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Light perception in Beroidae ctenophores: evidence from laboratory experiments and genomics data

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Motivation and Aim: Ctenophores are the basal Metazoa branch in which the evolution of the mechanisms of animals' light perception could be realized for the first time [2, 3]. However, there is a little bit of evidence about any aspects of light perception in ctenophores. Ctenophore behavioral responses to light were not known until recently, although photoreceptor-like structures have been described previously in several species. We have shown early that adult ctenophores *Mnemiopsis leidyi* respond to a sharp illumination change with a short-term increase in speed of movement [1]. Molecular aspects of light reception were studied on the same lobate ctenophore. In the *M. leidyi* genome, three opsin genes have been identified [2], two of them can be assigned to the group of ciliary opsins with ahigh confidence [3]. Here, we present the first experimental results on *Beroe ovata* response to high-intensity light exposure, as well as an analysis of the available transcriptomic data aimed to identify genes responsible for light perception in Beroidae.
Methods and Algorithms: Adult *Beroe ovata* were collected from the Black Sea nearshore waters (Martynova Bay, Sevastopol) in August 2021. Animals were placed in laboratory aquariums and the video recording of their behavioral responses to point illumination of various parts of their body (aboral organ, cten, and lobes) with lasers of violet, green, and red spectra was carried out. Video processing and analysis was conducted using Davinci Resolve video editor, ImageJ image analysis program with wrMTrck_Batch plug-in, and CtenophoraTrack data analysis program.
The search for protein sequences that may relate to photoreception was performed based on the analysis of transcriptomes of four Beroidae species available at NCBI: *Beroe forskalii* /USA: South Carolina/ (SRA: SRR6074515); *Beroe ovata* /USA: South Carolina/ (SRR6074516), *Beroe sp.* UF-2017 /Australia: Moreton Bay, Queensland/ (SRR5892577), *Beroe sp.* UF-2017 / Antartica: Weddell Sea/ (SRR5892576), as well as own transcriptome data on *Beroe ovata* /Russia: Sevastopol/. Data pre-preprocessing, de novo transcriptome assembling, prediction of protein sequences, and automatic annotation were carried out using the following programs: fastP v0.23.2, Trinity v2.13.2, TransDecoder v5.5.0, BLAST v.2.12.0, HMMER 3.2.1. SwisProt (11/17/2021) and Pfam-A (11/15/2021) Databases are used for annotation, as well as the Opsin database formed on the basis of SwisProt and TrEMBL
Results: After illumination of the adult *B. ovata* aboral organ with a violet spectrum laser pronounced behavioral responses were observed. Within 1-5 sec after the starting of exposure, the ctenophores shrink the body and entrails near the statocyst and begin to move from the laser beam (at a speed of about 3 mm/s) rotating the body so that the laser does not hit the aboral organ. No pronounced reactions of *B. ovata* to high-intensity light

exposure on their ctenes and lobes were found. The reactions of ctenophores to red laser were less pronounced than the response to violet light exposure.
We have identified protein sequences that are highly homologous to proteins of the opsin family in the transcriptomes of all considered species. The best homology rates corresponded to the Opsin 1 and Opsin 3 of M. leidyi and Pleurobrachia bachei ctenophores (more than 65 % identity with > 90 % coverage), as well as vertebrate Opsin 5 sequences (more than 40 % identity with > 70 % coverage). Based on it, we searched for loci in the genomes of *Beroe forskalii* (GCA_011033025.1) and *Beroe ovata* (GCA_900239995.1) containing the found protein-coding sequences.
Conclusion: Ctenophores have the ability to photoreception. The response of *Beroe ovata* to high-intensity violet light radiation is observed with a point impact on the aboral organ. Other parts of the ctenophores body are not sensitive to exposure to high-intensity light. Genes sequences that can respond to the photoreception in Beroidae have been obtained.
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References

1. Baiandina Iu.S. et al. Black Sea *Mnemiopsis leidyi* (Ctenophora) adult locomotion and light-induced behavior in laboratory experiments. *J Sea Res.* 2022;180:102152. doi: 10.1016/j.seares.2021.102152.
2. Schnitzler C.E. et al. Genomic organization, evolution, and expression of photoprotein and opsin genes in *Mnemiopsis leidyi*: a new view of ctenophore photocytes. *BMC Biol*. 2012;10:107. doi: 10.1186/1741-7007-10-107.
3. Fleming J.F. et al. Approach to investigate the effect of tree reconstruction artifacts in single-gene analysis clarifies opsin evolution in nonbilaterian Metazoans. *Genome Biol. Evol.* 2020;12(2):3906-3916. doi: 10.1093/gbe/evaa015.