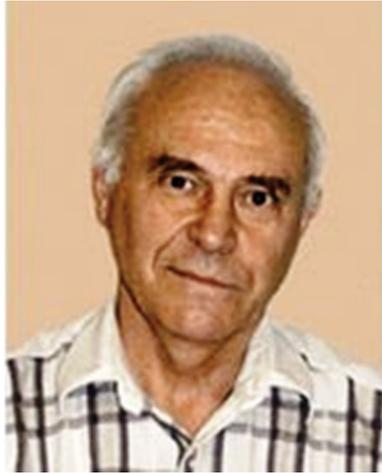


## LETTER TO THE EDITOR

## In memory of Lev Mukhametov



A renowned Russian biologist and neurophysiologist Lev M. Mukhametov (19.05.1938–18.06.2021) passed away. Early in his career, while working in Italy, he published several studies on neural activity during the sleep-wake cycle in cats, which later became classical, earning respect and admiration of his colleagues both in Soviet Union and abroad. In the 70–80s of the last century, Lev Mukhametov led studies at the Severstov Institute, Russian Academy of Sciences, which resulted in the discovery of a previously unknown phenomenon of alternating uni-hemispheric sleep in dolphins. This was the largest scientific contribution of Russian somnology in the 2nd half of the XX century, as it provided key empirical evidence for the influential theory of “local sleep”. Several researchers who worked with Lev Mukhametov at different times over the last 50 years shared their memories from their collaboration and friendship with this outstanding sleep researcher and marine mammal biologist.

*Giacomo Rizzolatti, Professor of Human Physiology, University of Parma, Italy*

I met Lev last time in Moscow in July 2019. He was in excellent shape, in good mood and full of energy as ever. His death arrived, therefore, to me as a shock. Lev was one of my best friends. We had that type of friendship that arises only when you become friends early in your life. It is a special link that does not change with time.

Lev arrived in Parma in 1967. It was a gift of Prof. G. Moruzzi. I was starting my lab in Parma University and I needed help. Moruzzi spoke with Lev and told him that in Parma there was one of his former pupils, who also spoke Russian, and suggested that he joined me, instead of going to Pisa. Lev accepted and it was a great success. In a short time we set up the lab and recorded single neuron activity

in unanesthetized freely moving cats. We described the single neuron activity pattern of the lateral geniculate body and the *nucleus reticularis thalami* in wakefulness, in slow sleep and in REM sleep. Subsequently Lev was able to build a lens with a mini-lamp inserted that we placed in the cat's eye. In this way we were able to describe the responsiveness of the visual system in the different phases of sleep and wakefulness. It was a very good period for our careers. In fact our collaboration resulted in several articles published in the most prestigious international journals.

At the end of the 1960s, my wife, for work reasons, was compelled to remain in Pisa. Thus, both Lev and I lived in the Istituto di Fisiologia of Parma University. In the morning after breakfast, we started our experiments in the same place where we lived. No time lost for transportation. The experiments were very long, from morning to night. Fortunately cats like to sleep. Occasionally we went to the movies. I also remember pleasant evenings in the Parco Ducale, the largest park of Parma, where we saw, projected on a large screen, the European Football Championship matches.

We worked very hard, but we also travelled, mostly for work. We went several times to Pisa, to tell Moruzzi our results, to Milan to discuss our data with Emilio Bizzi, who was there at that time, to Rome, and also to Udine, my home town, where Lev was invited to the marriage of my sister Tania. Lev was already part of my family.

Lev was a very talented exceptionally skillful scientist. His later studies on the sleep of dolphins and other aquatic mammals are outstanding studies, fundamental in that field. He was also a very practical scientist. He was able to survive the difficult transition period from Soviet regime to present time, when there was no money for research. His stories on how he survived that time with his dolphins were full of humour. They also showed his exceptional organization capacities, beside his scientific talent. It seems to me impossible that next time I will be in Moscow, he will not be there.

