Cannibalism: causes and effects

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CANNIBILISM IS RARE IN NATURAL SYSTEMS, IT IS GENERALLY NOT IMPORTANT FOR UNDERSTANDING POPULATION AND COMMUNITY DYNAMICS. DISCUSS.

In ecology, cannibalism is defined as killing and consuming a conspecific individual. It can also be referred to as intraspecific predation. The key difference between cannibalism and other feeding acts such as necrophagy is that cannibalism relates only to conspecifics and includes the act of killing the prey or feeding on it whilst it is still alive. Cannibalism appears common in nature and has been recorded in over 1500 species. This essay will aim to highlight the fact that cannibalism is an important part of population and community dynamics in many natural systems.

There are different types of cannibalistic behaviours that can occur. Size structured cannibalism is the consumption of a smaller or less advanced individual by a larger or more advanced individual. This is the most common type of intraspecific predation and takes place in a large variety of taxa including; 36 families of teleost fish (Smith and Reay 1991), crows (Yom-Tov), ground squirrels (Vestal 1991), dragonfly larva (Crowley et al 1987), isopods (Leonardsson 1991), reptiles (Keren-Rotem et al 2006) and salamanders (Rudolf 2006). Another form of size structured cannibalism is Infanticide cannibalism which is the consumption of the individuals own, or another conspecific's, offspring.

Sexual cannibalism is when one member of a mating pair kills and eats the other member. This is restricted mainly to arthropods, insects and amphipods (Polis 1981). Cannibalism can even take place before birth as ' intrauterine cannibalism', where the largest embryos feed on smaller ones. It has been well studied in carnivorous sharks and teleost fish (Crespi and Semeniuk 2004). Sibling cannibalism can also occur amongst the newborns; this has been recorded in over 100 species (Polis 1981) and primarily occurs when the siblings differ in size or strength.

Numerous studies have been carried out to discover if cannibalism's prevalence in nature relates to an important role in the dynamics of populations and communities. The majority of these studies have suggested that cannibalism may indeed have a large role in the regulation of many natural systems.

When considering population dynamics, the components of the density dependent regulation of the population size is a major aspect. Cannibalism is of such importance in some species that it has been recorded as the main population regulating density dependent factor for them in their natural habitat. In young wolf spiders, this was tested using field and laboratory experiments (Wagner and Wise 1996). Field experiments showed that removing all natural enemies of the spiders did not reduce spider mortality as would have been expected if the population was regulated by predation. Also, increasing spiderling densities did not reduce the spider's prey density and only affected growth slightly, suggesting prey amount is not a key regulating factor. However, the effects of emigration could not be accounted for entirely which prompted more controlled experiments. These laboratory experiments showed that cannibalism and mortality rates amongst young spiders increased when prey availability decreased, and higher densities exaggerated this effect (FIG 1.)

Although this shows that cannibalism is sufficient to regulate the density of a population of wolf spiders, it does not confirm that in natural systems the enemies of wolf spiders are not the true cause of the mortality. It may only be when the natural enemies are removed that cannibalism takes over regulating the population density.

In larval dragonflies it was shown that cannibalism was the main cause of mortality and that the amount of cannibalism was determined by density (Buskirk 1989). The mortality due to cannibalism was determined by comparing normal populations with populations that had their labial palps removed so they could not kill one another. It was found that non-cannibalism groups survived significantly better and this effect was greater at higher densities. The cannibalism groups showed reduced size distributions as only smaller instars were eaten. This meant that it was possible to fit the results to a predator prey model, that incorporated size structure, which indicated that cannibalism can affect size structure and result in a relatively lower number of young larvae.

It is not uncommon for population structure to be affected by cannibalism; recruitment rate variations and biased age distributions have been accounted for by intraspecific predation in multiple species, such as teleost fish(Smith and Reay 1991), some polychaetes and molluscs(Polis 1981). Nevertheless, it has also being found that cannibalism can reduce fluctuations in recruitment rate by stabilizing population dynamics (Brownell 1985).

Cannibalism in tribolium beetle populations was found to cause cycling in some life stages while stabilizing others (Benoit et al 1998). Separating the different stages of the lifecycle showed that the cycles in the larval and egg stages were due to larval cannibalism whilst cannibalism of eggs and pupa by adults stabilized the population structure and density. When adult cannibalism of pupa was stopped, the rate of population increase approached exponential. Although clearly an important factor in laboratory experiments, the effects of cannibalism in natural tribolium systems may be weakened due to many other factors influenced by density.

