultures were measured. Parthenogenetic females were acclimatized to the laboratory conditions over ten generations. Experiments were carried out in incubators in the temperature of 23.6 ± 0.5 °C, photoperiod of 12 hours light/12 hours dark and food supply (algal suspension of the chlorophycean *Selenastrum capricornutum* at 10^5 cells./mL and 0.02mL of a mixed suspension of yeast, and fish ration added per organism, at equal proportion) that were kept constant. Observations were made once or twice a day, so as to record individual growth, age and size of the primipara, fecundity and longevity. *Chydorus pubescens* achieved a maximum size of 389.12 mm, while the primiparous instar measured 339.54 mm on average, at an age of 2.37 days. The mean fecundity of *Chydorus pubescens* was 2 eggs/female and the mean total number of eggs produced by a female during its life was 22.3. Embryonic development time was 1.96 days and the maximum longevity found was 31 days.

Key-words: Chydoridae, life cycle, development time, fecundity, longevity.

RESUMO: Aspectos do ciclo de vida de *Chydorus pubescens* Sars, 1901 (Cladocera, Chydoridae).

O estudo do ciclo de vida de um organismo é muito importante pois serve de base para o entendimento de diferentes aspectos ecológicos de uma espécie, como a sua distribuição geográfica, a dinâmica das populações e a produção secundária das espécies individuais. Este estudo visou o conhecimento de alguns aspectos do ciclo de vida de *Chydorus pubescens* (Cladocera, Chydoridae) cultivado em laboratório. As fêmeas partenogenéticas foram aclimatadas por dez gerações. Os experimentos foram mantidos em incubadora com temperatura ($23,6 \pm 0,5$ °C), fotoperíodo (12 horas luz/12 horas escuro) e alimentação (*Selenastrum capricornutum* na concentração de 10^5 cels./mL e and 0,02mL/organismo de uma suspensão mista de fermento e ração de peixes em proporção igual) controladas. As observações foram feitas uma ou duas vezes ao dia para o acompanhamento do crescimento do corpo, idade e tamanho da primipara, fecundidade e longevidade. Esta espécie teve um tamanho máximo de 389,12 mm e atingiu o instar de primipara medindo em média 339,54 mm, com 2,37 dias de idade. A fecundidade média de *Chydorus pubescens* foi de 2 ovos/fêmea/ninhada e o número total de ovos produzidos por fêmea durante todo o ciclo de vida foi, em média, 22,3 ovos. O tempo de desenvolvimento embrionário foi de 1,96 dias e a longevidade máxima foi de 31 dias.

Palavras-chave: Chydoridae, ciclo de vida, tempo de desenvolvimento, fecundidade, longevidade.

Introduction

The zooplankton community is a key element in the functioning of aquatic ecosystems, since it is the major route for energy flux in the plankton based food web. The knowledge of individual species life cycles can provide information for a better understanding of the role of each species

in the community and basic data for secondary production investigations.

Most existing studies on cladoceran life cycles concern limnetic species, although some studies have been carried out on Chydoridae species, typical inhabitants of the littoral zone. Examples of such work are the study on the life cycle of *Pleuroxus*

denticulatus, carried out by Shan (1969), on *Alona affinis*, *Graptoleberis testudinaria*, *Pleuroxus uncinatus*, *Chydorus sphaericus*, *Eurycercus lamellatus* and *Acroperus harpae* by Bottrell (1975), on *Leydigia leydigi* and *Disparalona rostrata* by Robertson (1988), on *Leydigia acanthocercoides* by Murugan & Job (1982), on *Euryalona orientalis* and *Leydigia ciliata* by Venkataraman (1990) and on *Alonella excisa* by Sharma & Sharma (1998). Kotov (1997) also analysed the initial development of *Eurycercus lamellatus* and *Chydorus sphaericus*. In Brazil, Melão (1999) analyzed the life cycle of *Chydorus dentifer* and *Acroperus harpae*.