*Vladimir M. Kovalzon, principal researcher of A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russia*

Lev Mukhametovich Mukhametov was a real nugget with rare scientific and organizational skills. His keen mind penetrated into the investigated object, illuminating, like a ray of light, its internal laws. His enthusiasm and energy knew no limits. At one time, while in Cuba, together with the director of the Institute, academician Vladimir E. Sokolov, he successfully operated on a Caribbean manatee in water, an animal he had never seen before, implanted electrodes and recorded over 24 hr the electrical activity of the brain using a long cable and a small writing instrument for this animal swimming in the pool. Prof. Sokolov was so amazed that soon after that he made Lev

Mukhametov his deputy. In this position, Lev stayed for many years, but it weighed him down, and he left this post at the first opportunity. Like the hero of the famous movie by Bob Fosse "All that jazz", he loved life and did not want to die, but he could not bring himself to lead the measured lifestyle of an armchair scientist or a common man in the street. Lev Mukhametov is a world-famous neurophysiologist and somnologist, the pride of our Institute, and grieving over his departure, we can only say: *sic transit gloria mundi*...

*Jerome M. Siegel, Professor of Psychiatry, University of California Los Angeles (UCLA), and Director of Center for Sleep Research, USA*

Dr Mukhametov's pioneering studies of marine mammals brought fundamental insights into the function of sleep and particularly the role of REM or paradoxical sleep. For his studies of sleep in the dolphin he pioneered the development of minimally invasive implants that allowed EEG recording without large incisions. His love of "everything connected with marine mammals" led to him creating dolphinariums across Russia, to spread his appreciation of these unique animals. He pioneered studies of bottlenose dolphins, gray whales, white whales and fur seals, leading to important insights into the evolution and function of sleep. He was incredibly welcoming and warmly supportive of collaboration with me in the later portions of this work, and for this I will be eternally grateful. He will be greatly missed.

*Oleg I. Lyamin, researcher of A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russia and Center for Sleep Research, University of California Los Angeles (UCLA), USA*

I met Lev Mukhametov in 1982 after graduating from Moscow State University. In the same year, I became a member of his research group and quickly ended up at the Utrish Marine Station of A.N. Severtsov Institute of Ecology and Evolution located at the coast of the Black Sea near the city of Novorossiysk (Russia). The station was founded in 1974 to study marine mammals, and Lev Mukhametov was at the forefront. He supervised the development of the station up until his last few years, and was a quintessential part of "life at the station" in all its many aspects. I am sure that "Utrish" (as we called the station) with its special atmosphere (particularly in the 80s of the last century) would be completely different without him. The study of sleep in marine mammals was one of the priorities in Utrish from the very beginning. Lev Mukhametov initiated, directed and supervised these studies for many years. Together with his colleagues, he discovered uni-hemispheric sleep in dolphins, and then proceeded to study sleep and its different features in more than 10 species of aquatic mammals, including cetaceans, pinnipeds, manatees and sea otters.

In 1984, Lev Mukhametov founded Utrish Dolphinarium Ltd, with the idea that a portion of the profit from commercial activity would help fund scientific research on marine mammals. This model

worked successfully for many years. Lev Mukhametov financed (fully or partially) the capture and maintenance of animals for scientific research, the construction of laboratories and living quarters at the station, and expeditions and trips to research conferences.

Lev Mukhametov was the supervisor of my PhD dissertation. Under his guidance, I conducted my first studies of sleep in northern fur seals. Together we travelled to Peru to study sleep in manatees and sea lions, which was my first trip abroad and it remains the most memorable. On his recommendation, I underwent fellowships in the laboratories of Prof. Giacomo Rizzolatti and Alexander Borbély. Thanks to Lev Mukhametov, I met Jerome Siegel and we launched a new phase in sleep studies in Utrish. Together, Lev and I have written over 40 papers on sleep in aquatic mammals.

Lev Mukhametov was not an ordinary person. He was irreconcilable in defending his scientific views. At times, it was challenging to work with him, but we always reached an agreement in the end. He was also a decent and generous person. Lev lived humbly and was always prepared to offer his help to those who were in need.

The last years have been difficult for Lev and his family. He was not involved in scientific activity as much as before while he tried to follow research on marine mammals. He rarely visited Utrish. The last time we spoke was on his birthday, a month before his death. He was in a good mood and continued to make absolutely incredible plans for new research and travel throughout our conversation. He sounded as if he was planning to live forever...

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**How to cite this article:** Kovalzon, V. M., & Lyamin, O. I. (2022). In memory of Lev Mukhametov. *Journal of Sleep Research*, 31, e13470. <https://doi.org/10.1111/jsr.13470>