Poeciliid Research

A rival for the guppy in behavioral studies: The pentamorphic fish, *Poecilia parae* Eigenmann, 1894

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Abstract. *Poecilia parae*, or penta, stands out for its vibrant colors, livebearing nature, and ecological importance. Penta is important for understanding ecology, evolution, and behavior due to its adaptability, reproductive strategies, ecological role, genetic diversity, and relevance to conservation efforts. The knowledge gained from studying this species contributes to a broader understanding of freshwater ecosystems and the factors influencing the dynamics of aquatic communities. Understanding the diversity of body colors and morphs in *P. parae* provides valuable insights into the species' ecology, evolutionary history, and adaptation strategies. Additionally, the visual appeal of these fish makes them popular choices for aquarium enthusiasts, leading to further exploration of selective breeding and the development of distinct color variants in captivity. This paper presents the alternative of using a new poeciliid, in addition to the well-known guppy, for behavioral studies, behavioral ecology and evolutionary ecology.
Key words: aggression, behavioral ecology, boldness, morphs, penta, receiver-bias, sexual selection.

Introduction. *Poecilia parae* Eigenmann, 1894, commonly known as the penta or pentamorphic livebearer, is a species of freshwater fish belonging to the Poeciliidae family. Native to South America, this species is recognized for its distinctive characteristics and ecological significance. This paper presents the alternative of using a new poeciliid, in addition to the well-known guppy, for behavioral studies, behavioral ecology and evolutionary ecology.

Taxonomy and Classification. *P. parae* is a member of the Poeciliidae family, which also includes other popular aquarium fish such as guppies, mollies, platys and swordtails. The species is closely related to the well-known *Poecilia reticulata* Peters 1859, the common guppy. Etymology: *Poecilia*: Greek, poikilos = with a lot of colours.

Infraclass Teleostei (teleosts, the largest infraclass in the class Actinopterygii);
Order Cyprinodontiformes (Rivulines, killifishes and livebearers);
Family Poeciliidae (Poeciliids);
Subfamily Poeciliinae;
Genus *Poecilia.*

Habitat and Distribution. *P. parae* is native to South America: from Guyana to the Amazon River delta (Lucinda 2003). More exactly, the species was reported from Guyana, Suriname, French Guiana and Brazil (Froese & Pauly 2003). Its natural habitat includes freshwater streams, rivers, and estuaries with a preference for brackish water conditions. It is benthopelagic; pH range: 7.0 - 7.5; dH range: 5 - 10; non-migratory; tropical; 24-28°C (Baensch & Riehl 1991; Froese & Pauly 2003).

Physical Characteristics. Pentas typically display vibrant and striking colors, with variations of red, orange, yellow, and black (Lucinda 2003). Females are generally larger (max length: 5.0 cm TL) and have a more subdued coloration, while males exhibit brighter hues and often feature elongated dorsal fins (max length: 3.0 cm TL male/unsexed (Wischnath 1993; Froese & Pauly 2003).

Reproductive Biology. *P. parae*, like many livebearing fish, gives birth to live fry rather than laying eggs. The female is capable of giving birth to a number of fry in a single reproductive event (Lucinda 2003). It produces 5-15 young after about 24 days of gestation (Froese & Pauly 2003).

Aquarium Popularity. *P. parae* is a popular choice among aquarium enthusiasts due to its vibrant colors, ease of care, and interesting behavior. The species adapts well to captivity and can thrive in community aquariums with proper water conditions. The popularity of *P. parae* in the aquarium trade provides an opportunity to study the effects of selective breeding on the species' traits. Additionally, the captive breeding of these fish for aquariums contributes to our understanding of artificial selection and its implications for the genetic diversity of populations.

Conservation Concerns. While *P. parae* is not currently listed as a threatened species, like many freshwater species, it may face habitat degradation and competition with invasive species. Conservation efforts are essential to preserve the natural habitats of pentas and maintain their ecological role.