Given the great richness of species found among Chydoridae in tropical freshwaters, the number of species whose life cycle has been studied is still very restricted, compared to that of other families and species of Cladocera, not reaching 20 % of the known species of Chydoridae. There is a need, therefore, to expand such studies to a larger number of species. There is no available information on the life cycle of *C. pubescens*, a species widely distributed in São Paulo State. This species was registered in 39 water bodies of São Paulo State, belonging to 14 among 22 of its Hydrographic Districts. Furthermore *C. pubescens* is relatively abundant in some of the lakes and reservoirs examined, including the Água Branca Reservoir in the North Littoral hydrographic unity in the Ubatuba District, SP. Hence, the aim of the present study was to contribute with detailed information on the life cycle traits of this ubiquitous species of the Chydoridae family, by growing the species in the laboratory, under controlled conditions.

Materials and methods

The organisms for starting cultures were collected in the littoral zone of the Água Branca Reservoir (23°50'42" S and 45° 21'18" W) in the northern coastal region of São Paulo State, Ubatuba district, Brazil, by vertical and horizontal hauls using a zooplankton net of 68mm mesh size. Samples were taken close and inside macrophyte stands in the littoral region of the reservoir. Água Branca Reservoir is a small reservoir used for the public water supply. It is surrounded by thick gallery forest, and it has thick and large macrophyte stands in the littoral region. In the laboratory, adults of *Chydorus pubescens* were isolated and placed in 2 L beakers containing 45 mm net filtered water, from

nearby ponds. This culture media had pH 7.1, conductivity 200 mS.cm⁻¹ and hardness 200 mg.L⁻¹ CaCO₃. Experimental cultures were maintained in growing chambers at constant temperature of 23.6°C (the mean temperature found in the reservoir at the time the organisms were collected) and 12 h light/12 h dark photoperiod and fed on a suspension of the small chlorophycean *Selenastrum capricornutum*, cultured in Chu 12 medium and cropped in the exponential phase, at concentration of 10⁵ cells.mL⁻¹, and 0.02mL of a mixed suspension of yeast, and fish ration added per organism (USEPA, 1994; ABNT, 2004), at equal proportion (1:1). Animals were acclimatized through approximately 10 generations (30 days). Ten egg-bearing females were isolated and kept until offspring were produced. Fifteen neonates less than 24 hours old were individually placed in 50mL flasks and placed in growth incubators under the above specified temperature, light and food conditions and accompanied for obtaining life cycle parameters.

Culture media and food suspensions were completely renewed daily with a fresh suspension at the same temperature. Once or twice a day the animals were observed under the stereomicroscope in order to determine the number of eggs produced per brood and the longevity. The body growth of each individual was measured daily under the optical microscope, using a micrometric grid and a 40X magnification.

Results

Chydorus pubescens is widely distributed in São Paulo State, Brazil, being found in 14 of the 22 Hydrographic Planning and Monitoring Districts, occurring in 39 of 219 water bodies sampled throughout the Biota study program (Fig. 1).

The main results on the life cycle of *Chydorus pubescens* are presented in Tab. 1. Neonates had a mean length of 241.58 mm, reaching maturity after 2.37 days with 339.54 mm mean size. The maximum longevity was 31 days and the mean longevity was 25.4 days. Mean embryonic development duration was 47 hours. Parthenogenetic females fecundity was always 2.0 eggs per brood and along the life cycle the mean total fecundity was 22.3 eggs per female.

The mean individual growth curve of *Chydorus pubescens* is shown in Fig. 2. The maximum size of 389.12 mm was attained after 11 days of age. The initial mean size of the neonates was 241.58 mm.

