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WAR OF CHROMOSOMES AND CLONES: NOVEL TRAITS ARE GENERATED EVEN BY GENE LOSS

Changing the number or gene content of chromosomes in an organism is assumed to have grave, often fatal, consequences. However, scientists from the Institute of Animal Physiology and Genetics CAS have discovered that some animals do not mind such changes, but instead, they benefit from them by developing novel traits. Thanks to a unique study of asexual reproduction in loaches, experts have described the evolutionary processes of intracellular gene conflict leading to the emergence of new species that are successful in changing environments.

Their results may be of considerable importance, for example, in applied agriculture, where hybrids and higher gene copy numbers are used to achieve higher yields.

A typical animal's genetic makeup should always contain two variants of each gene passed on to it by both parents. Yet, in reality, the genomes of most organisms and humans have undergone multiple cycles of chromosome duplication and loss of chromosome sections or even entire chromosomes as well as hybridisation with other organisms. However, how such events occur and what they entail, remains unclear.

Scientists from the Institute of Animal Physiology and Genetics CAS studied the relations among the portions of an organism's genome of three fish species. *"Our work demonstrates that as soon as the genomes of different species come together in one hybrid organism, their chromosomes start to fight each other both at the level of mutual gene regulation, by turning particular genes on and off, as well as at the level of mutual destruction and deletion of DNA fragments in individual chromosomes,"* says the research team leader, Karel Janko, describing the study results.

Fierce intracellular gene wars can generate novel traits

However, gene activity is under very tight cellular control, so such changes often have fatal consequences. One such example is the duplication of human chromosome 21, which causes Down syndrome. *"By reading the genome of several loach clones, we were able to identify which genes are active and in how many copies. By comparing the behaviour of individual clonal lines in nature, we were then able to observe how these genome changes affect the traits of the whole organism,"* Karel Janko explains the role of genomic conflicts.

"Quite surprisingly, we found out that particular gene losses are capable of generating novel beneficial traits that lead to the emergence of new, successful populations as well as entire species. Moreover, we have discovered that the more gene copies an organism has, the more tolerant it is to partial losses of individual chromosomes," adds the scientist.

Loaches - by creating clones they serve as an ideal model for evolutionary studies

Such findings are generally difficult to make on well-known model organisms such as mice, nematodes or fruit flies. That is because if their genomes have in fact undergone similar processes, it happened in the distant past, and therefore it is not entirely clear which of their traits are the direct result of hybridisation and genome duplication, and which have evolved gradually over time.

In the Laboratory of Fish Genetics of the Institute of Animal Physiology and Genetics CAS, scientists have long been studying the alternative reproductive strategies in fish. An absolutely unique model group is made up of *Cobitis* loaches, small fish that live buried in sand all over Europe.

"Thanks to their unique ability to reproduce clonally, i.e. asexually and without the associated shuffling of maternal and paternal genetic material, they reproduce in identical copies, which makes it much easier to study them, since all the offspring are the same. Moreover, these clones have been generated by hybridisation of several original species only recently, so their genome rearrangements are easily identifiable. We are thus able to observe their genome evolution processes between generations," Karel Janko explains the importance of such a method of reproduction in loaches.

These inconspicuous fish, or rather their individual species with their hybrids and clonal lineages, represent a completely unique and diverse natural laboratory for the study and understanding of evolutionary processes.

"Our discovery is crucial in that it partly explains why some organisms are so sensitive to intragenomic rearrangements, while others are utterly indifferent and even turn the losses of fragments of their own genetic material into an advantage for survival in changing environment. In practice, these traits may prove to be of utmost importance especially for the applied agricultural disciplines, where it is fairly common to use hybrids and higher gene copy numbers to achieve better traits and higher yields," says Karel Janko, describing the exploitation of work results.

The study was carried out in collaboration with colleagues from the Wroclaw Museum of Natural History, the Institute of Experimental Botany of the Czech Academy of Sciences, University of Ostrava, University of South Bohemia, VSB - Technical University of Ostrava and the Czech University of Life Sciences.

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We offer the media the option to film at the loach breeding facilities and in the laboratories of IAPG CAS in Liběchov.

Photo gallery:

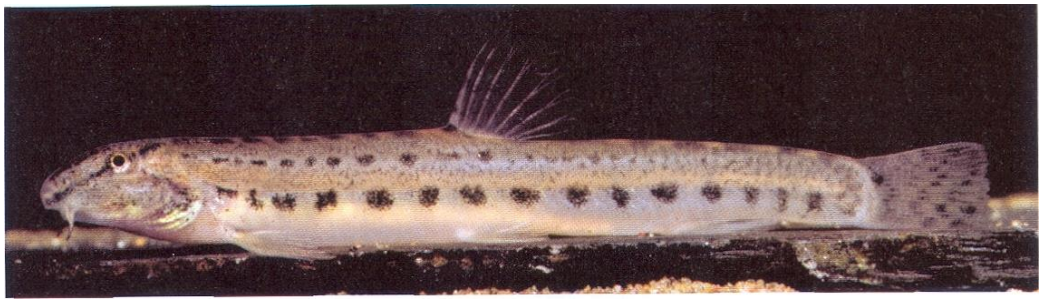

Fig. 1. Spined loach - an ideal model for the study of asexual reproduction Photo: IAPG archive.

