Poeciliid Research

# Behavioural plasticity in female colour preference induced by diet cues in *Poecilia reticulata*

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**Abstract**. This *News & Views*-style paper critically examines recent evidence of behavioural plasticity in female colour preference in the guppy, *Poecilia reticulata* Peters, 1859, focusing on the role of diet-derived visual experience. The aim is to highlight how short-term environmental cues, particularly diet colour, can dynamically reshape female mate choice, challenging the traditional view of fixed sensory biases in sexual selection. Studies have shown that females reared on differently coloured diets exhibit rapid, reversible shifts in preference for male colour patterns, suggesting that associative learning links foraging cues with sexual attraction. This plasticity implies that selection on male coloration is more fluctuating and context-dependent than previously assumed, offering new insights into how ecological variability and sensory experience sustain phenotypic diversity in natural guppy populations.
**Key words**: associative learning, behavioural plasticity, colour preference, diet colour, ethology, female mate choice, *Poecilia reticulata*, polymorphism, sensory conditioning, sexual selection.

In natural waters, phytoplankton serves as food for the water's filter-feeding microfauna. Both phytoplankton (mostly indirectly) (Figure 1a) and aquatic invertebrate animals (directly) (Figure 1b) serve as food and sources of pigments for poeciliid fish in their natural environment.

The guppy, *Poecilia reticulata* Peters, 1859, has long been a cornerstone model in behavioural ecology and sexual selection research, particularly because of its remarkable diversity in male colour patterns and the intricate female preferences that maintain this variation (Petrescu-Mag 2023ab). For decades, studies have shown that female guppies tend to prefer males displaying bright orange spots - a preference linked to carotenoid-based ornamentation, which is often associated with male health and foraging ability (Petrescu-Mag 2007ab). However, recent ethological findings suggest that this preference may not be as stable or genetically hardwired as previously thought. Instead, it appears to be influenced by short-term environmental factors, particularly those related to the female's own visual and foraging experience.

A series of experiments published over the last few years has demonstrated that the colour composition of a female's diet can dynamically modulate her mate preference (Herdegen-Radwan 2022; Kato & Karino 2024). In controlled laboratory conditions, female guppies reared on orange-tinted diets developed a stronger attraction to orange-spotted males, whereas females reared on darker or differently coloured diets (such as those containing spirulina or black algal pigments) shifted their attention towards males with darker body spots. Strikingly, these preferences were reversible: when females were switched to a diet of another colour for only a week, their preference changed accordingly.