Scientific research. *P. parae* is of interest to scientists studying reproductive behavior, genetics, and adaptation to varying environmental conditions. Research on this species contributes to a broader understanding of livebearing fish and their evolutionary dynamics (Breden et al 1999).

Adaptability to varied environments. *P. parae* exhibits a remarkable ability to thrive in diverse aquatic environments, including freshwater streams, rivers, and brackish estuaries. Studying this adaptability contributes to our understanding of how species cope with environmental changes and variations in salinity.

Reproductive strategies. As a livebearing fish, *P. parae* provides insights into reproductive strategies, particularly ovoviviparity. The study of their reproductive biology helps researchers understand the evolutionary advantages and trade-offs associated with livebearing, as opposed to egg-laying, in different ecological contexts (Lindholm et al 2006).

Behavioral ecology. Observing the behavior of *P. parae* in its natural habitat and in captivity allows scientists to study social interactions, mating behaviors, and predator-prey relationships (Hurtado-Gonzales et al 2010). These observations contribute to our understanding of the role of behavior in the survival and reproduction of the species.

Ecological role in mosquito control. Pentas play a crucial ecological role in controlling mosquito populations by feeding on mosquito larvae. Understanding the dynamics of this predator-prey relationship contributes to our knowledge of how species interact within ecosystems and the potential impact of a single species on broader ecological processes.

Genetic diversity and adaptation. Investigating the genetic diversity within *P. parae* populations provides valuable information on the mechanisms of adaptation and evolution (Nater et al 2008; Muntean et al 2022; Fast et al 2023). The species' ability to inhabit different environments suggests that there may be genetic variations contributing to its adaptability.

Conservation implications. *P. parae* serves as a model for understanding the impact of habitat degradation and invasive species on freshwater ecosystems. Studying this species can inform conservation strategies aimed at preserving biodiversity and mitigating threats to aquatic habitats.

Comparison with close relatives. Comparative studies with other *Poecilia* species, such as the common guppy (*P. reticulata*), allow scientists to explore the evolutionary relationships within the genus. Understanding the similarities and differences between closely related species contributes to our knowledge of speciation and evolutionary divergence.

Various morphs. *P. parae* exhibits a variety of body colors and morphs, contributing to the species' visual appeal and the interest it holds for both researchers and aquarium enthusiasts. The body coloration and morphological variations are influenced by genetic factors, environmental conditions, and selective pressures.

Vibrant coloration. Pentas are known for their vibrant and striking coloration, which adds to their aesthetic appeal. The colors commonly observed include shades of red, orange, yellow, blue and black. The intensity and distribution of these colors can vary among individuals (Bourne & Watson 2009).

Sexual dimorphism and morphological variations. Like many species within the Poeciliidae family, *P. parae* exhibits sexual dimorphism in terms of body color and morphology. Males often display more vivid and varied colors compared to females. The differences in coloration are particularly pronounced during courtship displays, where males showcase their colors to attract potential mates. While body color is a prominent feature, morphological variations also contribute to the overall appearance of *P. parae*. Male individuals may have elongated dorsal fins and anal fins, contributing to their visual appeal during courtship displays. Females, on the other hand, generally have a more streamlined and less ornamented appearance (Figure 1).

Five color forms (or morphs) of males are recognized (Bourne & Sammons 2008), the frequency of which may depend upon predation pressure (Keith et al 2000). The five morphs are: blue *melanzona*, red *melanzona*, yellow *melanzona*, *parae* (stripe-coloured tail) and *immaculata* (female mimic) (Figure 1).

