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Advantages and disadvantages of facultative parthenogenesis compared to sexual reproduction

Parthenogenesis is a natural form of asexual reproduction which allows the production of offspring with an unfertilised egg cell. It occurs naturally in a variety of organisms including fish, amphibians, reptiles and more commonly, plants and invertebrate animals. Some parthenogenetic animals are obligate, meaning they exclusively reproduce without a male, others are facultative and are able to switch between asexual and sexual reproduction. In this essay I will discuss the advantages and disadvantages of facultative parthenogenesis and how it impacts populations with the absence or a limited number of males, and there- fore little to no chance of reproducing sexually, and how this compares to the benefits and drawbacks of sexual reproduction.

Parthenogenesis can occur in haploid or diploid cells; if the process occurs in a haploid cell, it can only produce a haploid adult, therefore this is rare. The process more commonly occurs in diploid cells, which can be produced either by a single haploid gamete cell duplicating its chromosomes, or two haploid gamete cells merging together. These diploid cells are not true clones of the parent because the genetic material is separated and rearranged. Diploid cells can also undergo mitosis, whereby the sex cells replicate their DNA and split into two cells, producing a genetically identical clone cell, the offspring will therefore be an exact copy of the parent.

According to the Mate Scarcity Hypothesis (*Burke, N.W. et al, 2015)*; some organisms are able to switch from reproducing sexually to parthenogenetically in the absence of a sexual- ly viable male. How the switch actually occurs is still somewhat unknown and it has been suggested that parthenogenesis could be accidental, but in this theory it is thought that sex is the preferred method and parthenogenesis will only occur as the result of the absence of a mate. This is enables continuation of a species and prevents extinction. Reproducing in this way, however, limits the variation within the offspring due to the lack of ‘new’ gene combinations; lack of variation can prevent a population from being able to quickly adapt to changes in the environment, which can lead to increased competition from other species and a reduction in food resources. If a population cannot adapt, the species may face a significant reduction in numbers or even extinction. For this reason, sexual re- production is more beneficial because each

individual in a population possesses different strengths, allowing at least some of them the opportunity to adapt and survive when an environmental change occurs.

In contrast, being able to reproduce without needing to find a mate can benefit a small population by allowing numbers to increase rapidly. The Komodo dragon is an endangered species whose numbers have decreased significantly in the last 50,000 years (*Shine, R. Et al, 2019)* due to loss of habitat and increased competition. Since they have smaller populations, it has now become apparent that they are able to reproduce parthenogenetically when a mate is not available. One female in captivity in Chester zoo, who had never been kept with a male, managed to produce viable offspring (*Watts, P.C. et al, 2006)*. Genetic fingerprinting of the offspring and the eggs that weren't viable showed that their DNA matched their mother's exactly with no varying genetics, showing that she had conceived parthenogenetically. Another female kept at London Zoo, who had not been kept with a male for over two years, also produced viable offspring and then later went on to reproduce sexually with another male. This provides evidence that Komodo dragons are facultatively parthenogenetic.

Sexual conflict can also play a part in the favouring of parthenogenetic reproduction; if sex is too costly, females will avoid potential mates and choose to reproduce asexually (*Kawatsu, K., 2013)*. A study was conducted to test this theory on the spiny leaf stick insect (*Burke, N.W. et al, 2015)*, and it was found that pre-reproductive females appeared to avoid males by curling their abdomens away and kicking their legs at them when they at- tempted to mate. They also produced a secretion that repelled males and were them- selves repelled by the male's odour. The study also showed that parthenogenetic females started ovipositing sooner than mated females, which would be beneficial for increasing populations quickly. The limitation of this study is that the stick insects were not observed in their natural habitat; in the wild they, and other species, may not succeed in avoiding copulation due to being overpowered by males, and therefore parthenogenetic capabilities would be obsolete (see figure 1 below). "...sexually antagonistic coevolution might help to explain why

obligate sex is so widespread compared with parthenogenesis." (*Burke, N.W. et al, 2015)*.

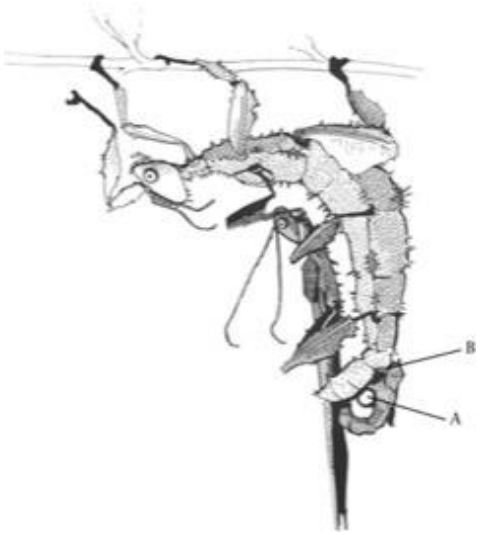

Figure 1: Copulating spiny leaf stick insects.
During sex, a large white spermatophore (labelled A) is transferred. The male mounts the female and grips onto the female's abdomen with his genital clasping organ (labelled B). The female is then unable to curl her abdomen to resist mating.
Drawing: David Sindel.
Image and text adapted from: Burke, N.W. et al, 2015

Invasive species find parthenogenetic reproduction useful because they rely on having large numbers to overcome any competition and occupy new or extended habitats. Some species of earthworm are able to reproduce by parthenogenetic cloning (*Hendrix, P.F., 2006)*, whereby the usual process of meiosis does not take place and therefore gametes only undergo mitosis, producing exact replicas of the parent. This allows a population to increase their numbers rapidly because individuals do not waste time finding a mate and can conserve their energy for potential conflict when invading a habitat.

From an evolutionary perspective, sexual reproduction is clearly a preferable choice, given that it would be the only way to diversify species and thus allowing individuals and populations to overcome relatively sudden changes in the environment or the arrival of competition. However, with each scenario that can result in parthenogenetic reproduction, there seem to be some obvious benefits. Sex can be physically costly,

time consuming, and relying on it could make a species vulnerable to extinction. Considering all that we currently know on the subject, my informed opinion is that being facultatively parthenogenetic would be the best option for both survival and continuation of species; a reduced population could increase in number rapidly, and lack of a viable mate would not prevent a species from surviving, while the presence of a mate would offer the genetic variation needed for adaptation.

References:

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