Cooperative fish take turns with gender roles

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Chalk bass (Serranus tortugarum) are small sea bass in the grouper family. What makes these fish interesting is that they are simultaneous hermaphrodites: they have both male and female reproductive tissue at the same time.

While other animals in the same situation might compete over who gets to fertilize whose eggs, chalk bass seem to have solved the issue through

cooperation. Pairs of chalk bass spawn daily, but they have a negotiation with their partners. They take turns releasing eggs for their partners to fertilize.

"They'll go up into the water column and spawn once with one individual as female and the other individual as male. They'll come back down to the substrate, maybe do some courtship behaviors, and then they'll switch gender roles and do it again," says Mary Hart of the University of Florida.

The fish repeat these spawning bouts over and over in a reproductive tactic called egg parceling. In return for letting their partner fertilize a parcel of their eggs, they receive a parcel of eggs from their partner to fertilize.

Egg parceling is a classic example of reciprocity between unrelated individuals. Both partners benefit – by getting their own eggs fertilized, and by fertilizing a partner's eggs – but the benefits depend on partners trading equal numbers of eggs. This situation involves the risk of exploitation, e.g., one individual fertilizing its partners' eggs but holding back its own eggs. Exploitation is less likely if the same individuals have many interactions together and reciprocate cooperative actions. Therefore, long-term relationships may be an integral component to egg parceling.

Serranus tortugarum (chalk bass) pair getting ready to spawn on a reef near Bocas Research Station, part of the Smithsonian Tropical Research Institute in Panama. Chalk bass spawn in the pelagic column with individuals taking turns releasing eggs for their partner to fertilize. Credit: Mary K. Hart.

In a new study, Hart, along with co-authors Andrew Kratter and Philip Crowley, looked at whether chalk bass mating involved long-term partner fidelity, reciprocation in the number of egg parcels exchanged, and matching in the number of eggs produced in a single day by fish within pairs.

For the duration of the six-month study, all chalk bass pairs remained together with their original partners until one or both of them disappeared from the study site. This means that chalk bass pairs stay together for much, if not all, of their adult lives.

Hart says she was expecting more pairs to break up over the study period, especially if partners did not take turns releasing eggs. While the researchers did not observe any break-ups, they did see that the fish matched reproductive investment.

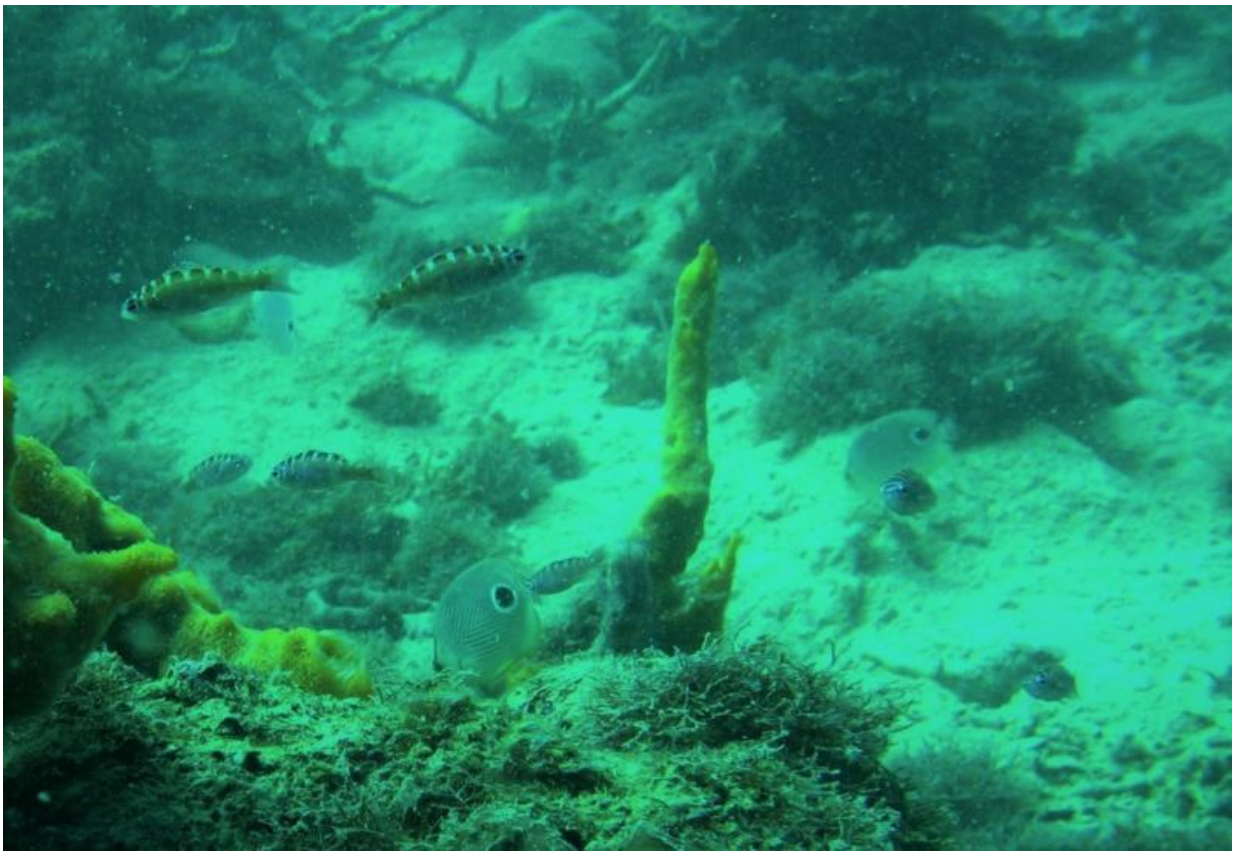
"Pairs tended to be of similar size, and size and fecundity are related in fish," says Hart. "Even when the effect of size was removed, daily fecundity was matched in pairs. Some fish have more eggs than would be predicted by their size, and some have fewer. That suggests that partners are matching their investment in female function."

