Egg trading between hermaphroditic fish: Why would you give when you can just take?

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Hamlets during mating. Credit: Carlos & Allison Estapé, carlosestape.photoshelter.com

The sex life of hermaphroditic animals is determined by one fundamental question: Who assumes the female role and produces the costly eggs? Hamlets avoid this dilemma by engaging in reciprocal egg trading. Scientists have now used microeconomic models to analyze the circumstances required for this complex system of trading to work. Their results have been published in *The American Naturalist*.

The hamlets that live in coral reefs in the Caribbean are hermaphrodites. One of their mating strategies is to pass eggs on to each other. Here, the role of the sperm donor is preferable because producing eggs requires more energy. If both animals adopt the two roles successively when mating with the same partner, neither is at a disadvantage—it's a fair deal.

Traders, providers, and cheaters

Other populations from the Serranidae family do not engage in trading of this kind. Instead, they pass their eggs on unconditionally when they encounter an individual of the same species who is available for mating.

Reciprocal egg trading is presumably not an original evolutionary strategy, as the exchange is reliant on complex reciprocal behavior. An interdisciplinary team of researchers has now investigated the factors that could be responsible for the evolution of egg trading in hamlets—but not in other Serranidae.

For this, the researchers developed a model that takes account of a third type of behavior that can undermine the success of the egg trading strategy: one of the two fish—the "cheater"—pretends to want to reciprocate by providing eggs of their own, but then withdraws from the trade after fertilizing their partner's eggs.

Biology and game theory

Professor Georg Noeldeke, an economist at the University of Basel, is an expert in game theory. "Game theory asks how decision behavior can best be adapted to situations that are primarily determined by the decision behavior of other individuals," he says. "In principle, it doesn't make much difference whether this is animal behavior or the behavior

of humans."

In collaboration with the marine biologist Oscar Puebla and the behavioral ecologist Jorge Peña, the microeconomist Noeldeke therefore believed he could design a game-theoretic model of the mating behavior of hermaphrodites that explained both the emergence of egg trading and the prevalence of this strategy over other possibilities.

Four necessary conditions

The results reveal restrictive conditions that must be met in order for reciprocal trading to invade and be maintained in a population. First, eggs must be relatively costly to produce. Second, it must not be too difficult to find a partner. "It only makes sense to wait for someone with whom a fair trade is possible if there's a relatively high probability that I'll encounter someone like that in the first place," explains Noeldeke.

Third, it mustn't be too easy to find a partner either, as otherwise the possibility of cheating is too attractive. Last of all, it must be possible to identify cheaters prior to fertilization and hence avoid mating with them. This is the only way that the trading strategy is worth pursuing, says the researcher.

"This model has enabled us to demonstrate theoretically, for the first time, which factors hold the key to explaining the egg trading system," says Noeldeke, describing the significance of the findings. "We now hope that other biologists will gather the necessary data to test our theory, and we can't wait to see the results."

More information: Jorge Peña et al, The Evolution of Egg Trading in Simultaneous Hermaphrodites, *The American Naturalist* (2019). DOI: 10.1086/707016

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