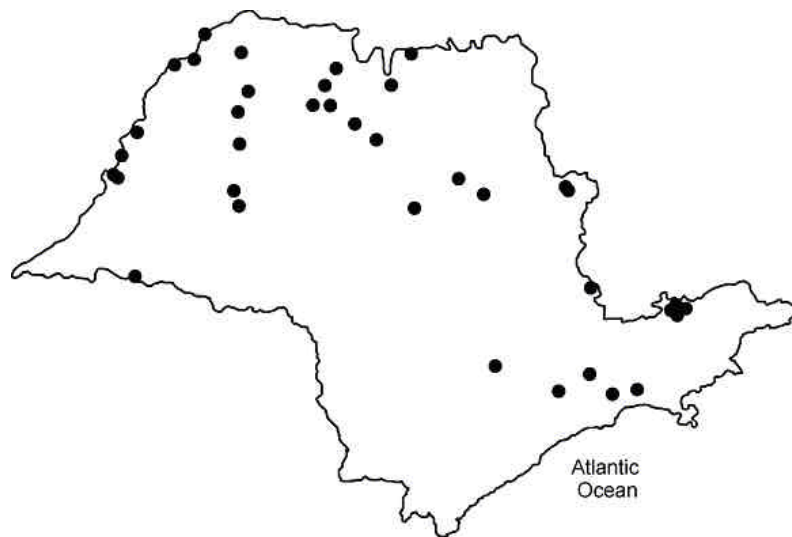


Figure 1: Distribution of *Chydorus pubescens* in 39 of 219 water bodies sampled throughout 1997-2001, in São Paulo State.

Table 1: Mean size (\pm SD) and development times of *Chydorus pubescens* (Cladocera, Chydoridae) from laboratory cultures at 23.6°C. N=15.

Maximum adult size (mm)	389.12
Neonate mean size (mm)	241.6 (\pm 17.7)
Primipara mean size (mm)	339.5 (\pm 10.5)
Minimum size of primipara (mm)	316.6
Number of instars between neonate and primipara	2
Maximum number of instars in the whole life cycle	13
Mean number of eggs in the whole life cycle	22.3 (\pm 5.1)
Mean fecundity (eggs /female/brood)	2
Maximum longevity (days)	31
Mean longevity (days)	25.4 (\pm 4.6)
Mean embryonic development time (days)	1.96 (\pm 0.18)
Primipara age (days)	2.37 (\pm 0.43)

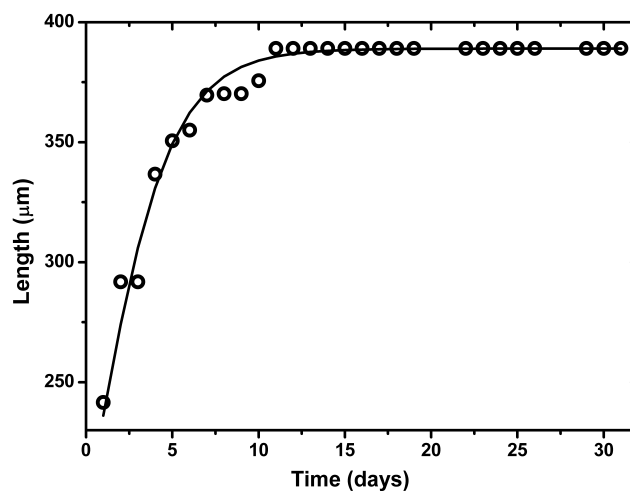


Figure 2: Mean individual growth curve of *Chydorus pubescens* (Cladocera, Chydoridae) grown in the laboratory at 23.6°C, in a 12h light and 12h dark regime, fed on a mixed suspension of *Selenastrum capricornutum* (at 10^5 cells.mL⁻¹) and 0.02mL of a mixed suspension of yeast, and fish ration added per organism, at equal proportion).

Discussion

Geographical distribution

Chydorus pubescens is widely distributed in South America. It has been recorded in several localities in Brazil, including the states of Pará, Mato Grosso, Minas Gerais, São Paulo and Rio Grande do Sul (Smirnov, 1996; Elmoor-Loureiro, 1997). In São Paulo State this species occurred in 14 of the 22 hydrographic districts, and in 39 of the 219 water bodies sampled.

Life cycle

According to Kotov (1997), the neonates of *Chydorus sphaericus*, *Eurycercus lamellatus* and *Bosmina* sp suffer a special ecdysis soon after being liberated from the mother brood pouch, which would then signal the first juvenile instar. Therefore it is probable that in the present study the

initial measurements corresponded to the first juvenile instar.

Chydorus pubescens can be considered a small species compared to other cladocerans. The mean length of its neonate (242 μm) is much less than that of *Chydorus dentifer*, which measured on average 302 μm (Melão, 1997). Similarly, the maximum size attained by *Chydorus pubescens* was 389 μm long, whereas *Chydorus dentifer* reached 494 μm (Melão 1997).