Cannibalism can clearly have largely influential effects on the dynamics of individual populations, therefore any communities that these populations are involved in will also be affected. In IGP (Intraguild predation) systems, the predator, often omnivorous, and the prey share a common resource. Models not considering cannibalism designed to predict the structure of these food webs (Holt and Polis 1997) matched well with empiricial data found in studies with microbial systems (Morin 1999) but not others.

The four main predictions of the non-cannibalism models were:

- For coexistence, prey must be more efficient at exploiting the common resource and predator must significantly gain from eating prey.
- The prey can survive at a lower amount of shared resource but in high enrichment conditions the predator will cause the extinction of the prey by apparent competition.
- A decrease in predator density will increase prey, therefore decreasing the resource.

- Only in a small area of the shared space is coexistence possible.

However, the models which included cannibalism made predictions which differ from these but match better with empirical data and the observed fact that IGP systems are stable (Holyoak and Sachdev 1998) and widespread (Arim and Marquet 2004) in nature. These models, which considered cannibalism (Rudolf 2007), found that if the predator is cannibalistic it can exploit resources more effectively which may enable it to exist at lower shared resource levels. A change in the effect of enrichment will also occur so prey extinction does not happen at high resource densities. Furthermore, if the prey is cannibalistic, a decrease in predators will increase the shared resource density. This is due to less resource consumption by the predator stage and little or no change in resource consumption by the prey due to increased mortality and feeding from cannibalism from the lack of predators.

This study showed that cannibalism was found to support the coexistence of the intraguild predator and prey. However, this only represents the findings of the predictions of a model which has not yet undergone a great deal of scrutiny. Nevertheless, it illustrates the necessity to account for cannibalism to enable accurate predictions of community dynamics as cannibalism effectively establishes an additional trophic level and population feedback loops. Consequently, it is incorrect for food web theory to view cannibalism merely as a contributor to density dependent mortality that has no effect on interacting species (Hart 2002). Incorporating interspecific and intraspecific interactions into food web theory which account for the size structure of the populations will undoubtedly improve understanding of community dynamics.

Due to these inter-population feedback loops, nonlinear interactions within predator and prey systems can take place (Rudolf 2008). When the prey has cannibalistic individuals and the predator consumes these individuals, mortality in the prey due to cannibalism is reduced (FIG 2. A). This is a density mediated indirect interaction, just as if the predator consumed non-cannibalistic prey, increasing competition between the cannibals and the predators (FIG 2 B).

Cannibalism can affect the behaviour of the smaller individuals of the population in multiple species (Crowley et al 1987, Persson and Eklov 1995, Keren-Rottem et al 2006, Leonardsson 1991) causing them to change their habitat or their activity. These general predation evading responses by the smaller individuals will reduce cannibalism and have a behaviour mediated indirect interaction by decreasing the interspecific predation rate (FIG 2. C). Higher interspecific predation rates causing a behaviour change, therefore reducing intraspecific predation(FIG 2 D) is also an behaviour mediated indirect interaction. These indirect interactions reduce the predator’s overall impact on the prey and can cause nonlinear relationships (Rudolf 2008). These nonlinear relationships have the potential to alter community dynamics significantly in predator prey systems with size structures.

It is clear that to assert cannibalism as rare and unimportant in population and community dynamics is false. Cannibalism’s regular occurrence in nature makes it undoubtedly a factor which must be considered as important. When cannibalism is considered within populations, both theories and empirical evidence have illustrated its varying impact on population dynamics. With this sort of influence at the population level, it seems surprising that an inclusion of cannibalism into general community dynamic theory is not common practice. Continued work by Volker Rudolf however, is showing cannibalism's role in predator prey interactions and trophic chains, yet empirical evidence of this is still lacking. Regrettably, until this has been collected, cannibalism may persist as possibly one of the most underappreciated factors that functions in community dynamics. The lack of studies investigating cannibalism in systems in which it appears scarce and unimportant is profound. Presumably, this is because it may seem meaningless to carry out or publish a study which proves cannibalism as non-existent or unimportant in a system that it was already previously assumed to be unaffected by it. For this reason, it is important to be vigilant when estimating the importance of cannibalism on a whole in understanding population and community dynamics. Nevertheless, to allow theories concerning population demography, predator prey interactions, trophic chains and other interactions to be implemented into natural systems, it would certainly be beneficial to consider cannibalism's role.