The University of Vermont
Dept of Biology, Marsh Life Sciences Bldg

Press Release 4 September 2012

contact: Josh Mitteldorf 215.837.4497; jmitteld@uvm.edu

The purpose of life is to reproduce. We have understood as much since Darwin. So why have women evolved to *stop* reproducing at a certain age? So much about our bodies seems to be optimized for survival, leading to reproduction. Why should evolution have produced a menopause?

In the past, evolutionary biologists have proposed different answers to this question. Perhaps a woman needs time to care for her children or grandchildren, free of the distraction of pregnancy and nursing. This idea seemed reasonable until it was discovered that humans are not alone in outliving our capacity to reproduce. Many birds stop laying eggs, but go right on living and eating. Even more puzzling are fish and worms that live on after they can no longer reproduce. These lower animals don't care for their young at all, so their continued life after reproduction ends seems particularly pointless.

Another hypothesis, popular until recently, has been that post-reproductive life is an artifact created by the coddled existence of zoo animals. Perhaps, in the wild, animals don't live long enough to go through menopause. But no – field surveys indicate that it's not just about artificial environments, that there are large numbers of animals in nature that outlive their fertility as well.

The big picture is that for many animals in the biosphere, life seems to continue after reproduction stops, and this presents a fundamental challenge to evolutionary theory. The organism seems to be wasting resources on an evolutionary cul-de-sac.

Charles Goodnight, professor of Biology at University of Vermont, and Josh Mitteldorf, a visiting scholar in the same department have proposed a resolution of this dilemma. In an article that came out this week they offer an explanation for menopause that is broad enough to encompass animals that don't care for their young. Mitteldorf and Goodnight think that menopause can help prevent extinctions.

Here's how it works: Animals in natural ecosystems are often subject to a feast-or-famine environment. While food supplies hold out, populations tend to rise on an accelerating (exponential) curve. This can lead to population overshoot, until mass starvation causes a population die-off. Such events are dangerous for the whole ecosystem. They can lead to extinction.

Mitteldorf and Goodnight think that cessation of reproduction is a particularly effective way to stabilize the ecosystem, and lessen the danger of extinction. The obvious consequence of slower reproduction is that the rest of the ecosystem has more time to adjust before the population grows out of control. But beyond the obvious, ceasing to reproduce, while still living in a weakened state, can offer unique advantages as a way to prevent population overshoot. While there's plenty of food, the post-reproductive population continues to eat and to slow population growth. But later, as famine looms, they are the first ones to die, and that's a good thing. Their sacrifice means fewer mouths to feed, but it doesn't affect the population's capacity to regrow when the famine is over. The weak, aging post-reproductive animals serve as a buffer that moderates the severity of the overpopulation crisis, and protects the younger members.

The article in Oikos, the European journal of ecology, describes a computer model developed by Mitteldorf, based on concepts that he and Goodnight evolved cooperatively. They start with the traditional idea that natural selection is always tending to favor animals that reproduce faster, so that population growth is pushed higher and higher. This is great for the fitness of individual animals, but for the community it can be a "tragedy of the commons". If the animals are reproducing at a faster rate than their food source, the population will overshoot into unsustainable territory. Even so, Darwinian logic says that those animals that reproduce faster will continue to expand at the expense of any that reproduce more slowly. Eventually, the ecosystem has trouble finding any kind of stability, because populations are rising and falling faster than the system can keep up. (This is called "dynamic chaos" as described by a new research field that has offered surprising insights since the 1980s.)

"Everywhere we look, we see ecosystems that seem to persist, species that coexist without their populations either blowing up or crashing to zero. You might conclude that stable ecosystems come for free – they're just what happens when you put together a bunch of competing species and let them adapt to each other. But theory tells us something different. It's actually quite hard to create a stable situation, when everybody is trying to grab all they can get and reproduce as fast as possible. Maybe evolution had to work like heck to make stable ecosystems possible. Maybe the life cycles that we see in nature bear the imprint of natural selection for stable communities."

The thinking of the two UVM evolutionists is bound to be controversial because it depends implicitly on the idea that communities and groups of animals can have Darwinian fitness of their own, independent of the fitness of their individual members. Traditional evolutionists like to think that the Darwinian struggle for survival takes place exclusively at the level of one individual against another. Mitteldorf and Goodnight are in the minority here – they believe that natural selection also works on groups and communities. This idea runs afoul of the "selfish gene" theory that is the predominant paradigm in the field.

"Group selection has been in a backwater of evolutionary biology for forty years now. In some circles, it's still very controversial, while a minority of us have developed the idea and pushed it forward. But here's a form of group selection that can't be denied. It's not an evolutionary frill that helps groups to get along a bit better. It's actually what keeps whole ecosystems from crashing into extinction."

Both scientists are eager to see whether their idea is accepted as a radical solution to a difficult scientific problem, or whether it is attacked for its reliance on group selection.

The full-text article: *Post-reproductive life span and demographic stability* can be found at http://mathforum.org/~josh/PRLS4Oikos.pdf