In Table II, the embryonic development duration (EDD) of several chydorids are compared. *Chydorus pubescens* had a development time slightly longer than that recorded for *Acroperus harpae* and slightly smaller than that of *Chydorus dentifer*. The development time might have been lengthened as a consequence of the lower experimental temperature in the current study, 23.6° C, compared to the 25° C for the two species with shorter EDD.

Table II: Comparison of embryonic development times and fecundity of chydorid cladocerans from the present study and reported in the literature. EDD = embryonic development duration (days), PA = primipara age (days), F = fecundity (eggs/female/brood), CF= cumulative fecundity (total numbers of eggs), L = longevity (days) and T = temperature (°C).

Species	EDD	PA	F	CF	L	T (°C)	Author
<i>Chydorus pubescens</i>	1.96	2.37	2	22.3	25.44	23.6	Present study
<i>Chydorus dentifer</i>	2.20	5.73	2		11.39	25	Melão, 1997
<i>Chydorus sphaericus</i>	3.10		2		74	20	Bottrell, 1975
<i>Acroperus harpae</i>	1.56	3.70	1.59		9.79	25	Melão, 1999
<i>Acroperus harpae</i>	3.18				74	20	Bottrell, 1975
<i>Pleuroxus uncinatus</i>	3.16		2				Bottrell, 1975
<i>Alonella excisa</i>		3.17	2	46	73.4	19 e 23	Sharma & Sharma, 1998
<i>Leydigia acanthocercoides</i>		3.00	2	20	23.2	28 e 30	Murugan & Job, 1982
<i>Leydigia ciliata</i>			2	50	46	28 e 30	Venkataraman, 1990
<i>Euryalona orientalis</i>			2	20	23.8	28 e 30	Venkataraman, 1990

Several authors have noted the strong influence of temperature and food on the development of cladocerans (Allan, 1976; Rocha, 1983; Hardy, 1989; Hardy & Duncan, 1994). For some tropical cladocerans, Hardy & Duncan (1994) found that lowering the temperature or decreasing the food concentration increased the duration of post-embryonic development times.

Chydorus pubescens primipara age was shorter than those found for *Chydorus dentifer* and *Acroperus harpae* by Melão (1999). The age at maturity of *C. pubescens* was close to that recorded for *Bosminopsis*

deitersi by Melão (1997), despite the former being a species of smaller maximum size.

In the present study two juvenile stages were recorded for *Chydorus pubescens*. According to Bottrell (1975) the number of juvenile instars varies from three to eight, among cladocerans. The number is usually constant for each species although it may increase under limiting food conditions. Kotov (1997) found 2 juvenile instars for species belonging to both Chydoridae and Bosminidae families. Sharma & Sharma (1998) reported that *Alonella excisa* has two juvenile instars. Smirnov (1974), Lynch (1980)

and Venkataraman (1990) recorded one to three juvenile instars among the species of Chydoridae and observed that this range of variation is smaller than that observed for other Cladocera families, which can have from 2 to 7 instars. Murugan & Job (1982) observed 3 juvenile instars in *Leydigia acanthocercoides* and also reported that, in addition, this species has 13 adult stages, with a total of 16 instars during the whole life cycle.

Alonella excisa, on the other hand, has 26 adult instars making a total of 28 developmental instars. Smirnov (1974) pointed out that the maximum number of instars already recorded for Chydoridae was 49. In the present study, the maximum number of instars recorded for *Chydorus pubescens* was 13, probably an intrinsic characteristic of the species.

Mean longevity of *Chydorus pubescens* was 25.4 days. For *Leydigia acanthocercoides*, Murugan & Job (1982) recorded a mean longevity value of 23.2 whereas for *Euryalona orientalis* Venkataraman (1990) found 23.8 days, at a higher temperature range (28 to 30 °C). According to Smirnov (1974), the length of Chydoridae life cycles can vary from 5 to 94 days and according to Lynch (1980) from 24 to 42 days.

The mean fecundity of *Chydorus pubescens* was 2 eggs/female/brood, equal to the value reported by several authors (Sharma & Sharma, 1998; Murugan & Job, 1982; Melão, 1999) for other species of Chydoridae. This parameter seems to be less variable among the species. Regarding Cladocera life histories, there is an agreement among authors that the last instars stop producing eggs, and this was also observed for *Chydorus pubescens* in the present study.