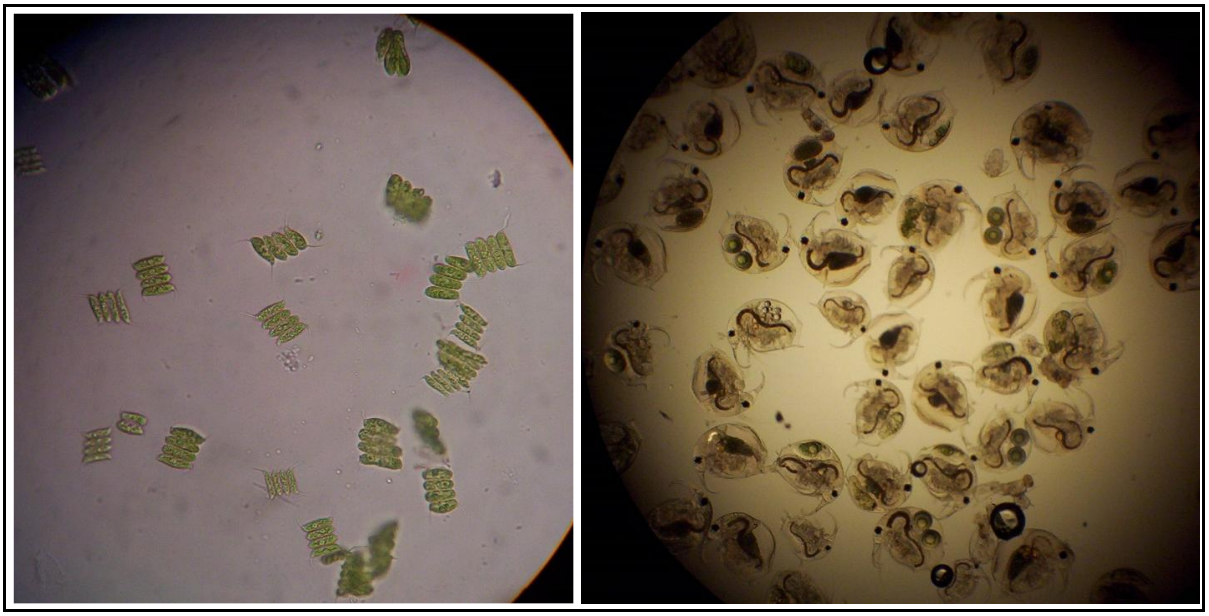

Figure 1. Examples of phytoplankton (*Scenedesmus* spp.) (a - left) and zooplankton (*Daphnia* spp.) (b - right) as indirect and direct sources of nutrients and pigments for guppies (photo: Dan Rasiga).

This phenomenon reveals a previously underestimated level of behavioural plasticity in guppy mate choice. It suggests that females do not simply inherit a fixed sensory bias toward certain colours, but rather fine-tune their mating preferences through recent sensory experiences. The mechanism appears to involve sensory conditioning, in which the female's visual system links foraging cues - such as the colour of food particles - with rewarding stimuli. Over time, the colour associated with successful feeding becomes preferentially salient, influencing not only food detection but also sexual attraction toward males displaying that hue.

Such a flexible system would make adaptive sense in the natural environments guppies inhabit. In the wild, guppy populations experience high variability in the visual background of streams and in the availability of food sources with different pigmentation levels. A female whose diet consists largely of orange-coloured invertebrates, for example, might be primed to detect orange objects more effectively - including orange male ornaments. Conversely, under shaded conditions where dark organic matter dominates the substrate and diet, darker males may become more visually salient and thus more attractive. This context-dependent mate preference could help maintain male colour polymorphism within populations by preventing the fixation of a single ornament type (Sakai et al 2018; Valvo et al 2019; Kato & Karino 2024).

The implications for sexual selection theory are profound. Traditional models have assumed relatively stable female preferences that drive directional selection on male traits. Yet, if female guppies exhibit rapid, reversible changes in preference based on diet-derived visual experience, the selection pressure acting on male coloration becomes far more dynamic. This behavioural flexibility could generate fluctuating selection over time and space, contributing to the persistence of multiple male morphs within the same population - an enduring puzzle in guppy evolution.

Moreover, this finding strengthens the view that learning and experience play a substantial role in mate choice, alongside genetic predispositions. Similar mechanisms have been observed in other taxa - for instance, in zebra finches, where early visual exposure shapes later song or colour preferences - but the guppy example provides a particularly vivid demonstration of sensory–sexual coupling through ecological experience.

From an ethological perspective, the discovery underscores how subtle environmental cues can influence behavioural decision-making even in small-brained

vertebrates. The fact that female guppies can adjust their mate preferences within days highlights the cognitive flexibility underlying what was once considered a fixed, instinctual process. It opens new avenues for research on the neural and perceptual bases of such plasticity - for instance, whether the observed preference shifts correspond to measurable changes in retinal sensitivity, opsin expression, or neural processing of colour cues.

**Conclusions**. The recent evidence of diet-induced plasticity in female mate preferences challenges long-held assumptions about the rigidity of sexual selection in *Poecilia reticulata*. It demonstrates that female choice is a dynamic behaviour shaped not only by evolutionary history, but also by immediate ecological experience. This adaptive flexibility likely contributes to the remarkable diversity of male colour patterns seen in natural guppy populations, offering an elegant example of how environmental heterogeneity and learning interact to sustain biodiversity at the behavioural and evolutionary scales.

**Acknowledgements**. The photographs were generously provided by Ioan Valentin Petrescu-Mag and expertly taken by Dan Rasiga, a specialist from the Alexandru Borza Botanical Garden, Cluj-Napoca.

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

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Received: 30 August 2025. Accepted: 18 October 2025. Published online: 22 November 2025.
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How to cite this article:
Popescu M., Păpuc T., 2025 Behavioural plasticity in female colour preference induced by diet cues in *Poecilia reticulata*. Poec Res 15(1):1-3.