Hart and her colleagues found that both daily egg production and the number of egg parcels exchanged within pairs were coordinated: Pairs tended to alternate gender roles and match the number of egg parcels exchanged between partners.

Even in one case where a pair of chalk bass did not appear to be taking turns over a single spawning period, the pair remained together.

"We know that they stay together for a long time, so maybe it doesn't matter that much if one partner is not reciprocating on any one day," says Hart. "Or, it is possible that those fish were in a new relationship and had not sorted it out yet."

About 20% of the fish studied exchanged a few egg parcels with fish that were not their long-term partners. The team also observed some streaking, a behavior in which a fish rushes up to a spawning pair and releases its sperm. Egg parceling, extra-pair mating, and streaking may all be used as reproductive tactics by chalk bass to maximize their spawning success.



Serranus tortugarum (chalk bass) on a reef near Bocas Research Station, part of the Smithsonian Tropical Research Institute in Panama. Pairs can be identified by proximity of individuals to each other and similarity in body size. Credit: Mary K. Hart

It's thought that egg parceling helps maintain the stability of simultaneous hermaphroditism. It keeps individuals from being exploited.

"What if an individual gave up all their eggs at once to a partner and the partner fertilizes them and leaves?" says Hart. "If they give away all their eggs at once, they risk being cheated."

Hart and her colleagues say a novel finding from their study is that the fish live in stable sites at high density. It's one of the first examples where there are large social groups in which alternative partners are present, yet chalk bass still have strong fidelity to their partners. It suggests that matching reproductive investment can help long-term cooperation among non-related animals, even when there are opportunities to mate with other fish.

Hart still has many questions about chalk bass mating. "How is matching maintained? Are there coercive behaviors going on within the partnership? What do they do if their partner refuses to reciprocate? Do they not switch partners because it is too costly to find another partner?

"I would like to look at the costs of losing a partner and examine the behaviors of partners toward individuals that do not reciprocate or have lower fecundity than they do," Hart says.

Chalk bass show that cooperation, especially between non-related individuals, is more complicated than just tit-for-tat. There is always the potential for exploitation in these systems. Animals like chalk bass have found ways to prevent being exploited and maximize their reproductive potential by paying attention to what their partners are doing.

More information: Mary K. Hart et al. Partner fidelity and reciprocal investments in the mating system of a simultaneous hermaphrodite, *Behavioral Ecology* (2016). DOI: 10.1093/beheco/arw065

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