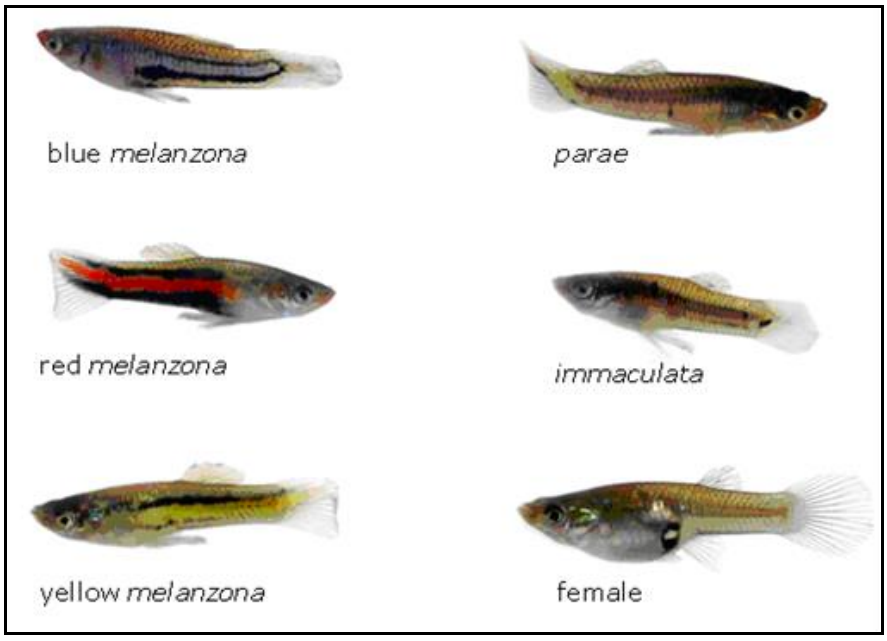

Figure 1. The five morphs of *Poecilia parae*: blue *melanzona*, red *melanzona*, yellow *melanzona*, *parae* and *immaculata* (source: Bourne & Sammons 2008).

Selective breeding and captive variants. Selective breeding in captivity has led to the development of different color morphs and variants in *P. parae*. Aquarium enthusiasts have bred and selected for specific color patterns, resulting in captive populations with a wide range of color variations beyond those observed in the wild.

Environmental influences. Environmental factors, such as water quality, habitat type, and light conditions, can also influence the expression of body colors in *P. parae*. Changes in these environmental variables may lead to variations in pigmentation and overall coloration.

Cryptic coloration. In their natural habitats, *P. parae* may exhibit cryptic coloration to blend in with their surroundings, providing a form of camouflage. This adaptation can help them avoid predators and navigate their complex aquatic environments.

Geographical variation. There may be geographical variations in body color and morphs among different populations of *P. parae*. Environmental differences across their range could contribute to regional variations in appearance.

A rival for the guppy in behavioral studies. Examples

Behavioral syndromes. Boldness, aggression and exploration were investigated in a behavioral study to evidence the behavioral syndrome in male pentamorphic livebearing fish (Bourne & Sammons 2008). A behavioral syndrome, also known as animal personality, refers to consistent and correlated patterns of behavior across different situations or contexts within an individual organism (Sih et al 2004). This phenomenon challenges the traditional view that behavior is highly context-dependent and suggests that individuals may exhibit predictable and stable behavioral traits across various circumstances. These behavioral syndromes are analogous to human personality traits, such as extroversion, agreeableness, or neuroticism (Dochtermann & Dingemanse 2013).

Key characteristics of behavioral syndromes

Consistency. Behavioral syndromes are characterized by the repeatability of specific behavioral traits within an individual across time and situations. For example, an animal displaying bold behavior in one context is likely to exhibit boldness in different situations.

Correlation. Different behavioral traits are often correlated, meaning that individuals displaying a particular behavior in one context may also exhibit similar patterns in other situations. For instance, an animal that is bold may also display higher levels of aggression or exploration.

Individual variation. While behavioral syndromes highlight consistent patterns, there is still room for individual variation. Not every individual within a species will necessarily conform to a specific behavioral syndrome, and the degree of consistency can vary among individuals.

Adaptation. The presence of behavioral syndromes suggests that these consistent patterns of behavior may have adaptive significance. Certain behavioral traits may confer advantages in specific ecological or social contexts, contributing to the individual's overall fitness.

