

Poeciliidae fish as a model organism

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Abstract. Model organisms are used for understanding different biological processes. Model organisms have some specific recommended characteristics. In recent years, a large number of fish have been used in different types of research. In this review, we argue for and highlight the use of fish from the Poeciliidae family as model organisms. The Poeciliidae family has some of the most popular ornamental fish. Their morphological and physiological characteristics represent interest for biologists. This fish are useful in general for environmental studies and, specifically, for assessing the genotoxic effects of water pollution. It also provides new insights for understanding the evolution of vertebrate organisms. The reproductive and genetic peculiarities of fish can be utilized in experiments necessary in biomedicine, but also in aquaculture. The available information on the genome and the existence of standardized strains for many species of Poeciliidae make the members of this group ideal candidates for use in studies and research in the current fields.

Key Words: biological, model, poeciliidae fish, research.

Introduction. Model organisms are used to determine certain processes considered to be common in other organisms (Ankeny & Leonelli 2020). Many of the fundamental principles of biology have been discovered through the use of model organisms and are essential for the progression in medicine and in environmental research (Alfred & Baldwin 2015; Adamski et al 2019).

Poeciliidae fish are used in a wide variety of biological and medical studies (Bragança et al 2020; Safian et al 2021) and are recognized to be some of the most popular ornamental fishes (Alderton 2012; Tolon 2018). Moreover, these fish have invaded aquatic ecosystems of most continents and are models for obtaining information in understanding invasive species (Holitzki et al 2013), for studying the ecological consequences and the long term effects of environmental pollutants (Tobler & Plath 2011; Gomes-Silva et al 2020).

In this paper, we highlight that fish species of the Poeciliidae family can be used as models to identify the causes of some processes from different areas of interest. Taking into account the attributes required in establishing the model organism, we present the applications of this group of fish in various fields of research and discuss their importance in biomedicine, environmental studies, including ecosystem monitoring or aquaculture, which are closely linked.

Specific features of the model organisms. There are different types of model organisms; in order to use them and understand various biological processes, they must present certain specific characteristics. (https://teaching.ncl.ac.uk/bms/wiki/index.php/Model_organism). According to Ankeny & Leonelli (2020), there are some well defined characteristics for choosing and implementing a model organism. Dietrich et al (2020) establish a set of 20 criteria that take into account some ethical, philosophical and financial considerations, as well as comparative approaches and potential use in biomedicine (Table 1).

Table 1

Parameters in the establishment an organism model in the biological researches (adapted from Ankeny & Leonelli 2020; Dietrich et al 2020)

<i>Characteristics</i>	<i>Criteria</i>
Easily handled in the lab	Ease of supply
Response to lab environment ¹	Access to the phenomenon of interest
Size of organism	Ethical considerations
Ease of storage	Standardization
Ease of breeding	Viability and durability
Length of life cycle	Responsiveness ²
Fertility rates	Availability of methods and techniques
Physical accessibility of features of interest	Researcher risks
Availability of standardized strains	Previous use ³
Size of genome	Epistemic resources
Power as genetic tools	Training requirements ⁴
Variability of specimens	Informational resources
Designing the results of research on a large group of organisms	Institutional support
Number of phenomena and processes that can be explored	Financial considerations
The ability to form the basis for comparisons with other organisms	Community support
The ability to adapt to different areas of research	Affective and cultural attributes
	Commercial and other applications
	Comparative potential
	Translational potential
	Novelty

Note: ¹ food, light, temperature, cages, program, experimental design; ² the selected organism has certain characteristics which facilitate the experimentation of a biological process or mechanism; ³ in the choice of the model organism, the knowledge already available is important, which also refers to its physiology, genetics and behavior; ⁴ time required to develop research expertise and competence.

Fish as model organisms. Fish are a diverse and remarkable group that perform various biological functions in the ecosystem (Helfman et al 2009; Harris et al 2014) and, in recent years, many species are commonly used as model organisms (Schartl 2014; Spagnoli et al 2016). The general and specific characteristics have been proven useful for providing information in establishing therapeutic strategies for human diseases (Schmale et al 2007; Harris et al 2014), organ regeneration (Gerhard 2007), environmental studies (Govind 2013) or ecotoxicology (Norrgrén 2012; Yancheva et al 2015).

Interest of using Poeciliidae fish in various fields. The Poeciliidae fish family includes about 273 species (Froese & Pauly 2021) and the diversity of their habitats indicates that a robust and highly adaptable group (Meffe & Snelson 1989).

Poeciliidae are characterized by the presence of a gonopodium in males, internal fertilization and viviparity for the majority of species (Petrescu-Mag et al 2019; Petrescu-Mag et al 2020; Bragança et al 2020; Furness et al 2020). Species of this family, such as *Poecilia* sp., *Xiphophorus* sp., are easy to keep in an aquarium and breed in laboratory conditions (Gavriloaie et al 2016; Tamaru et al 2001) and are commonly used in a wide variety of biological studies (Safian et al 2021). The small size, viviparous mode of reproduction, the fast reproductive rate (Bragança et al 2020), their short generation times (Meffe & Snelson 1989), ease to maintain in laboratory conditions (Gavriloaie et al 2016) and their remarkable biological diversity (Reznick et al 2017) represent features that prove the potential of these species as model organisms. In addition, the genomes of some species from genera *Poecilia*, *Xiphophorus*, *Gambusia* and *Poeciliopsis* were sequenced and assembled (van Kruistum et al 2020).

