August 9, 2018

Jaclyn Caruso
Salem State University
Salem, MA
j_caruso5@salemstate.edu

PERSONAL CARE PRODUCTS PRESERVATIVES CAUSE SEA URCHINS TO DEVELOP ABNORMALLY

Poor development indicates detrimental effects on marine life when these chemicals wash into the ocean

Hazardous waste finding its way into the ocean is a major concern for many coastal communities. Although regulations have greatly limited the deliberate dumping of waste products into marine habitats, household waste may not be completely eliminated by wastewater and sewage treatment and could pose a risk to marine life. Among the most widely used household products that lead to such waste are personal care products.

Personal care products (PCPs) include sunscreen, deodorant, shampoo, cosmetics, toothpaste, and more. These daily-use products comprise a market worth billions of dollars annually. Because of their regular use, PCPs often contain preservatives to inhibit the growth of bacteria and mold. The most common preservatives are a class of chemicals called parabens.

Several studies published between 2002 and 2009 provided troubling evidence that parabens can accumulate in human breast tissue, impact estrogen-gene expression, and potentially affect male fertility. Because of the serious health risk implications of these chemicals, PCP manufacturers began replacing parabens with newer and supposedly safer preservatives. As the ultimate destination of many PCPs is the ocean, it is crucial to understand the impacts of these preservatives on marine species. Unfortunately, there have been few studies on their potential effects in the marine environment.

Some of the most vulnerable marine life include species that reproduce by releasing their young into the water. In sea urchins, for example, fertilized eggs develop into a free-floating larval stage that is highly susceptible to environmental stressors due to its small size. These stages are often crucial parts of the marine food web, as they are consumed by commercially important species like fish and crustaceans. Because the ocean is the ultimate destination of many cosmetics preservatives, it is crucial to understand their impacts on marine species.

To test the effects of PCP preservatives on marine life, Jaclyn Caruso and Dr. Bob Podolsky conducted research through the Research Experience for Undergraduates (REU) program at the College of Charleston (CofC). They tested for lethal and sublethal effects of the preservatives methylparaben (MP) and two newer alternatives, 2-phenoxyethanol (2-PE) and chlorphenesin (CPN), on the development of sea urchin embryos.

Caruso and Podolsky exposed sea urchin embryos to five concentrations of each chemical and allowed them to develop for two days. After a standard test exposure of 48 hours, the developmental stages were counted, and their body size and shape were measured in three dimensions. These measurements were used to tell whether these chemicals compromised survival and growth.

Their findings were both surprising and disturbing. At a concentration of 1000 parts per million (ppm; for perspective, approximately 0.1 ounce per gallon of seawater), embryos exposed to all three chemicals failed to develop. Development was arrested around the 2- or 4-cell stage—the stage at which the embryos were added to the chemicals—suggesting that the effects were nearly instantaneous. The same effects were seen in MP at a concentration of 100 ppm.

At lower concentrations of each chemical, larvae developed more slowly than those in plain seawater. Additionally, some larvae exposed to MP and CP at concentrations as low as 32 and 316 ppm, respectively, had improperly formed skeletons. These results indicate effects that may be detrimental to populations of sea urchins and potentially other animals in the environment.

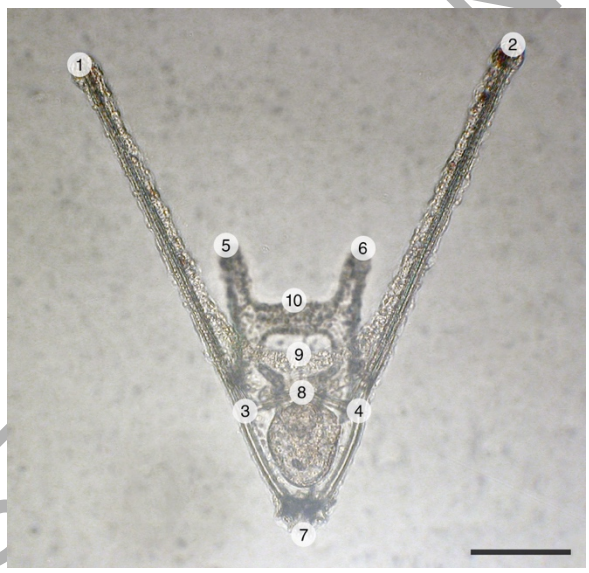
Ambient environmental levels of these chemicals appear to be much lower than the concentrations tested in the present study, though very few measurements have been taken. One study of rivers in Japan measured only 0.01 ppm of 2-PE. Other studies in different parts in the world of marine environments and wastewater treatment plants found much lower concentrations of the other preservatives. However, the toxicity studies that have been conducted with these preservatives have involved short exposures to high concentrations; in the ocean, a much more likely scenario is long-term exposure to low concentrations.

In the present study, the higher survival in the alternative preservatives (CPN or 2-PE) than in the more widely-used parabens (MP) suggests that the newer preservatives adopted by the PCP industry may be a better choice for future use. However, these alternatives still showed many harmful effects in the early life stages of sea urchins, and thus cannot be deemed entirely safe for the environment at these concentrations. Implications for the potential effects on human health cannot be ascertained from these results, but warrant further study.

“Our results demonstrate how important it is to test effects of new chemicals on a variety of organisms prior to their use in products that will enter the ocean,” said Dr. Podolsky. The introduction of harmful toxins like 2-PE, CPN, and MP from personal care products into the marine environment may upset important ecosystems in large enough quantities. Because the early stages of many species are important in the marine food web, it is imperative to guard their health in the ocean.

Further, while cosmetics and other PCPs are regulated by the United States Food and Drug Administration (FDA), their ingredients do not need FDA-approval prior to sale to consumers. Manufacturers have a responsibility to produce safe products for people, but not necessarily for marine life. Future steps may be needed to monitor ambient environmental levels of harmful preservatives and ensure that they do not reach unsafe concentrations. This action includes testing the effluent of wastewater treatment plants for these preservatives, and if necessary, changing how the effluent is treated before it is released into the ocean.

Arbacia punctulata *is a model for toxicology studies. Scale bar = 1 cm. Jaclyn Caruso, 2018.*



Normal preserved four-arm pluteus larva with 10 landmarks on the skeleton. Scale bar = 0.1 mm. Jaclyn Caruso, 2018.

Abnormal arm development in CPN at 10 ppm. Scale bar = 50 µm. Jaclyn Caruso, 2018.

Embryo after the first division of the fertilized egg in MP at 1000 ppm. Scale bar = 50 µm. Jaclyn Caruso, 2018.

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This work was supported by the Fort Johnson REU Program, National Science Foundation Award No. DBI-1757899 to the Grice Marine Lab, College of Charleston. For more information, visit: http://reu.cofc.edu. Read the CofC REU blog at: http://blogreu.wordpress.com.

Thank you to Dr. Cheryl Woodley (NOAA) for graciously providing her insight and resources and Pete Meier (CofC) for assisting with the setup and maintenance of aquaria.

AUTHOR
Jaclyn Caruso
Salem State University
Salem, MA
j_caruso5@salemstate.edu

AUTHOR
Bob Podolsky, Ph.D.
College of Charleston
Charleston, SC
podolskyr@cofc.edu