Examples of behavioral traits studied in syndromes

Boldness. The tendency to take risks or show low levels of fear in novel situations (Wilson & Godin 2009).

Aggression. The inclination to engage in confrontational or competitive behaviors, particularly in the context of resource competition or mate selection.

Exploration. The willingness to investigate new environments or interact with unfamiliar objects (Petrescu-Mag 2023).

Sociability. The degree of preference for social interactions or the ability to form and maintain social bonds.

Research methodologies. Scientists studying behavioral syndromes employ various experimental setups, often exposing individuals to controlled situations that elicit specific behaviors. Observations are made in diverse contexts to identify consistent patterns and correlations between different traits. Understanding the existence and significance of behavioral syndromes provides insights into the underlying mechanisms of behavior, genetics, and the ecological factors influencing an organism's life. These studies contribute to the broader field of behavioral ecology, helping scientists comprehend the complex interplay between genetics, environment, and behavior in shaping the survival and reproductive success of individuals within a population.

Testing the Receiver-Bias Hypothesis for the nonsexual origin of mate choice. The Receiver-Bias Hypothesis in behavioral ecology and evolution proposes that the evolution of certain traits or behaviors is influenced by pre-existing sensory biases in the receivers (typically, the females in the context of mate choice) (Bourne & Watson 2009). In other words, this hypothesis suggests that the receivers already possess sensory preferences that drive the evolution of specific traits in the signaling individuals. This concept is often associated with the study of sexual selection, where traits that are attractive to mates may evolve not solely due to adaptive benefits but also because they exploit pre-existing sensory biases in the choosing individuals.

Key points regarding the Receiver-Bias Hypothesis. The Receiver-Bias Hypothesis highlights the importance of considering the sensory and perceptual aspects of communication and mate choice in the study of evolutionary processes, shedding light on how traits and behaviors evolve in response to the existing preferences of the individuals making the choices (Jansson & Enquist 2003; Smith et al 2004).

Sensory biases. The hypothesis assumes that receivers (e.g., females choosing mates) have pre-existing sensory biases or preferences (Bourne et al 2003). These biases can be based on sensory modalities such as visual, auditory, or olfactory cues.

Exploitation of biases. According to the Receiver-Bias Hypothesis, traits or behaviors in the signaling individuals that align with the pre-existing sensory biases of the receivers are more likely to be favored and spread through a population (Petrescu-Mag & Proorocu 2022). Essentially, these traits exploit the existing sensory preferences of the choosing individuals.

Evolution of signals. The hypothesis is often invoked in the context of the evolution of elaborate mating displays, ornaments, or courtship behaviors. Such traits may evolve not only because they directly benefit the individual (e.g., indicating genetic fitness) but also because they align with the sensory preferences of potential mates.

Mate choice. In many cases, the hypothesis is closely tied to the evolution of mate choice, particularly in species where females play a prominent role in selecting mates (Bourne et al 2003). The idea is that the traits displayed by males have evolved to match or stimulate the sensory biases of females, enhancing the chances of successful mating.

Link to sexual selection. The Receiver-Bias Hypothesis contributes to our understanding of the mechanisms driving sexual selection. It complements other theories, such as the

Fisherian runaway selection or good genes models, by emphasizing the role of pre-existing sensory biases in shaping the evolution of sexually selected traits.

Conclusions. *P. parae* stands out for its vibrant colors, livebearing nature, and ecological importance. Penta is important for understanding ecology, evolution, and behavior due to its adaptability, reproductive strategies, ecological role, genetic diversity, and relevance to conservation efforts. The knowledge gained from studying this species contributes to a broader understanding of freshwater ecosystems and the factors influencing the dynamics of aquatic communities. Understanding the diversity of body colors and morphs in *P. parae* provides valuable insights into the species' ecology, evolutionary history, and adaptation strategies. Additionally, the visual appeal of these fish makes them popular choices for aquarium enthusiasts, leading to further exploration of selective breeding and the development of distinct color variants in captivity.

Conflict of Interest. The author declares that there is no conflict of interest.

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