It appears, therefore, that the life cycle parameters found for *Chydorus pubescens* in the present study closely followed the pattern reported for other members of the Chydoridae family at similar temperatures and food levels.

Acknowledgements

To FAPESP (São Paulo State Research Aid Foundation) for the financial support. This paper is a result of the Subproject "Zooplankton diversity and the state of degradation of São Paulo State freshwaters,

part of the Biota/FAPESP Program – The Institute of Virtual Biodiversity (www.biotasp.org.br).

References

- Associação Brasileira de Normas Técnicas – ABNT. 2004. NBR 12713: Ecotoxicologia aquática – toxicidade aguda – método de ensaio com *Daphnia* spp (Cladocera, Crustacea). Rio de Janeiro. 21p.
- Allan, J.D. 1976 Life history patterns in zooplankton. *Am. Nat.*, 110:165-180.
- Bottrell, H.H. 1975. Generation time, length of life, instar duration and frequency of moulting, and their relationship to temperature in eight species of Cladocera from the River Thames, Reading. *Oecologia*, 19:129-140.
- Elmoor-Loureiro, L.M.A. 1997. Manual de identificação de cladóceros límnicos do Brasil. Universa, Brasília. 156p.
- Hardy, E.R. 1989. Effect of temperature, food concentration and turbidity on life cycle characteristics of planktonic cladocerans in a tropical lake, Central Amazon: field and experimental work. London, Royal and Bedford New College, 337p (Thesis).
- Hardy, E.R. & Duncan, A. 1994. Food concentration and temperature effects on life cycle characteristics of tropical Cladocera (*Daphnia gessneri* Herbst, *Diaphanosoma sarsi* Richard, *Moina reticulata* Daday): I. Development time. *Acta Amazônica*, 24:119-134.
- Kotov, A.A. 1997. A special moult after the release of the embryo from the brood pouch of Anomopoda (Branchiopoda, Crustacea): a return to an old question. *Hydrobiologia*, 354:83-87.
- Lynch, M. 1980. The evolution of cladoceran life histories. *Q. Rev. Biol.*, 55:23-42.
- Melão, M.G. 1997. A comunidade planctônica (fitoplâncton e zooplâncton) e produtividade secundária do zooplâncton de um reservatório oligotrófico. São Carlos, UFSCar, 147p (Thesis).
- Melão, M.G. 1999. Desenvolvimento e aspectos reprodutivos de cladóceros e copépodos de águas continentais brasileiras. In: Pompêo, M.L.M. *Perspectivas da Limnologia no Brasil*. Gráfica e Editora União, São Luis. p.45-58.
- Murugan, N. & Job, S.V. 1982. Laboratory studies on the life cycle *Leydigia acanthocercoides* Fisher (1854) (Cladocera: Chydoridae). *Hydrobiologia*, 89:9-16.

- Robertson, A.L. 1988. Life histories of some species of Chydoridae (Cladocera: Crustacea). *Freshwater Biol.*, 9:75-84.
- Rocha, O. 1983. The influence of food-temperature combinations on the duration of development, body size, growth and fecundity of *Daphnia* species. London, University of London, 337p (PhD Thesis).
- Shan, R.K. 1969. Life cycle of a chydorid cladoceran. *Pleuroxus denticulatus* Birge. *Hydrobiologia*, 34:513-523.
- Sharma, S. & Sharma, B.K. 1998. Observations on the longevity, instar durations, fecundity and growth in *Alonella excisa* (Fisher) (Cladocera, Chydoridae). *Indian J. Anim. Sci.*, 68:101-104.
- Smirnov, N. 1974. Chydoridae fauna USSR. Zoological Institute Academy Nauk, Leningrad. 664p.
- Smirnov, N.N. 1996. Cladocera: the chydorinae and sayciinae (chydoridae) of the world. Guides to the identification of the microinvertebrates of the continental waters of the world. SPB Academic Publishing, Netherlands. 197p.
- Usepa - United States Environmental Protection Agency. 1994. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates. Report EPA 600/R-94/024. United States Environmental Protection Agency, Duluth. 133p.
- Venkataraman, K. 1990. Life-history studies on some cladoceran under laboratory conditions. *J. And. Sci. Assoc.*, 6:127-132.

Received: 04 January 2006
Accepted: 31 October 2006