"The Adaptive Significance of Temperature-Dependent Sex Determination in a Reptile" (2008), by Daniel Warner and Richard Shine [1]

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In 2008 researchers Daniel Warner and Richard Shine tested the Charnov-Bull model by conducting experiments on the Jacky dragon, Amphibolurus muricatus [5], in Australia. Their results showed that temperature-dependent sex determination [6] (TSD) evolved in this species as an adaptation to fluctuating environmental temperatures. The Charnov-Bull model, proposed by Eric Charnov and James Bull in 1977, describes the evolution [7] of TSD, although the model was, for many years, untested. Many reptiles and some fish [8] exhibit non-genetic sex determination [9], in which an embryo's environment can influence the sex of the adult organism. Environmental conditions such as humidity or population density can alter sex in some organisms, and a widespread form of non-genetic sex determination [6] is temperature-dependent sex determination [6]. TSD reveals how embryonic development can contribute to the evolution [7] of physiological processes. Researchers have documented TSD in a wide range of species, and they continue to investigate how such a sex determining system has evolved.

According to the Charnov-Bull model, for TSD to evolve, the same environmental conditions must influence male and female reproductive success (fitness) differently. For example, females may benefit more than males from a warmer developmental temperature that causes the clutch of eggs to hatch earlier than normal. Young females that are larger than normal at the end of their first reproductive season may be able to lay eggs in their first year of life, thus increasing their reproductive potential compared to the females that do not lay eggs in their first year of life. Young males that are larger than normal may still not be large enough to compete against other males, thus the increased temperature of development would not alter their reproductive success. In this example, the reproductive success of each sex should be maximized at different temperatures, which would favor natural selection [9] for TSD.

Few tests of the Charnov-Bull model occurred prior to 2008 for at least two reasons. First, researchers had to test the reproductive success of one sex at temperatures that naturally produce that sex in the wild, as well as at temperatures that produce the opposite sex. In species for which the development of sex organs depends on the temperature of the environment, it is difficult to produce both sexes at temperatures that would naturally only produce one sex. However, using hormonal manipulations, Warner and Shine were able to produce males at temperatures that would naturally produce females, and vice versa.

Second, researchers had to develop methods to measure reproductive success for species with TSD. Reproductive success is a measure of the number of offspring produced by an individual that survives long enough to reproduce. Researchers take this measurement over the lifetime of an organism by calculating its reproductive success each year. Researchers must also measure the survival of that individual’s offspring to sexual maturity. The work involved for researchers increases with the length of an organism's life, as researchers must account for reproductive success each year, and they must follow offspring from each year. Because most reptile [10] species that exhibit TSD live for more than a decade, researchers struggle to measure the reproductive success of these organisms. However, in 2000, researchers discovered that a lizard native to Southeastern Australia, called the Jacky dragon, lives only three to four years and exhibits TSD. This discovery made measurement of lifetime reproductive success for a vertebrate species with TSD more feasible.

In TSD of Jacky dragons, temperature can influence the development of sex in an embryo by regulating production of hormones [11] responsible for the development of sex organs. Specifically, the enzyme aromatase aids in the conversion of male sex...
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They continue to investigate how such a sex determining system has evolved. They also discovered that embryos' environment can influence the sex of the adult organism. Environmental conditions such as humidity or population density can alter sex in some organisms, and a widespread form of non-genetic sex determination is temperature-dependent sex determination (TSD). TSD reveals how embryonic development can be influenced by environmental temperature. Researchers have documented TSD in a wide range of species, and the Charnov-Bull model, proposed by Eric Charnov and James Bull in 1977, described the evolution of TSD, although the model was, for many years, untested. Many reptiles and some fish exhibit non-genetic sex determination, in which an embryo's environment can influence the sex of the adult organism. Environmental conditions such as humidity or population density can alter sex in some organisms, and a widespread form of non-genetic sex determination is temperature-dependent sex determination. TSD reveals how embryonic development can contribute to the evolution of physiological processes. Researchers have documented TSD in a wide range of species, and they continue to investigate how such a sex determining system has evolved.

Sources


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