Preliminary data on larval development of Caucasian cave-dwelling shrimp Troglocaris (Xiphocaridinella) kumistavi Marin, 2017 (Crustacea: Decapoda: Atyidae)

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ABSTRACT. Up to date, any characteristics of the development of stygobiotic Troglocaris shrimp larvae remained unknown. The article briefly describes the first case of finding of ovigerous females, larval development and the use of yolk lipid in larval nutrition of Caucasian cave-dwelling shrimp Troglocaris (Xiphocaridinella) kumistavi Marin, 2017 (Crustacea: Decapoda: Atyidae). Troglocaris larvae are planktonic and lecithotrophic, able to develop using the expense of egg yolk exclusively, without feeding. This trait allows shrimp of the genus Troglocaris completing metamorphosis in oligotrophic planktonless cave water reservoirs during the low water period, thus shrimp larvae are not washed away; however, alochtonic organics do not enter into caves during this period as well. Characteristics of larval development of T. kumistavi also make it possible to understand that these cave shrimps can reproduce only in large stable water reservoirs (underground lakes), and therefore spend much of the life cycle there, than in rivers or streams.

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Introduction

Limitation and irregular supply of food is a major driving force for the evolution of cave animals [Vandel, 1965; Barr, 1968]. Subterranean animals, including shrimps, fishes and salamanders, are able to live without food for long periods, up to several years.
According to the energy-economy hypothesis, the adaptation of subterranean animals to low energy includes a reduction in pigments and eyes, infrequent reproduction, small brood size, reduced metabolism and growth rates, and increased longevity [Poulson, White, 1969; Howarth, 1983]. Most of specialized animals possess specific metabolism and organs storing food and resources. The crustacean hepatopancreas is the primary site for lipid metabolism and organs storing food and resources. The longevity [Poulson, White, 1969; Howarth, 1983].

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Material and methods

Shrimps were collected in subterranean cave streams and lakes in Kumistavi Cave, Tskaltubo-Kumistavi (42°22′35.8″N 42°36′03.2″E) by hand net in February 2016 that represent the period of larva hatching clearly correlated with the low water in cave reservoirs occurred in winter season, from December to March. The period in the winter season differs from the summer season (June–September) by a lower level of karst water in the cave. Collected ovigerous females were transported to the lab in the Moscow State University where 4 planktonic larvae successfully hatched. After hatching, all larvae were removed to a separate clean water 1-liter tank, and were photographed alive each 2 days and then fixed in 90% ethanol for further morphological analysis. Fixed larvae are deposited in the collection of A.N. Sverzov Institute of Ecology and Evolution of Russian Academy of Sciences, Moscow, Russia (LEMMI). Species names and modern taxonomic position are given according to the international database WoRMS (World Register of Marine Species) and Marine Species Identification Portal. The study does not include endangered or protected species.

Results and discussion

Only 4 larvae were successfully reared and hatched under the temperature about 20–21 °C in the water tank. It was impossible to assess the number of zoal stages and examine zoal morphology in details because we tried to keep all larvae alive. Detailed morphological description of larval stages will be the aim of our further study. However, it is possible to describe the development of T. kumistavi larvae as complete, but abbreviated and accelerated. Preliminary, we conclude that T. kumistavi possess 4 or 5 zoal stage in their development showed in Figs 1, 2. At the same time, no exuviae were found in the tank where larvae of Troglocaris stayed during the study as well as it was impossible to select exact molting stages in their development. It is possible that the remains of the exuviae were eaten by larvae very quickly, before they were seen. Studied Troglocaris larvae possessed with thin soft (membranous) cuticle and, possibly, were able to grow appendages without molting. Non-feeding larvae are deprived of the opportunity to replenish the food resources and the absence of molting as well as the discharge of the exuvium seems to be a very valuable feature of their development and an excellent adaptation to the underground way of life. Freshly hatched larvae possessed with partly developed pereiopods and developed pleopods (Fig. 2a, b) used for swimming and skipping. They actively swam with tail fun up, they were not reacting to lighting (any phototaxis (positive or negative) was not detected) and did not show indication of feeding. Most of time of observation larvae moved randomly. Morphology of zoal stage I (Fig. 2a, b) is similar to the “abbreviated metamorphosis.
Preliminary data on larval development of *Troglocaris (Xiphocaridinella) kumistavi* Marin, 2017:

**Fig. 1.** Larval development of *Troglocaris (Xiphocaridinella) kumistavi* Marin, 2017: *a, b, e* — 2 days after hatching; *c, d* — 4 days after hatching.