The studies show the scientific opportunities for the species of the Poeciliidae family, and show the utility as model organisms in aquaculture, behavior, ecology, biology, evolution, medical genetics, endocrinology, and also in providing information about the mechanisms, diagnosis and treatment of diseases (Table 2).

Table 2

The fields of the Poeciliidae fish applications as a model organism

<i>Research</i>	<i>Species</i>	<i>References</i>
Genetics and breeding in aquaculture	<i>Poecilia reticulata</i>	Nakajima & Taniguchi 2001
Biological water quality monitoring and assessment	<i>Poecilia reticulata</i> <i>Phalloceros caudimaculatus</i>	Gomes-Silva et al 2020
Aging research and regenerative medicine	<i>Poecilia reticulata</i>	Gerhard 2007
The endocrine disrupting effect of some chemicals	<i>Poecilia reticulata</i> <i>Gambusia holbrooki</i> <i>Poecilia sphenops</i>	Baatrup & Junge 2001 Brockmeier et al 2013 Khushboo et al 2018
Behavioral ecology, toxicology, population genetics	<i>Gambusia affinis</i>	Shao et al 2020
Human disease models	<i>Poecilia formosa</i> <i>Xiphophorus</i> spp. and their hybrids	Schartl 2014
Adaptation to extreme environments and ecological speciation	<i>Poecilia mexicana</i>	Kelley et al 2012

Features such as the short life cycle, ease of breeding, reproductive ability, genetic variability and the availability of laboratory strains allow the use of *Poecilia reticulata* as a model organism in fish genetics, with applicability in conducting useful experiments for aquaculture (Nakajima & Taniguchi 2001). The use of two phylogenetically distant species reveals that this group of fish can be used for integrated biological assessment of water quality. The results obtained by Gomes-Silva et al (2020) demonstrate that *P. reticulata* and *Phalloceros caudimaculatus* can be used to assess the genotoxic effects of water pollution and also to facilitate a future comparative analyzes of these effects for other animals. From the fin regeneration studies to the histological research of various tissues throughout the life of *Poecilia reticulata*, Gerhard (2007) indicates the gerontological perspective as an area of which this species can be used. Most environmental contaminants have been identified as endocrine disruptors. Exposure to such contaminants is another area where these fish are proved to be useful and the results obtained by Baatrup & Junge (2001) and Brockmeier et al (2013) confirm the use of *P. reticulata* and *Gambusia holbrooki* in determination of the potential biomarkers of androgen exposure. Also, to test the potential for endocrine disruptors, Khushboo et al (2018) used *Poecilia sphenops* and tested the effect of the industrial chemicals on the rate of growth and development. In addition to the fact that *Gambusia affinis* proved to be an important research model for studying invasion biology, genomic data obtained by Shao et al (2020) by genome assembly is a reference point in the study of chromosome evolution, reproductive characteristics and sexual dimorphism for this species.

The studies present models of fish established for developing the diseases observed in humans. Schartl (2014) argues the use of *Poecilia formosa* species and *Xiphophorus* species and their hybrids in various models of human diseases, such as different melanoma, diseases related to the impaired regulation of food absorption, energy balance and onset of sexual maturity. Moreover, *Xiphophorus* is a research tool and the genetic system is frequently used as a model in behavioral genetics, as well as in

the study of the mechanisms of sexual selection, bio-geographical systematics, and molecular events leading to speciation (Walter et al 2006).

By characterizing the transcriptome of *Poecilia mexicana*, Kelley et al (2012) provided useful results in the study of the molecular basis of adaptation to extreme environments and ecological speciation and also contributed to the enrichment of available genomic resources for species in the family Poeciliidae.

Conclusions. The study area, the biological phenomenon studied, the scientific hypotheses and questions, the selected species and the typical characteristics are general attributes that must be taken into account when choosing a model organism. The morphological and physiological characteristics of the species from the Poeciliidae family are the most important advantages that recommended use in various fields of interest. The fact that it is a robust and highly adaptable group of fish, with species resistant to various environmental conditions, with ease of reproduction, are also a gain. The already available knowledge about the genome and behavior of many species of this group, their ability to form the basis for comparisons with other organisms are attributes and tools that allow access to understand phenomena and processes.

Conflict of Interest. The authors declare that there is no conflict of interest.

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*** https://teaching.ncl.ac.uk/bms/wiki/index.php/Model_organism

Received: 08 September 2021. Accepted: 12 October 2021. Published online: 30 November 2021.

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How to cite this article:

Boaru A., Struti D., Georgescu B., 2021 Poeciliidae fish as a model organism. *Poec Res* 11(1):12-17.