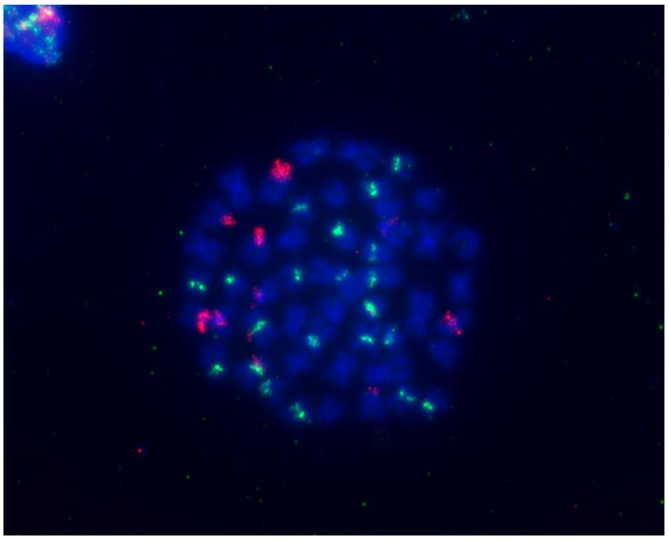

Fig. 2: Colour coding of the origin of paternal (green probe) and maternal (pink probe) chromosomes in a hybrid loach cell using DNA-specific probes. Photo: A. Marta.

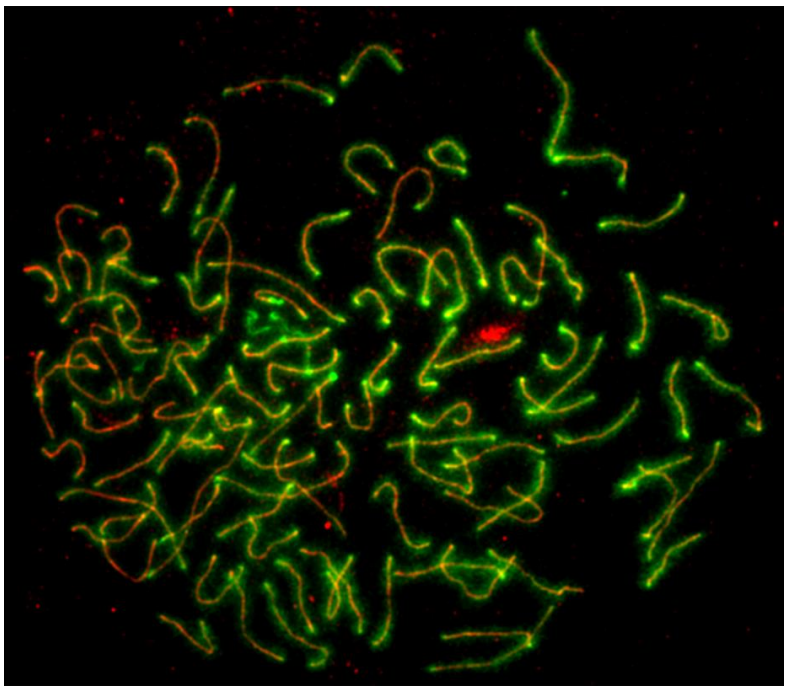

Fig. 3: Cytogenetic evidence that chromosomes pair also in the gametes of a clonal individual (red probe indicates the protein bridges between pairs of identical chromosomes). Photo: A. Marta.

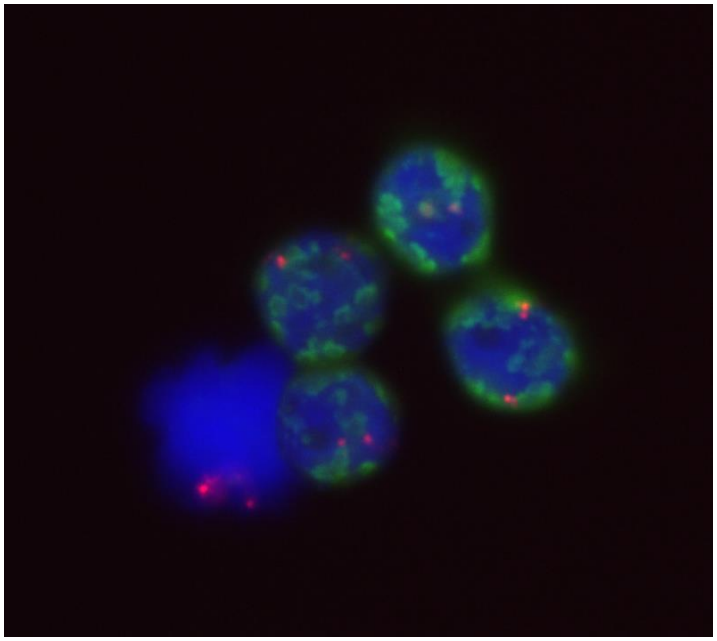

Fig. 4: Chromosomes of different origin are located in different places in the nuclei of hybrid germ cells. Photo: A. Marta.