Рис. 1. Личиночное развитие *Troglocaris (Xiphocaridinella) kumistavi* Marin, 2017: *a, b, e* — 2 дня после выхода из яйцевых оболочек; *c, d* — 4 после выхода из яйцевых оболочек.
Fig. 2. Larval development of *Troglocaris* (*Xiphocaridinella*) *kumistavi* Marin, 2017: *a–c* — 6 days after hatching; *d, e* — 8 days after hatching.

Рис. 2. Личиночное развитие *Troglocaris* (*Xiphocaridinella*) *kumistavi* Marin, 2017: *а–с* — 6 после выхода из яйцевых оболочек; 
*д, е* — 8 дней после выхода из яйцевых оболочек.
type” reported by Glaister [1976]. Although abbrevi- ated or direct development is described for larvae of Atyidae (for example, *Caridina singhalensis* (Benzi, De Silva, 1983) and could be suggested for cave-dwell- ing representatives of the family. The reduction in the number of moults and shortened larval life is probably characteristic for *Troglocaris*. In our experiment the water temperature was higher than in cave water reservoir (about 12–14 °C) and we are unable to make such conclusion as the influence of temperature is clearly correlated with the time duration of each stage of cold water shrimps [Knowlton, 1974; Criales, Anger, 1986; Schultz, Anger, 1997]. Anyway, after just 8 days our larvae metamorphosed to fully functional postlarvae settled to the bottom of the tank (Fig. 2d, e). A visual decrease of yolk deposits was observed during the period of the development (Figs. 1, 2) indicating this to be the only feeding resource of larvae. At the same time, such lipid yolk reserves are absent in adult *Troglocaris* shrimps, having only olespheres in hepato- pancreas. Larvae of hydrothermal vent shrimps of the genus *Rimicaris* Williams et Rona, 1986 (Crustacea: Decapoda: Alvinocarididae) [Pond et al., 1997] were also found to be rich in lipids absent in the adults. Pond et al. [1997] postulated that these lipid reserves were an adaptation to prolong the larval life need to find new biotopes or to survive unfavorable natural conditions.

Shokita [1981] and Hayashi & Hamano [1984] suggested to divide all representatives of the family Atyidae into three groups based on egg size including the species with “small egg” species generally exhibiting extended development and “large egg” species exhibiting abbreviated or direct development. Moreover, species with direct development usually spend their entire life cycle in upland streams while extended larval de- velopers tend to utilize marine or estuarine environ- mental resources for larval development [Walsh, 1993]. According to our preliminary investigation, *T. kumistavi* spending all lifecycle in closed freshwater cave reservoirs is referred to species with large lecitotrophic eggs (see Marín, 2017) and relatively small broods but pos- sessioning, on the other hand, relatively large planktonic larvae with 4–5 abbreviated stages characteristic for other representatives of the family Atyidae (see exam- ples in Walsh, 1993). Probably, large yolk lipid larval reserves allow larvae to complete metamorphosis into benthic post-larva without feeding on planktonic or- ganisms or suspended organic matter absent or highly deficient in cave reservoirs. Such combination of these two features of larval development and correlation of hatching time with the lowest water level additionally characterizes *Troglocaris* as relict estuarine or brack- ish water dwellers highly adapted to troglobiotic life- style in the hypogean aquatic habitats with slow or zero flow. It is very likely, that shrimps require subterra- nean water bodies with permanent and non-flowing water reservoirs for reproduction and larval develop- ment. Their finding in subterranean rivers or streams is evidently the result of their export/washing out from such permanent underground reservoirs (lakes).

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References

Barr T.C., Jr. 1968. Cave ecology and the evolution of troglobites // Evolutionary Biology. Vol.2. P.35–102.

Benzie J.A.H., De Silva P.K. 1983. The abbreviated larval development of *Caridina singhalensis* Ortmann, 1894 (Decapoda: Atyidae) endemic to Sri Lanka // Journal of Crustacean Biolo- py. Vol.3. P.117–126.

Chang E.S., O’Conner J.D. 1983. Metabolism and transport of carbohydrates and lipids // Mantel L.H. (ed.). The biology of Crustacea. Academic Press, New York. Vol.5. P.263–287.

