Research on “anomaly P” syndrome

In the 1950s, famous French writer and biologist **Jean Rostand** (1894-1977) discovered morphological anomalies of an unknown etiology in water frogs of the genus *Pelophylax*, which he named “**Anomalie P**”. The anomaly P is the morphological deformations of water frogs that have light and severe forms of manifestation.

The **light** form of the anomaly is symmetrical polydactyly. Specimens suffering from **severe** forms of the anomaly have symmetrical brachymely, polydactyly, hind limb edema, bone outgrowths, spikes, flexions, and additional limbs in the inguinal region.

The Rostand’s anomaly P, in comparison with deformities caused by trematode *Ribeiroia ondatrae*, had no additional full limbs and can have small autopod elements in inguinal regions only. The most important difference is **symmetry** of bilateral traits: number of structures and their shapes usually same on both sides of the body.

The study of anomaly P was discontinued after Jean Rostand and did not resume for almost **50 years**. In 2016, we found first severe cases of anomaly P in the Khopyor River drainage (Central Russia). And two years later we described new localities from Russia where severe cases of anomaly P was observed in two species of western Palearctic water frogs.

Svinin A.O., Bashinskiy I.V., Litvinchuk S.N., Neymark L.A., Osipov V.V., Katsman E.A., Ermakov O.A., Ivanov A.Y., Vedernikov A.A., Drobot G.P., and Dubois A. First record of the Jean Rostand’s “anomaly P” in the marsh frog, *Pelophylax ridibundus*, in central Russia // Alytes, 2019. 37: 31–45.

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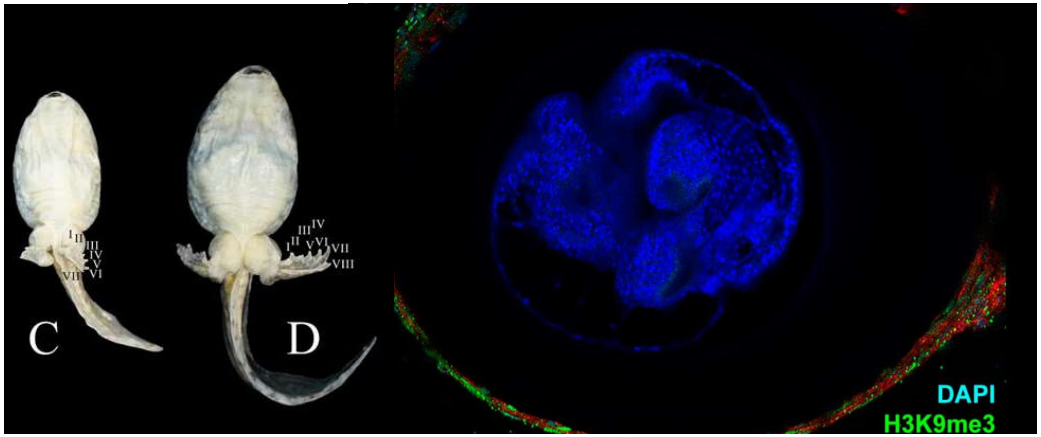

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Svinin A.O., Bashinskiy I.V., Litvinchuk S.N., Ermakov O.A., Ivanov A.Yu., Neymark L.A., Vedernikov A.A., Osipov V.V., Drobot G.P., and Dubois A. *Strigea robusta* causes polydactyly and severe forms of Rostand's anomaly P in water frogs // Parasites & Vectors 13 (381).

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The frequency of anomaly P occurrence in the studied population reached 24.7% (*n* = 384). Moreover, the severe forms of the anomaly P were noted in 4.7% of cases, and the light (polydactyly) form were noted in 20.0%.
Jean Rostand suggested that the anomaly P could be caused by some infectious agent transmitted by fish, which he hypothesized to be a **teratogenic virus** with a temporary effect on limb development.

We found that the mollusk *Planorbarius corneus* could be an intermediate host of the infectious agent of the anomaly P: symmetrical cases of polydactyly and severe cases of the anomaly P were obtained in the laboratory when tadpoles reared together with mollusk. As the most probable cause, we assume a species of **trematodes**, for which the first intermediate hosts are planorbid snails.

The direct experiments with exposure to certain cercariae doses provide compelling evidence that ***Strigea robusta*** (Trematoda: Strigeidae) leads to anomaly P in tadpoles of water frogs. The manifestation of anomaly P turned out to be dependent on the stage of development, cercariae dose, and the location of the cysts.

The anomaly P for a long time considered to be specific for water frogs of the genus *Pelophylax*. We described polydactyly and heavy forms of the anomaly P syndrome in toads of the genera *Bufo* and *Bufotes*, as a result of exposure to *S. robusta* cercariae. All anomalies in the toads were similar to those observed in water frogs.

Even though we have demonstrated the ability of tadpoles to become infected and to show the anomaly P phenotype, there is a deficit of anomaly P severe forms observations in natural populations of amphibians. The study of interactions between phenology of spring migrations of birds, time of breeding of amphibians, and development of their larvae, lifespan features of mollusks, from the one side, and trematodes lifecycle features, from another, will help to answer on question about mosaic distribution of the anomaly P hotspots observed in nature.

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