Behav Ecol Sociobiol (2017) 71: 141
DOI 10.1007/s00265-017-2369-2

EDITOR'S CHOICE

Kin recognition and filial cannibalism in an amphibious fish

Joachim G. Frommen[1]

Published online: 5 September 2017

Parents occasionally consume their own offspring. Such filial cannibalism has been demonstrated in viviparous and oviparous species including mammals, birds, reptiles, amphibians, and many invertebrates (see Deal and Wong 2016 for a recent summary). However, it is best investigated in teleost fishes, thus far, probably because it is especially common in this taxon (Manica 2002). At first, cannibalizing own offspring appears highly detrimental; however, under some conditions, this paradox behavior bears fitness benefits (summarized in Manica 2002; Mehlis et al. 2009; Bose et al. 2014; Deal and Wong 2016). For example, parents may remove sick or dead embryos from their clutch to reduce the risk of spreading diseases to healthy offspring. Further, they may specifically target offspring with a low probability to reach adulthood to avoid investing time and energy in them. By cannibalizing parts of their progeny, parents can further adjust the size and composition of their brood according to local conditions like food abundance. Finally, parents might consume their own offspring to gain energy whenever the costs of care are greater than its benefits. This energy can be invested in the remaining progeny or in future reproduction. This "energy-based hypothesis" received considerable attention in the literature (Manica 2002), with studies presenting both support (e.g., Mehlis et al. 2009) and contradictory evidence (e.g., Bose et al. 2014).

The occurrence of cannibalism is expected to be most likely if parenthood is uncertain, for example, due to extra-pair fertilizations, territory take-overs, or brood mixing. In the case of broods consisting of related and unrelated individuals, parents that cannibalize only unrelated young avoid investing resources into such offspring, while at the same time gaining nutritional benefits, which can be directed to related young. Here, the ability to discriminate between own and foreign young is crucial. Furthermore, cannibalism should take place as early as possible in order to keep prior investment at a minimum (Vallon and Heubel 2016). Thus, recognizing unrelated young already at the egg stage appears to be adaptive. Interestingly, few studies have demonstrated that animals assess their parenthood already at that stage (e.g., Mehlis et al. 2010; Bose et al. 2014) and evidence for recognition of single eggs is even more scarce (but see Loiselle 1983).

The study by Wells and Wright (2017) in this issue of *Behavioral Ecology and Sociobiology* investigated functions and mechanisms of filial cannibalism in fishes using an amphibious killifish (the mangrove rivulus *Kryptolebias marmoratus*) as a model system. These hermaphrodites are capable of internal self-fertilization, leading to high levels of homozygosity. Still, there exist males, which occur at different ratios depending on the population. These males occasionally reproduce with hermaphrodites, generating heterozygous offspring. Importantly, individuals of this species can discriminate between related and unrelated adult con-specifics (Edenbrow and Croft 2012).

By using individuals of two different strains, the authors tested in a well-designed experiment whether parents can distinguish single own from foreign eggs. To do so, they presented fish that recently spawned either with an own egg, an egg that originated from the same strain, or with an egg from a different strain. They measured how individuals behaved towards these eggs, including filial cannibalism. The fish approached unrelated eggs faster than related ones and spent more time nibbling on unrelated eggs. This indicates that egg recognition probably includes chemical cues, which are

✉ Joachim G. Frommen
joachim.frommen@iee.unibe.ch

[1] Department of Behavioural Ecology, Institute of Ecology and Evolution, University of Bern, Wohlenstraße 50a, 3032 Hinterkappelen, Switzerland

detected near the egg. Importantly, individuals readily consumed embryos derived from a different strain, while they never showed cannibalism of own eggs. Furthermore, strain dependent differences in behavior underline the importance of the genetic background. Individuals obtained from a population with frequent occurrence of males showed higher amounts of within-strain cannibalism, maybe because regular sexual reproduction increases genetic diversity in that strain.

Next, Wells and Wright tested the energy-based hypothesis by measuring the likelihood to cannibalize eggs in fish that either had been fed three times a week or had been food deprived for 2 weeks, resembling starving periods under natural conditions. In contrast to the expectations derived by the energy-based hypothesis, food-deprived fish did not show a higher propensity to consume eggs than satiated ones, making nutritional benefits an unlikely explanation for the occurrence of filial cannibalism in this species.

Taken together, this sophisticated study is one of the first showing how egg-based kin recognition mediates filial cannibalism in a fish. Future studies on this fascinating model system might elucidate which ecological factors trigger the occurrence of filial cannibalism and how differences in heterozygosity account for variation in the ability to discriminate between related and unrelated offspring.

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