Gibson R., Barker P.L. 1979. The decapod hepatopancreas — *Oceanography* and Marine Biology — An Annual Review. Vol.17. P.285–316.

Criales M.M., Anger K. 1986. Experimental studies on the larval development of the shrimps *Crangon crangon* and *C. allman- ni* // Helgoland Meeressuntersuchungen. Vol.40. P.241–265.

Glaister J.P. 1976. Postembryonic growth and development of *Caridina niloticus arnensis* Roux (Decapoda: Atyidae) reared in the laboratory // Australian Journal of Marine and Freshwater Research. Vol.27. P.263–278.

Hayashi K.I., Hamano T. 1984. The complete larval development of *Caridina japonica* De Man (Decapoda, Caridea, Atyidae) reared in the laboratory // Zoological Science. Vol.1. P.571–589.

Howarth F.G. 1983. Ecology of cave arthropods // Annual Review of Entomology. Vol.28. P.365–389.

Hüppop K. 1985. The role of metabolism in the evolution of cave animals // NSS Bulletin. Vol.47. P.136–146.

Juberthie-Jupeau L. 1969. Reproduction et mue chex les Decapo- des souterrains duc genre *Troglocaris* Dormitzer, 1853 // Fifth congres internationaler du speleologie, Stuttgart. P.B32.–B32.2.

Jugovic J., Praprotnik E., Buzan E.V., Lužnik M. 2015. Estimating factors in decapod Crustacea, with emphasis on Caridea // Animal Biodiversity and Conservation. Vol.38. No.1. P.77–86.

Knowlton R.E. 1974. Larval developmental processes and control- ling factors in decapod Crustacea, with emphasis on Caridea // *Thalassia Jugoslavica*. Vol.10. P.139–156.

Mali J.N. 2013. [Atlas of Decapod Crustaceans of Russia], Moscow: KMK Scientific Press. 145 p. [in Russian with English abstract].

Marin I. 2017. *Troglocaris* (*Xiphocaridinella*) kumistavi sp. nov., a new species of stygiobiotic atyid shrimp (*Crustacea: Decapoda: Atyidae*) from Kumstavi Cave, Imereti, Western Georgia, Caucasus // Zootaxa. Vol.4311. No.4.P.576–588.

Marin I., Sokolova A. 2014. Redescription of the stygiobiotic shrimp *Troglocaris* (*Xiphocaridinella*) jushaschjanii Brištien, 1948 (Decapoda: Caridea: Atyidae) from Agura River, Sochi, Russia, with remarks on other representatives of the genus from Caucasus // Zootaxa. Vol.3754. No.3. P.277–298.

Matjasic J. 1958. Postembriornalni razvoj jamske kozice *Troglo- caris* // Biološki vestnik.Vol.6. P.76–92.

Morgan S.G., Christy J.H. 1995. Adaptive significance of the tim- ing of larval release by crabs // *American Naturalist*. Vol.145. P.457–479.

Pond D., Dixon D., Sargent J. 1997. Wax-ester reserves facilitate metamorphosis of larval *Rimicaris* // Helgolander Meeresuntersuchungen. Vol.40. P.241–265.

Poulson T.L., White W.B. 1969. The cave environment // *Science*. Vol.165. P.971–981.
Schultze K., Anger K. 1997. Larval growth patterns in the aesop shrimp *Pandalus montagu* // Journal of Crustacean Biology. Vol.17. P.472–479.

Shokita S. 1981. Life-history of the family Atyidae (Decapoda, Caridea) // Aquabiology. Vol.12. P.15–23.

Vandel A. 1965. Biospeleology: the Biology of Cavernicolous Animals. Oxford: Pergamon Press. 524p.

Vogt G., Strus J. 1992. Oleospheres of the cave-dwelling shrimp *Troglocaris schmidtii*: a unique mode of extracellular lipid storage // Journal of Morphology. Vol.211. P.31–39.

Vogt G., Strus J. 1999. Hypogean life-style fuelled by oil // Naturwissenschaften. Vol.86. P.43–45.

Walsh C.J. 1993. Larval Development of *Paratya australiensis* Kemp, 1917 (Decapoda: Caridea: Atyidae), Reared in the Laboratory, with Comparisons of Fecundity and Egg and Larval Size between Estuarine and Riverine Environments // Journal of Crustacean Biology. Vol.13. No.3. P.456–480.

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